

DESCRIPTION

TITLE

5 IL-33 ANTAGONIST-CONTAINING THERAPEUTIC AGENT FOR ENDOMETRIOSIS

FIELD

[0001]

10 The present invention relates to a therapeutic agent for endometriosis comprising an interleukin-33 (IL-33) antagonist as an active ingredient.

BACKGROUND

15 [0002]

Endometriosis is a benign (non-malignant) disease in which endometrial tissue proliferates at a site away from the uterine cavity and affects approximately 10% of all women of reproductive age. Endometriosis affects 25-50% of infertile women.

[0003]

20 Although there are various theories pertaining to the cause of endometriosis, one cause is thought to be that endometrial cells reach other tissue via menstrual blood causing endometrial tissue to form and proliferate ectopically.

[0004]

25 Uterine adenomyosis uteri is a disease in which a lesion resembling endometrium is observed in the myometrium. Although this disease is histologically similar to endometriosis, it is treated as a different disease since the mechanism of occurrence and clinical picture are different. This disease has a peak age of onset in the forties and is associated with the observation of dysmenorrhea, lower abdominal pain, lower back pain, infertility and hypermenorrhea. The typical clinical symptom is menstrual pain and there are many patients
30 who complain of intense pain to a degree that impairs daily life. Patients with adenomyosis uteri may also be complicated with endometriosis and uterine myoma.

[0005]

35 Although methods for treating endometriosis or adenomyosis uteri consist of surgery and drug treatment, both of these approaches are symptomatic treatments and a fundamental treatment method for these diseases does not exist. Even in cases in which surgery is selected, it cannot achieve a complete cure due to the need for preserving fertility, and treatment is

frequently combined with post-surgical drug therapy to prevent recurrence. Examples of drug therapy include low-dose oral contraceptives, gonadotropin releasing hormone (GnRH) antagonists (such as Leuplin), androgen (such as Danazol), and progesterone (such as Dienogest). However, all of these drugs have adverse side effects due to affecting hormone balance. Namely, Dienogest is known to cause an increase in embryo mortality rate following administration to pregnant rats. Consequently, use during pregnancy is prohibited for all of these drugs. Since many of these drugs are associated with symptoms of pseudomenopause and pseudopregnancy, they have side effects resembling menopausal disorders such as infertility, hot flashes or osteoporosis. Thus, it has been anticipated to develop a preventive agent or therapeutic agent for endometriosis or adenomyosis uteri that is highly safe and does not have an effect on pregnancy.

[0006]

Interleukin-33 (IL-33) is a cytokine belonging to the Interleukin-1 family that is thought to play a role in an inflammatory condition. IL-33 is constantly expressed within the nuclei of epithelial cells and vascular endothelial cells and functions as an alarmin that is released in conjunction with cell destruction due to tissue damage attributable to infection or physical or chemical stress. Expression of IL-33 is also thought to have a mechanism by which it is increased and secreted in response to stimulation of substances such as lipopolysaccharides. IL-33 released outside from cells binds to IL-33 receptors expressed on cells, thereby an intracellular signal is activated. IL-33 receptors are expressed on various immune system cells and epithelial cells and IL-33 induced intracellular signal transduction occurs in these cells.

[0007]

IL-33 is thought to induce allergic inflammation (such as asthma, atopic dermatitis, hay fever or anaphylactic shock) by inducing the production of Th2 cytokines (such as IL-4, IL-5, IL-6 or IL-13) from Th2 cells, mast cells, eosinophils, basophils, natural killer (NK) T-cells and group 2 innate lymphoid cells among immune system cells expressing IL-33 receptors (NPL1: Tatsukuni Ohno et al., Allergy, 2012, Vol. 67, p.1203). Clinical studies have recently been conducted on asthma, atopic dermatitis and peanut allergies as indications for anti-IL-33 antibodies and anti-IL-33 receptor antibodies, which are IL-33 antagonists.

[0008]

Mbarik, et al. (NPL2: Maruoa Mbarik et al., Immunol. Lett., 2015, Vol. 166, pl) reported that as a result of analyzing the serum and ascites of endometriosis patients, IL-33 increases in the ascites etc. in endometriosis as the patient's condition (stage) progresses, which make it possible to use as a surrogate marker. IL-33 was reported by. According to the report by Mbarik et al., the concentration of soluble IL-33 receptor (sST2), which functions as an IL-33 antagonist, in ascites is roughly 100 times higher than that of IL-33 and increases together with the

progression of endometriosis in the same manner as IL-33. Thus, whether increased expression of IL-33 during endometriosis is a cause of the disease or a result thereof, and what type of pathology it functions in response to are still unclear.

[0009]

IL-33 antagonists have been reported to be used in the treatment of local fibrosis (PTL1: WO 2016/140921). Although PTL1 mentions endometriosis as one case of local fibrosis, the therapeutic effect against endometriosis is not investigated in the examples. PTL1 merely lists endometriosis as one form of fibrosis and nothing is found regarding the role of IL-33 in endometriosis etc.

CITATION LIST

PATENT LITERATURE

[0010]

PTL1: WO 2016/140921

PTL2: WO 2014/164959

PTL3: WO 2015/099175

NON-PATENT LITERATURE

[0011]

NPL1: Tatsukuni Ohno et al., Allergy, 2012, Vol. 67, p.1203

NPL2: Maruoa Mbarik et al., Immunol. Lett., 2015, Vol. 166, p.1

SUMMARY

[TECHNICAL PROBLEM]

[0012]

An agent is sought for treating endometriosis or adenomyosis uteri that is highly safe and does not have an effect on pregnancy.

[SOLUTION TO PROBLEM]

[0013]

As a result of conducting extensive studies to solve the aforementioned problems, the inventors of the present invention identified IL-33 as an exacerbating factor of endometriosis or adenomyosis uteri. The inventors of the present invention found that an IL-33 antagonist capable of inhibiting the action of IL-33 is useful for treating, preventing or alleviating endometriosis or adenomyosis uteri, thereby leading to completion of the present invention.

[0014]

The present invention relates to that indicated below.

[0015]

[1] A therapeutic agent for endometriosis or adenomyosis uteri comprising an IL-33 antagonist as an active ingredient.

5 [2] The therapeutic agent described in item 1, which alleviates the pain of endometriosis or adenomyosis uteri.

[3] The therapeutic agent described in item 1 or 2, which inhibits the growth of ectopic endometrial tissue (including cysts) in endometriosis or adenomyosis uteri.

10 [4] The therapeutic agent described in any of items 1 to 3, which inhibits angiogenesis in ectopic endometrial tissue (including cysts) of endometriosis or adenomyosis uteri.

[5] The therapeutic agent for endometriosis or adenomyosis uteri described in any of items 1 to 4, which inhibits fibrosis or proliferation in ectopic endometrial tissue (including cysts).

15 [6] The therapeutic agent described in any of items 1 to 5, which inhibits adhesion of ectopic endometrial tissue (including cysts) in endometriosis to various organs.

[7] The therapeutic agent for endometriosis or adenomyosis uteri described in any of items 1 to 6, wherein the IL-33 antagonist is anti-IL-33 antibody, anti-IL-33 receptor antibody or soluble IL-33 receptor.

20 [8] The therapeutic agent for endometriosis or adenomyosis uteri described in item 7, wherein the IL-33 antibody is A10-1C04, A23-1A05, A25-2C02, A25-3H04 or A26-1F02.

[9] The therapeutic agent for endometriosis or adenomyosis uteri described in item 7, wherein the soluble IL-33 receptor is sST2-Fc.

[10] A therapeutic method for endometriosis or adenomyosis uteri comprising administration of an IL-33 antagonist.

25 [11] A use of an IL-33 antagonist in the production of a therapeutic agent for endometriosis or adenomyosis uteri.

[12] An IL-33 antagonist for use in the treatment of endometriosis or adenomyosis uteri.

[13] The therapeutic method, use or IL-33 antagonist described in any of items 10 to 12, which alleviates the pain of endometriosis or adenomyosis uteri.

30 [14] The therapeutic method, use or IL-33 antagonist described in any of items 10 to 12, which inhibits the growth of ectopic endometrial tissue (including cysts) of endometriosis or adenomyosis uteri.

35 [15] The therapeutic method, use or IL-33 antagonist described in any of items 10 to 12, which inhibits angiogenesis in ectopic endometrial tissue (including cysts) of endometriosis or adenomyosis uteri.

[16] The therapeutic method, use or IL-33 antagonist described in any of items 10 to 12,

which inhibits fibrosis or proliferation in ectopic endometrial tissue (including cysts).

[17] The therapeutic method, use or IL-33 antagonist described in any of items 10 to 16, wherein the IL-33 antagonist is anti-IL-33 antibody, anti-IL-33 receptor antibody or soluble IL-33 receptor.

[ADVANTAGEOUS EFFECTS OF INVENTION]

[0016]

The therapeutic agent for endometriosis or adenomyosis uteri of the present invention has a therapeutic effect on endometriosis or adenomyosis uteri. The therapeutic agent for endometriosis or adenomyosis uteri of the present invention demonstrates at least one action selected from the group consisting of alleviation of pain, inhibition of growth of ectopic endometrial tissue (including cysts), inhibition of angiogenesis in ectopic endometrial tissue (including cysts) and inhibition of fibrosis or proliferation in ectopic endometrial tissue (including cysts) associated with endometriosis or adenomyosis uteri.

BRIEF DESCRIPTION OF DRAWINGS

[0017]

FIG. 1 is a graph indicating inhibition of the growth of a cystic lesion, which is ectopic endometrial tissue, in IL-33 gene knockout mice (IL-33KO) in comparison with wild type control mice (control) in an endometriosis model.

FIG. 2 is a graph indicating promotion of the growth of a cystic lesion, which is ectopic endometrial tissue, in IL-33 dosed mice (IL-33 ip) in comparison with control mice (control) in an endometriosis model.

FIG. 3 is a graph indicating inhibition of the growth of a cystic lesion, which is ectopic endometrial tissue, in IL-33 antagonist-dosed mice (sST2-Fc) in comparison with control mice (cont Fc) in an endometriosis model.

FIG. 4 depicts azan-stained images indicating inhibition of fibrosis of a cystic lesion, which is ectopic endometrial tissue, in an IL-33 antagonist-dosed mouse (sST2-Fc) in comparison with a control mouse (cont Fc) in an endometriosis model.

FIG. 5 is a graph indicating inhibition of the growth of a cystic lesion by administration of anti-IL-33 antibody (anti-IL-33) in comparison with control antibody (Control Ab) in an IL-33-dosed endometriosis model.

FIG. 6 is a graph indicating inhibition of cell proliferation (percentage of Ki-67-positive cells) in a cystic lesion by administration of anti-IL-33 antibody (Anti-IL-33 Ab) in comparison with control antibody (Control Ab) in an IL-33-dosed endometriosis model.

MODE FOR CARRYING OUT THE INVENTION

[0018]

5 The following provides an explanation of terms used in the present invention in order to facilitate understanding of the present invention.

[0019]

[IL-33]

10 IL-33 is a cytokine belonging to the IL-1 family. Human IL-33 is comprised of 270 amino acids as shown in SEQ ID NO:1 of the sequence listings and the mRNA sequence thereof is shown in SEQ ID NO: 2. IL-33 has a chromatin binding domain on the N-terminal side thereof, has an IL-1-like cytokine domain of a molecular weight of 18 kD that has 12 β strands on the C terminal side thereof, and has cathepsin G cleavage sites at positions 95 and 109, an elastase cleavage site at position 99 and a caspase cleavage site at position 178. During the
15 course by which cells undergo necrosis, IL-33 is cleaved by enzymes such as elastase, cathepsin G or proteinase 3 originating in lysosomes resulting in the formation of various fragments containing mature forms of IL-33 such as IL-33 (residue 95 to residue 270) (IL-33 represented with the amino acid sequence from residue 95 to residue 270 from the N terminal in SEQ ID NO:1 of the sequence listings is denoted as “IL-33 (residue 95 to residue 270)”, and to
20 apply similarly hereinafter), IL-33 (residue 99 to residue 270), IL-33 (residue 109 to residue 270) or IL-33 (residue 112 to residue 270), and these are thought to function as cytokines. On the other hand, in the case cell death is apoptosis, IL-33 is thought to be cleaved at position 178 by caspase, which has been activated during the course of apoptosis, and form an inactive form of IL-33 such as IL-33 (residue 179 to residue 270).

[0020]

25 When released outside from the cell as a cytokine, IL-33 binds with IL-33 receptor and has the function of initiating intracellular signal transduction in the cell expressing said IL-33 receptor. The signal transduction induced by IL-33 non-restrictively includes an NF- κ B pathway and MAPKKs pathway, ultimately giving rise to the production of various types of cytokines, chemokines and inflammatory mediators. Examples of cytokines induced by IL-33 include TNF- α , IL-1 β , IFN- γ , IL-3, IL-4, IL-5, IL-6 and IL-13, etc. Examples of chemokines induced by IL-
30 33 include CXCL2, CCL2, CCL3, CCL6, CCL17 and CCL24, etc. Examples of inflammatory mediators induced by IL-33 include PGD2 and LTB4, etc. The cytokines, chemokines and inflammatory mediators induced by IL-33 relates to migration of immune system cells, production of cytokines and degranulation, thereby causing inflammation. In the present
35 invention, IL-33 refers to either total length IL-33 or an active fragment thereof in the case of

acting by binding to IL-33 receptor to be subsequently described, and may be a derivative or mutant thereof. In the present invention, IL-33 may be human IL-33 or IL-33 of other biological origin. In the present invention, IL-33 is preferably human IL-33 represented by the amino acid sequence of SEQ ID NO: 1 of the sequence listing.

[0021]

IL-33 receptor bound by IL-33 is composed of a heterodimer of ST2 and IL-1 receptor accessory protein (IL-1RAcP). In an IL-33 receptor, the site that specifically recognizes IL-33 and binds therewith is present in the extracellular region of ST2. IL-33 receptors are expressed in various immune system cells (such as Th2 cells, mast cells, eosinophils, basophils, macrophages, dendritic cells, NK cells, NKT cells, group 2 innate lymphoid cells (natural helper cells),

[0022]

[IL-33 Antagonist]

In the present invention, an “antagonist” refers to the general term for a substance that acts directly on a desired target, ligand thereof, receptor thereof or gene thereof (including mRNA) and has a neutralizing action on that function. Thus, antagonists not only include substances having an action that directly neutralizes a target function, but also substances having an action that neutralizes a target function indirectly by neutralizing the function of a substance interacting with a target protein or by suppressing gene expression of a target protein. Namely, an “IL-33 antagonist” may be a substance capable of inhibiting any function of IL-33 by binding to IL-33 or a substance capable of inhibiting the function of IL-33 by binding to an IL-33 receptor. Further, antisense and siRNA that suppress gene expression of IL-33 or IL-33 receptor are also included in IL-33 antagonists. IL-33 antagonists include, for example, but not intended to be limited to, anti-IL-33 antibody, anti-IL-33 receptor antibody, soluble IL-33 receptor and aptamers to IL-33 and IL-33 receptor. Anti-IL-33 antibody, anti-IL-33 receptor antibody and aptamers to IL-33 and IL-33 receptor are able to prevent association between IL-33 and IL-33 receptor by binding to IL-33 and IL-33 receptor, which respectively are target molecules thereof. On the other hand, soluble IL-33 receptors are able to prevent association between IL-33 and IL-33 receptors on the cell surface by binding with free IL-33.

[0023]

[IL-33 Receptor]

Although ST2 gene that encodes a subunit of IL-33 receptor encodes a transmembrane (ST2L) protein, it also encodes a secretory protein that lacks a transmembrane region and intracellular region due to selective splicing. The full length amino acid sequence of human ST2L is represented by SEQ ID NO: 3 of the sequence listings. Among the full length amino acid sequence, an intracellular signal transduction system is activated through binding of IL-33

binding to an IL-33 receptor (heterodimer) formed by association of ST2L with another IL-33 receptor subunit such as IL-1RAcP. IL-33 binds to the extracellular region of ST2L. Thus, ST2L is also simply referred to as an IL-33 receptor.

[0024]

[Soluble IL-33 Receptor]

The soluble IL-33 receptor in the present invention is a protein that comprises all or a part of the extracellular region of ST2L protein (residue 19 to residue 328 of SEQ ID NO: 3 of the sequence listings), and functions as an IL-33 antagonist as a result of binding with IL-33. The soluble IL-33 receptor may optionally be modified, for example be modified with polyethylene glycol or antibody constant region. In particular, soluble IL-33 receptor having the constant region of an immunoglobulin bound thereto is referred to as sST2-Fc. A preferable example of sST2-Fc is the fusion protein comprised of the extracellular region of human ST2L protein and the constant region of human IgG antibody, which is represented by SEQ ID NO: 5 of the sequence listings.

[0025]

[Antibody]

In the present invention, the term “antibody” is used in the broadest sense and refers that which includes monoclonal antibody and polyclonal antibody, as long as it exhibits a desired specific bindability. In the present invention, the antibody may be any arbitrary animal antibody such as mouse antibody, human antibody, rat antibody, rabbit antibody, goat antibody or camel antibody.

[0026]

[Monoclonal Antibody]

Among the antibodies of the present invention, monoclonal antibody refers to an antibody within an antibody population comprised of a single clone (single molecular species) in terms of a designed amino acid sequence. Monoclonal antibodies includes chimeric antibodies, humanized antibodies, human antibodies, multi-specific antibodies and artificial antibodies as well as functionally modified antibodies thereof, conjugate antibodies thereof and fragments thereof. The monoclonal antibody of the present invention can be produced using any known technique such as the hybridoma method, phage display method or a genetic engineering technique.

[0027]

[Chimeric Antibody]

Chimeric antibody refers to an antibody the light chain, heavy chain or both is composed of a variable region of derived from non-human immunoglobulin and a constant region derived from human immunoglobulin.

[0028]

[Humanized Antibody]

Humanized antibody refers to an antibody comprised of a complementarity determining region derived from non-human immunoglobulin, a variable region comprised of a framework
5 region derived from human immunoglobulin, and a constant region derived from human immunoglobulin.

[0029]

[Human Antibody]

Human antibody refers to an antibody derived from human immunoglobulin for both the
10 light chain and heavy chain. Human antibody is classified to, depending on the difference in the constant region of the heavy chain, IgG (including IgG1, IgG2, IgG3 and IgG4) having a γ chain heavy chain, IgM having a μ chain heavy chain, IgA (including IgA1 and IgA2) having an α chain heavy chain, IgD having a δ chain heavy chain and IgE having a ϵ chain heavy chain. The light chain comprises either a κ chain or a λ chain in general.

[0030]

[Multi-specific Antibody]

Multi-specific antibody refers to an antibody capable of being asymmetrical that has two or more independent antibody recognition sites having two or more different antigen
specificities, and examples thereof include bi-specific antibody having two antibody specificities
20 and tri-specific antibody having three antibody specificities. One or more antigens recognized by the multi-specific antibody of the present invention are an IL-33 molecule or IL-33 receptor molecule.

[0031]

[Artificial Antibody]

Artificial antibodies refers to, for example, protein scaffolds, which although do not have
25 the structure of immunoglobulin, have a function similar to that of immunoglobulin. The Kunitz human serine protease inhibitor domain, human fibronectin extracellular domain, ankyrin and lipocalin are used as protein scaffolds, and a protein scaffold that binds to an epitope in the present invention can be produced if the sequence at the target binding site on the scaffold is
30 modified (Clifford Mintz et al., BioProcess International, 2013, Vol. 11(2), pp40-48).

[0032]

[Functionally Modified Antibody]

A functionally modified antibody in the present application refers to an antibody in which
function other than the antigen binding function of the antibody, such as a cell killing function,
35 complement activating function or blood half-life, has been adjusted by modifying an amino acid or sugar chain of primarily the constant region of an immunoglobulin.

[0033]

[Conjugated Antibody]

A conjugated antibody in the present application refers to an antibody in which a functional molecule other than antibody, such as a non-peptidic polymer such as polyethylene glycol (PEG), radioactive substance, toxin, low molecular weight compound, cytokine, albumin or enzyme has been chemically, or using a genetic engineering technique, bound to the antibody.

[0034]

[Fragment]

An antibody fragment in the present application refers to a protein containing a portion of an antibody that is capable of binding to an antigen. Examples of antibody fragments include Fab fragment, Fv fragment, F(ab)'₂ fragment, Fab' fragment and scFv.

These antibody fragments may chemically, or using a genetic engineering technique, bind a functional molecule other than antibody such as a non-peptidic polymer such as polyethylene glycol (PEG), radioactive substance, toxin, low molecular weight compound, cytokine, albumin or enzyme.

[0035]

[Human Monoclonal Antibody]

Human monoclonal antibody refers to a monoclonal antibody having a variable region and constant region derived from the sequence of an immunoglobulin of a human germ line.

These include a monoclonal antibody derived from a transgenic mouse introduced with a human antibody gene and an antibody derived from a human antibody gene library.

[0036]

[Neutralization]

In the present application, “neutralization” refers to an action capable of inhibiting any target function. Inhibition of the function (biological activity) of IL-33 includes, but is not limited to, the inhibition of the production of IL-33-induced cytokines such as IL-6. An indication of the biological activity of IL-33 can be evaluated by one or more in vitro or in vivo analyses known in the art.

[0037]

[Complementarity Determining Region]

A complementarity determining region refers to a variable region of an immunoglobulin molecule that forms an antigen binding site, is also referred to as a hypervariable region, and exhibits a large change in the amino acid sequence in particular for each immunoglobulin molecule. A complementarity determining region has three complementarity determining regions for each of the light chain and heavy chain (complementarity determining region 1, complementarity determining region 2 and complementarity determining region 3). In the

present application, the complementarity determining region of an immunoglobulin molecule is determined in accordance with the Kabat numbering scheme (Kabat et al., 1987, Sequences of Proteins of Immunological Interest, US Department of Health and Human Services, NIH, USA).

[0038]

[Aptamer]

An aptamer refers to a nucleic acid molecule that specifically binds with a specific substance, and in the present application, refers to a molecule that functions as an antagonist by binding to IL-33 or IL-33 receptor. An aptamer in the present application may include an artificial nucleic acid molecule other than naturally-occurring nucleic acid molecules.

[0039]

[Antisense]

Antisense refers to an antisense nucleic acid (such as RNA or DNA) that is capable of hybridizing with the RNA of a target gene and has a function that suppresses expression of gene function. In the present application, antisense refers to a molecule that functions as an antagonist that suppresses expression of a gene by binding to mRNA of IL-33 or IL-33 receptor. Antisense in the present application may also include an artificial nucleic acid molecule other than naturally-occurring nucleic acid molecules.

[0040]

[siRNA]

Small interfering RNA (siRNA) refers to low molecular weight double-stranded RNA comprised of 15 to 30 base pairs. siRNA is involved in a phenomenon referred to as RNA interference and sequence-specifically suppresses expression of a gene by destroying the mRNA of a target gene. In the present application, siRNA refers to a molecule that functions as an antagonist that suppresses expression of a gene by destroying the mRNA of IL-33 or IL-33 receptor. siRNA in the present application may include an artificial nucleic acid molecule other than naturally-occurring nucleic acid molecules.

[0041]

[Endometriosis]

Endometriosis is a benign (non-cancerous) disease in which endometrial tissue propagates at a site away from the uterine cavity (ectopically), and examples of such sites include the ovaries, abdominal cavity, peritoneum, Douglas pouch, sigmoid colon, rectum, uterosacral ligament, vagina, vulva, urinary bladder, abdominal wall and navel. Ectopic endometrial tissue may undergo adhesion with various organs. A hematoma of endometrial tissue formed in the ovaries may be referred to as a chocolate cyst. A laparoscopy is performed to make a definitive diagnosis of endometriosis and ectopic endometrial tissue is observed directly. The Re-ASRM classification is used to classify the clinical stage of endometriosis, and

classifies endometriosis to Stage 1 to Stage 4 by scoring according to the site of the lesion, whether the lesion is superficial or deep and the degree of adhesion to other organs. The Beecham classification is used to monitor the progress of endometriosis and progress is classified to Stage 1 to Stage 4 corresponding to the progression of the condition.

5 **[0042]**

[Adenomyosis uteri]

Adenomyosis uteri is a disease in which endometrial tissue is observed in the muscle layer of the uterus, and is classified by MRI diagnosis as focal adenomyosis uteri, which is limited to a portion of the uterus, and diffuse adenomyosis uteri, which extends throughout the

10 **[0043]**

The following provides an explanation of embodiments of the present invention. The following embodiments are exemplary in order to explain the present invention and the present invention is not limited to these embodiments only.

15 **[0044]**

The present invention relates to a therapeutic agent for endometriosis or adenomyosis uteri comprising an IL-33 antagonist as an active ingredient thereof. The therapeutic agent is able to completely cure, alleviate symptoms or prevent exacerbation by being administered to a patient suffering from endometriosis or adenomyosis uteri. Examples of IL-33 antagonists

20 **[0045]**

In another aspect, the present invention relates to a pharmaceutical composition for treating, preventing or alleviating endometriosis or adenomyosis uteri comprising an IL-33 antagonist. In still another aspect, the present invention relates to a method for treating, preventing or alleviating endometriosis or adenomyosis uteri that includes administration of an IL-33 antagonist. The present invention also relates to a use of the IL-33 antagonist of the present invention in order to produce a drug for treating, preventing or alleviating endometriosis or adenomyosis uteri. The present invention also relates to an IL-33 antagonist for use in

30 **[0046]**

Endometriosis is a disease in which endometrial tissue develops at a location other than the endometrium. The disease in which endometrial tissue is present in the muscle layer of the uterus is referred to as adenomyosis uteri. Although this ectopic endometrial tissue undergoes repeated development and bleeding in coordination with the menstrual cycle in the same manner

blood. A hematoma formed in this manner is referred to as a chocolate cyst. As a result of the formation of a cyst, tissue undergoes fibrosis and can result in the formation of adhesion and induration. When ectopic endometrial tissue ends up adhering to other organs (such as the peritoneum, intestines or ovaries), it causes pain. Adhesion of the fallopian tubes causes infertility. Hormone therapy and resection by a surgical procedure are generally performed for endometriosis. At least one action selected from the group consisting of alleviation of pain associated with endometriosis or adenomyosis uteri, inhibition of the growth of ectopic endometrial tissue (including cysts), inhibition of angiogenesis in ectopic endometrial tissue (including cysts), inhibition of adhesion between various organs and ectopic endometrial tissue (including cysts), and inhibition of fibrosis or cell proliferation is demonstrated by treating, preventing or alleviating endometriosis or adenomyosis uteri.

[0047]

Patients suffering from endometriosis or adenomyosis uteri have symptoms such as increased menstrual volume and more intense menstrual pain accompanying fluctuations in menstrual cycle. Thus, a therapeutic agent containing an IL-33 antagonist or a pharmaceutical composition for treatment, prevention or alleviation can be administered to subject having changes in symptoms accompanying fluctuations in menstrual cycle and subjects presenting with complaints accompanying fluctuations in menstrual cycle. Such subjects can be distinguished from subjects simply having local fibrosis.

[0048]

In another aspect of the present invention, the present invention also relates to an alleviator of pain associated with endometriosis or adenomyosis uteri comprising an IL-33 antagonist as an active ingredient, an inhibitor of adhesion of various organs to ectopic endometrial tissue (including cysts) in endometriosis comprising an IL-33 antagonist as an active ingredient, an inhibitor of the growth of ectopic endometrial tissue (including cysts) in endometriosis or adenomyosis uteri comprising an IL-33 antagonist as an active ingredient thereof, an inhibitor of angiogenesis in ectopic endometrial tissue (including cysts) of endometriosis or adenomyosis uteri comprising an IL-33 antagonist as an active ingredient thereof, an inhibitor of fibrosis of endometrial stromal cells in ectopic endometrial tissue (including cysts) of endometriosis or adenomyosis uteri comprising an IL-33 antagonist as an active ingredient thereof, an inhibitor of cell proliferation in endometrial tissue (including cysts) of endometriosis or adenomyosis uteri comprising an IL-33 antagonist as an active ingredient, a superficial endometriosis therapeutic agent comprising an IL-33 antagonist as an active ingredient, a deep endometriosis therapeutic agent comprising an IL-33 antagonist as an active ingredient, a focal adenomyosis uteri therapeutic agent comprising an IL-33 antagonist as an active ingredient thereof, or a diffuse adenomyosis uteri therapeutic agent comprising an IL-33

antagonist as an active ingredient thereof.

[0049]

The IL-33 antagonist of the present invention preferably alleviates lower back pain, lower abdominal pain or defecation pain during menstruation in endometriosis or adenomyosis uteri patients, or lower back pain, lower abdominal pain or defecation pain at times other than menstruation, and more preferably eliminates that pain.

[0050]

The IL-33 antagonist of the present invention preferably alleviates pain in the pelvis, ovaries, abdominal cavity, peritoneum, Douglas pouch, sigmoid colon, rectum, uterosacral ligament, vagina, vulva, urinary bladder, abdominal wall and/or navel of endometriosis patients, and more preferably eliminates that pain.

[0051]

Alleviation of pain by the IL-33 antagonist of the present invention can be evaluated with, for example, the Biberoglu & Behrman scale that scores QOL associated with pain (Biberoglu, KO and Behrman, SJ, Am. J. Obstet. Gynecol., 139: 645 (1981)). According to this scale, pain such as pelvic pain, dysmenorrheal pain or coital pain other than during menstruation is evaluated as a subjective symptom.

[0052]

Alleviation of pain by the IL-33 antagonist of the present invention can be evaluated by a reduction in the number of times an analgesic is taken or the dosage thereof. The analgesic is preferably a non-steroid-based anti-inflammatory analgesic, examples of which include loxoprofen sodium hydrate, diclofenac sodium and aspirin.

[0053]

The IL-33 antagonist of the present invention preferably inhibits adhesion of ectopic endometrial tissue (including cysts) in the pelvis, ovaries, abdominal cavity, peritoneum, Douglas pouch, sigmoid colon, rectum, uterosacral ligament, vagina, vulva, urinary bladder, abdominal wall and/or navel of endometriosis patients, and more preferably eliminates that adhesion. The IL-33 antagonist of the present invention inhibits adhesion of the uterus and restriction of uterus mobility is preferably alleviated.

[0054]

The IL-33 antagonist of the present invention preferably inhibits the growth of ectopic endometrial tissue (including cysts) in the pelvis, ovaries, abdominal cavity, peritoneum, Douglas pouch, sigmoid colon, rectum, uterosacral ligament, vagina, vulva, urinary bladder, abdominal wall and/or navel of endometriosis patients, and more preferably reduces that ectopic endometrial tissue (including cysts).

[0055]

The IL-33 antagonist of the present invention preferably inhibits angiogenesis in ectopic endometrial tissue (including cysts) in the pelvis, ovaries, abdominal cavity, peritoneum, Douglas pouch, sigmoid colon, rectum, uterosacral ligament, vagina, vulva, urinary bladder, abdominal wall and/or navel of endometriosis patients.

5 **[0056]**

The IL-33 antagonist of the present invention preferably inhibits fibrosis or cell proliferation in ectopic endometrial tissue (including cysts) in the pelvis, ovaries, abdominal cavity, peritoneum, Douglas pouch, sigmoid colon, rectum, uterosacral ligament, vagina, vulva, urinary bladder, abdominal wall and/or navel of endometriosis patients.

10 **[0057]**

The IL-33 antagonist of the present invention preferably inhibits the production of cytokines and/or mediators in ectopic endometrial tissue (including cysts) in the pelvis, ovaries, abdominal cavity, peritoneum, Douglas pouch, sigmoid colon, rectum, uterosacral ligament, vagina, vulva, urinary bladder, abdominal wall and/or navel of endometriosis patients, and more preferably inhibits the production of IL-6, TNF- α and/or prostaglandins.

15

[0058]

The IL-33 antagonist of the present invention preferably cures patients suffering from Stage 1, Stage 2, Stage 3 and/or Stage 4 endometriosis according to an examination based on the Beecham classification, and preferably cures patients with Stage 1, Stage 2, Stage 3 and/or Stage 4 endometriosis by evaluation of a score determined according to the Re-ASRM classification.

20

[0059]

The IL-33 antagonist of the present invention preferably improves QOL associated with endometriosis. Improvement of QOL can be evaluated through interviews using, for example, the Endometriosis Health Profile-30 (EHP-30) (Jones, G. et al., Obstet. Gynecol., 98: 258 (2001)), the EQD-5D (Brooks, R. et al., Health Policy, 37: 53 (1997), or the Endometriosis Treatment Satisfaction Questionnaire (ETSQ) (Deal, LS et al., Qual. Life Res., 19(6), 899 (2010)). Examples of improvement of QOL including improvement of difficulty in standing upright, difficulty in sitting, difficulty in walking, appetite, insomnia, frustration, depression, weepiness, sadness, manic depression, short temperedness, violence, loneliness, loss of confidence and coital difficulty.

30

[0060]

A therapeutic agent for endometriosis or adenomyosis uteri that uses an IL-33 antagonist differs from commonly used drug therapy using hormone regulators in that it alleviates infertility and menopausal disorder-like adverse side effects. Thus, the IL-33 antagonist of the present invention is preferably a therapeutic agent for endometriosis or adenomyosis uteri that maintains a fertile state and is free of fetal toxicity during pregnancy, and is preferably a therapeutic agent

35

for endometriosis or adenomyosis uteri that is not accompanied by menopausal disorder-like adverse side effects. Examples of menopausal disorder-like adverse side effects include, but are not limited to, infertility, hot flashes, osteoporosis and depression.

[0061]

5 Anti-IL-33 antibody and anti-IL-33 receptor antibody include monoclonal antibodies and polyclonal antibodies. An antibody in the present invention may be an antibody derived from any animal species such as mouse antibody, human antibody, rat antibody, rabbit antibody, goat antibody or camel antibody. The IL-33 antibody and anti-IL-33 receptor antibody of the present invention are preferably monoclonal antibodies and more preferably, the anti-IL-33 antibody and
10 anti-IL-33 receptor antibody of the present invention are monoclonal antibodies that are chimeric antibodies, humanized antibodies or human antibodies.

[0062]

 The anti-IL-33 antibody and anti-IL-33 receptor antibody of the present invention can be acquired by any arbitrary method known in the art. In the case of monoclonal antibodies,
15 antibodies can be acquired using an arbitrary technique such as the hybridoma method, phage display method or a genetic engineering technique.

[0063]

 In the hybridoma method, a hybridoma is produced by fusing B cells acquired from the spleen or lymph nodes of an animal such as a rat or mouse immunized using an immunogen with
20 immortalized cells such as myeloma cells, followed by screening for a hybridoma that produces antibody having a desired bindability and producing that antibody using the screened hybridoma. Human antibody can be acquired by using a mouse introduced with a human antibody gene. In the case of acquiring monoclonal antibody from a hybridoma, a method is employed in which the hybridoma is cultured in accordance with ordinary methods followed by obtaining the
25 antibody in the culture supernatant thereof, or a method is employed in which the hybridoma is allowed to proliferate by administering to a mammal having compatibility therewith followed by obtaining the antibody in ascites thereof. The former method is suitable for obtaining highly pure antibody, while the latter method is suitable for large-volume antibody production. A known technology is used for the technology for producing the monoclonal antibody and this
30 monoclonal antibody can be produced in accordance with the description in, for example, Chapter 2 of Current Protocols in Immunology, Wiley and Sons Inc..

[0064]

 In the phage display method, phages selected from an arbitrary phage antibody library are screened using a target antigen (IL-33 or IL-33 receptor in the present application) followed by
35 selecting a phage having desired bindability for that antigen. Next, the antibody corresponding sequence contained in the phage is isolated or determined and an expression vector containing a

nucleic acid molecule encoding a monoclonal antibody is constructed based on the isolated or determined sequence information. A cell line transfected with this expression vector is then cultured to produce monoclonal antibody. Human antibody having a desired bindability can be produced by using a human antibody library for the phage antibody library.

5 **[0065]**

In a genetic engineering technique, antibody having enhanced affinity for antibody and/or a modified function can be produced by introducing a mutation into a sequence corresponding to a complementarity determining region (CDR) or other sequence in a gene sequence encoding an antibody, incorporating that sequence in an expression vector and using this vector to transform a host cell (see, for example, Borrebaeck, C.A.K. and Larrick, J.W., Therapeutic Monoclonal Antibodies, Published in the United Kingdom by MacMillan Publishers, Ltd., 1990).

10 **[0066]**

In the present invention, chimeric antibody, humanized antibody, multi-specific antibody or artificial antibody, for example, can be used for the purpose of lowering xenoantigenicity to humans or adding a different function, and these antibodies can be produced using a known method such as a genetic engineering technique.

15 **[0067]**

Chimeric antibody is obtained by linking DNA encoding the variable region of a non-human immunoglobulin with DNA encoding the constant region of a human immunoglobulin, incorporating this DNA in an expression vector and introducing the expression vector into a host to produce chimeric antibody (see EP 125023, WO 92/19759). Chimeric antibody useful in the present invention can be obtained by using this known method.

20 **[0068]**

Humanized antibody is obtained by linking complementarity determining regions (CDR) derived from a non-human immunoglobulin with DNA encoding the other part of the regions of a human immunoglobulin, incorporating this DNA in an expression vector and introducing the expression vector into a host to produce humanized antibody.

25 **[0069]**

Human antibody is prepared by using, for example, the procedure described in the Examples provided below. Human antibody can also be prepared by using trioma technology, human B-cell hybridoma technology (Kozbor, et al., 1983, Immunol. Today, 4, p.72) or EBV hybridoma technology for producing human monoclonal antibody (Cole, et al., 1985, Monoclonal Antibodies and Cancer Therapy, Alan R. Liss, Inc., p.77). Human antibody can also be produced by preparing a hybridoma by immunizing a transgenic mouse introduced with a human antibody gene with an antigen protein (IL-33 or IL-33 receptor in the present application). Examples of transgenic mice include a HuMab® mouse (Medarex), KMTM mouse

(Kirin Pharma), KM(FC γ RIIb-KO) mouse and VelocImmune mouse (Regeneron).

[0070]

Multi-specific antibody can be produced by a genetic engineering technique using the antigen-binding regions of two or more types of monoclonal antibodies. Genetic engineering techniques have already been established in the art. For example, a desired bi-specific antibody can be acquired by using a technology employing DVD-Ig, in which the antigen-binding regions of two types of monoclonal antibodies are linked directly (Wu, et al., Nature Biotechnology, 25(11), 1290 (2007)) or technology employing ART-Ig, in which the heavy chains of two types of antibodies that bind to different antigens are combined by modifying the constant regions of immunoglobulin (Kitazawa, et al., Nature Medicine, 18(10), 1570 (2012)).

[0071]

Artificial antibody can be acquired for use as artificial antibody that binds to a desired target by using, for example, the 10th unit of the human fibronectin type III domain (FNfn10) and introducing a mutation into the BC, DE and/or FG loop of that unit. In addition to the extracellular domain of fibronectin, peptides such as the Kunitz domain of serine protease inhibitor, ankyrin or lipocalin can be used as artificial antibodies. These artificial antibodies can be produced using a genetic engineering technique by introducing a vector containing a nucleic acid molecule encoding the peptide into Escherichia coli, yeast or animal cells, culturing the host cells and purifying from the culture supernatant (PTL4, Clifford Mintz, et al., BioProcesses International, 2013, Vol. 11(2), pp.40-48).

[0072]

Artificial antibodies can also be found as low molecular weight peptide molecules that specifically bind to an epitope of the present invention in the similar manner of antibody from random sequence library in which amino acids are randomly combined, instead of using a specific protein as described above or a portion of the amino acid sequence thereof (see, for example, Hipolito, et al., Current Opinion in Chemical Biology, 2012, Vol. 16, 196; Yamagishi, et al., Chemistry & Biology, 2011, Vol. 18, 1562). In addition to genetic engineering techniques, such peptides can also be produced by a chemical synthesis method such as the fluorenyl methyloxy carbonyl method or t-butyloxycarbonyl method.

[0073]

The monoclonal antibody used in the present invention may be, for example, a conjugated antibody bound with various types of molecules such as a non-peptidic polymer such as polyethylene glycol (PEG), radioactive substance or toxin. Such conjugated antibodies can be obtained by carrying out chemical modification on the resulting antibody. Chemical modification methods have already been established in the art. The monoclonal antibody in the present invention incorporates these conjugated antibodies (King, D.J., Applications and Engineering of

Monoclonal Antibodies, 1998, T.J. International Ltd.; Monoclonal Antibody-Based Therapy of Cancer, 1998, Marcel Dekker Inc.; Chari, et al., Cancer Res., 1992, Vol. 152, 127; Liu, et al., Proc. Natl. Acad. Sci. USA, 1996, Vol. 93, 8681).

[0074]

5 In the present invention, separate from the whole antibodies described above, fragments of monoclonal antibodies and modified forms thereof may also be used, as long as they have antigen bindability and demonstrate antagonist activity. Examples of antibody fragments include Fab fragments, Fv fragments, F(ab')₂ fragments, Fab' fragments and single chain Fv fragments (scFv) in which the Fv of the H chain and L chain are linked with a suitable linker. These
10 antibody fragments may also be linked to a functional molecule other than antibody such as a non-peptidic polymer such as polyethylene glycol (PEG), radioactive substance, toxin, low molecular weight compound, cytokine, albumin or enzyme by means of a chemical technique or genetic engineering technique.

[0075]

15 Production systems for producing monoclonal antibody are widely known in the art and can be suitably selected corresponding to the quality of the target formulation. For example, an in vitro or in vivo production system can be used. Examples of in vitro production systems include production systems using eukaryotic cells such as animal cells, plant cells or fungal cells, and production systems using prokaryotic cells such as bacterial cells of Escherichia coli or
20 Bacillus subtilis. Mammalian cells, for example commonly used cells, such as CHO, COS, myeloma, BHK, HeLa and Vero cells, insect cells or plant cells may be used. Examples of in vivo production systems include production systems using animals and production systems using plants. In the case of using an animal, examples include production systems using mammals and insects. Goats, pigs, sheep, mice or cows, for example, can be used as mammals (Vicki Glaser,
25 Spectrum Biotechnology Applications, 1993). Silkworms, for example, can be used as insects. A tobacco plant, for example, can be used in the case of using a plant.

[0076]

 In the case of producing monoclonal antibody with an in vitro or in vivo production system as described above, DNA encoding the heavy chain (H chain) or light chain (L chain) of
30 an immunoglobulin may be separately incorporated in an expression vectors to simultaneously transform a host, or DNA encoding an H chain and L chain may be incorporated in a single expression vector to transform a host (see WO 94/11523).

[0077]

 The resulting monoclonal antibody can be purified until uniform. Separation and
35 purification methods used with ordinary proteins may be used to separate and purify the monoclonal antibody. For example, monoclonal antibody can be separated and purified by

suitably selecting and combining a chromatography column such as that for affinity chromatography, filtration, ultrafiltration, salting out, dialysis, SDS polyacrylamide gel electrophoresis or isoelectric focusing (Antibodies: A Laboratory Manual, Ed Harlow and David Lane, Cold Spring Harbor Laboratory, 1988), although not limited thereto. Examples of columns used for affinity chromatography include a protein A column and protein G column. Examples of columns used a protein A column include Hyper D, POROS and Sepharose F.F. (Amersham Biosciences).

[0078]

The nucleic acid molecules of the present invention, such as an aptamer, antisense or siRNA, can be synthesized by, for example, the phosphoramidite method using a nucleic acid molecule of a monomer for the material. The phosphoramidite method can be carried out in accordance with a method complying with, for example, the method described in WO 2014/046212. The aptamer of the present invention preferably binds to IL-33 protein (SEQ ID NO: 1 of the sequence listings) or human IL-33 receptor protein (SEQ ID NO: 3 of the sequence listings), and the antisense or siRNA preferably binds to human IL-33 mRNA (SEQ ID NO: 2 of the sequence listings) or human IL-33 receptor mRNA (SEQ ID NO: 4 of the sequence listings). The nucleic acid molecules of the present invention consisting of aptamer, antisense and siRNA may include artificial nucleic acids, and examples of artificial nucleic acids include phosphorothioate (S-PO₃)-type oligonucleotides (S-oligo) and 2',4'-bridged nucleic acids (BNA)/2',4'-locked nucleic acids (LNA) (WO 98/39352, WO 2005/021570, WO 2003/068795, WO 2011/052436).

[0079]

A preferable aspect of the IL-33 antagonist of the present invention is, for example, an aptamer that is able to neutralize the action of IL-33 by binding to human IL-33 receptor, and an example thereof is RBM-009.

[0080]

The therapeutic agent or pharmaceutical composition comprising the IL-33 antagonist of the present invention may further comprise, a pharmacologically acceptable carrier, diluent or vehicle, in addition to IL-33 antibody, anti-IL-33 receptor antibody or soluble IL-33 receptor, or salts thereof, all of which relates to human IL-33 antagonist as an active ingredient. An active ingredient other than the IL-33 antagonist of the present invention, such as an anti-inflammatory agent or immunosuppressant, may also be contained. Although such a composition is provided as a drug form suitable for parenteral administration or oral administration, parenteral administration is preferable. Examples of parenteral administration, include, but are not limited to, intravenous, intraarterial, subcutaneous, local, intraperitoneal, intramuscular, transnasal, instillation, transdermal, transmucosal, intramedullary, rectal, intramuscular and intravaginal

administration.

[0081]

A suitable drug form can be selected for the therapeutic agent or pharmaceutical composition of the present invention corresponding to the administration route, and any drug form may be used, such as an injection, powder or infusion preparation. From the viewpoint of parenteral administration, an injection, infusion preparation or powder dissolved at the time of use is preferable. These formulations may also contain various adjuvants used for pharmaceuticals, namely carriers and other auxiliary agents such as stabilizers, preservatives, analgesics, emulsifiers and other additives.

[0082]

The IL-33 antagonist of the present invention can be introduced, for example, by continuous infusion or by bolus administration at an interval of once a day, once a week, once a month or 1 to 7 times in a year. The IL-33 antagonist can be introduced by intravenous, intraperitoneal, subcutaneous, local, transnasal, rectal, intramuscular or intravaginal administration. The preferable dosage protocol includes the maximum dose or dosage frequency that avoids serious adverse side effects. The dosage per administration is generally at least about 0.05 µg/kg of body weight, more generally at least about 0.2 µg/kg, most generally at least about 0.5 µg/kg, typically at least about 1 µg/kg, more typically at least about 10 µg/kg, most typically at least about 100 µg/kg, preferably at least about 0.2 mg/kg, more preferably at least about 1.0 mg/kg, most preferably at least about 2.0 mg/kg, more suitably at least about 10 mg/kg, even more suitably at least about 25 mg/kg, and optimally at least about 50 mg/kg.

[0083]

Examples of preferable aspects of the IL-33 antagonist of the present invention include the human IL-33 monoclonal antibodies of A10-1C04, A23-1A05, A25-2C02, A25-3H04 and A26-1F02. The respective amino acid sequences of the light chains and heavy chains of these monoclonal antibodies are SEQ ID NO: 7 and SEQ ID NO: 8 of the sequence listings (A10-1C04), SEQ ID NO: 9 and SEQ ID NO: 10 (A23-1A05), SEQ ID NO: 11 and SEQ ID NO: 12 (A25-2C02), SEQ ID NO: 13 and SEQ ID NO: 14 (A25-3H04) and SEQ ID NO: 15 and SEQ ID NO: 16 (A26-1F02). The constant regions of these antibodies are preferably constant regions of human antibody, and more preferably the constant region of human IgG1.

[0084]

Another aspect of the IL-33 antagonist of the present invention is, for example, an antibody that is able to neutralize the action of IL-33 by binding to human IL-33, and examples thereof include etokimab (also referred to as ANB-020), REGN-3500 (also referred to as SAR-440340), MEDI-3506, PF-06817024 and CBP-233.

[0085]

Another aspect of the IL-33 antagonist of the present invention is, for example, an antibody that is able to neutralize IL-33 by binding to human IL-33 receptor, and examples thereof include RG-6149 (also referred to as AMG-282, MSTT1041A or RO-7187807), GSK-3772847 (also referred to as CNTO-7160) and LY-3375880.

[0086]

Although soluble IL-33 receptor is a protein having all or a portion of the extracellular region (residue 19 to residue 328) of ST2L of SEQ ID NO: 3 of the sequence listings, an amino acid substitution, deletion or insertion may be contained, as long as the soluble IL-33 receptor demonstrates IL-33 antagonistic action. From the viewpoint of not impairing IL-33 antagonistic action, the number of substituted, deleted or inserted amino acids is preferably one or several, and any arbitrary number of 1 to 9 amino acids can be substituted, deleted or inserted. In another aspect, soluble IL-33 receptor may have identity of at least 80%, more preferably at least 90%, even more preferably at least 95% and still more preferably at least 98% with respect to the amino acid sequence of the extracellular region (residue 19 to residue 328) of ST2L of SEQ ID NO: 3 of the sequence listings, as long as it demonstrates IL-33 antagonistic action. From the viewpoint of improving pharmacokinetics, a constant region of an immunoglobulin and polyethylene glycol, for example, may be fused to the soluble IL-33 receptor. Soluble IL-33 receptor having an antibody constant region fused thereto can be referred to as sST2-Fc. Although the constant region of an immunoglobulin able to be bound may be a constant region derived from any arbitrary species, from the viewpoint of ensuring low antigenicity, a human constant region is preferable. A preferable example of human sST2-Fc is the fusion protein represented by SEQ ID NO: 5 of the sequence listings.

[0087]

sST2-Fc can form a dimer in the same manner as an immunoglobulin. An amino acid of sST2-Fc may be substituted, deleted or inserted into the original amino acid sequence, such as the amino acid sequence of SEQ ID NO: 5 or 6, as long as it demonstrates IL-33 antagonistic action. From the viewpoint of not impairing IL-33 antagonistic action, the number of substituted, deleted or inserted amino acids is one to several, and any arbitrary number of 1 to 9 amino acids can be substituted, deleted or inserted. In another aspect, sST2-Fc may have identity of at least 80%, more preferably at least 90%, even more preferably at least 95% and still more preferably at least 98% with respect to the amino acid sequence SEQ ID NO: 5 or 6 of the sequence listings, as long as it demonstrates IL-33 antagonistic action. These sST2-Fc preferably maintain the ability to form a dimer.

[0088]

A soluble IL-33 receptor such as sST2-Fc can be produced using an in vitro production system using a vector containing a nucleic acid that encodes soluble IL-33 receptor protein.

Examples of in vitro production systems include production systems using eukaryotic cells such as animal cells, plant cells or fungal cells, and production systems using prokaryotic cells, for example, bacterial cells, such as Escherichia coli or Bacillus subtilis. Mammalian cells, for example, commonly used cells, such as CHO, COS, myeloma, BHK, HeLa, Vero, 293, NSO, Namaiwa or YB2/0 cells, insect cells or plant cells may be used as animal cells. Soluble IL-33 receptor can be isolated by further purifying the protein produced in this manner.

[0089]

Although the following provides a more detailed explanation of the present invention through examples thereof, the present invention is not limited to the following examples unless specifically mentioned otherwise. All references mentioned in the present description are incorporated in the present description in their entirety by reference.

[0090]

Example 1: Effect of IL-33 Gene Deficiency in Endometriosis Model

Transplanted uterus mice administered estrogen were used as an animal model of endometriosis (Ricci, et al., Reprod. Sci., 2011, Vol. 18, p614). After subjecting wild type, 6-week-old female Balb/c mice (Charles River Laboratories, Japan) or Balb/c-background IL-33 knockout mice (Yasuda, et al., PNAS, 2012, Vol. 130, p184) (to be denoted as “IL-33KO mice”) to inhalation anesthesia with isoflurane (anesthesia maintained at an isoflurane concentration of 3.0% and ambient air flow rate or 300-400), a small incision was made somewhat to the left of the midline of the mice followed by extraction of the left and right uterus from the laparotomy opening in order and excision of the ovaries adhered to the end of the uterus. These mice were subcutaneously injected with an estradiol valerate injection solution (Fuji Pharma) (Estrogen) dissolved to 5 µg/mL with corn oil (Wako Pure Chemical Industries) beneath the skin of the posterior of the neck using a 22G syringe at the rate of 0.5 µg/100 µL/body for 2 weeks (once per week) to produce donor mice and recipient mice. Two weeks later, the donor mice were sacrificed by cervical dislocation and laparotomized followed by excising the uterus. The excised uterus was uniformly cut to a weight of 40 g in a Petri dish. Subsequently, the excised uterus was placed in a 25 mL wide-mouth, round-bottom Spitz tube together with 400 µL of PBS in which was dissolved ampicillin antibiotic (1 mg/mL) followed by finely crushing into the form of a sheet measuring 2 mm on a side with a Cooper scissors. The crushed uterus was aspirated with a 2.5 mL syringe. A small incision was added at the midline of the recipient mice subjected to inhalation anesthesia in the same manner as during ovariectomy, uterine tissue in the syringe was dispersed in the abdominal cavity, and the incision was sutured with 3-0 Monocryl suture. After transplanting the uterine fragment, the recipient mice were subcutaneously further administered estrogen by subcutaneous injection for 2 weeks (once/week). The mice were euthanized and laparotomized two weeks after transplant. The ectopic endometrial tissue (cystic) lesions formed

in the abdominal cavity were excised while avoiding damage thereto as much as possible followed by respectively measuring the weight and volume thereof. The volume of the cystic lesions was calculated using $V = (4/3)\pi b^2 A$ (b: small diameter, A: large diameter).

[0091]

As shown in FIG. 1, in the case of using IL-33KO mice for both the donor and recipient, the volume of the cystic lesion decreased significantly in comparison with the case of using wild type mice. Adhesion of the cystic lesions in the IL-33 KO mice to tissue such as the abdominal cavity was inhibited during excision in comparison with cystic lesions of the control mice. The number of blood vessels of the cystic lesions of the IL-33 KO mice appeared to have decreased in comparison with cystic lesions of the control mice. This result indicates that IL-33 is involved in growth of cystic lesions and adhesion to various organs (and adhesion to various organs is a cause of pain) as well as angiogenesis in an endometriosis model, and that inhibition of IL-33 makes it possible to inhibit growth of cystic lesions and their adhesion to various organs (pain) as well as inhibit angiogenesis.

[0092]

Example 2: Effect of Administration of IL-33 on Endometriosis Model

An endometriosis model was prepared according to the method described in Example 1 using wild-type, 6-week-old female Balb/c mice. The IL-33 dose group was intraperitoneally administered recombinant human IL-33 protein (residue 112 to residue 270) (Kondo, et al., Int. Immunol., 2008, Vol. 20, p791) dissolved with PBS starting at the time of transplant at the rate of 100 ng/200 μ L/body per administration three times per week for 2 weeks for a total of 6 administrations. The mice were euthanized and laparotomized two weeks after transplant followed by excising the cystic lesions that formed in the abdominal cavity and measuring the volume of each lesion. As shown in FIG. 2, the volume of the cystic lesions increased significantly in the IL-33 dose group in comparison with the medium dose group. This result indicates that IL-33 is involved in the growth of cystic lesions. Since the concentration of IL-33 increases in the ascites and serum of endometriosis patients (NPL2), a human IL-33-dosed endometriosis model is thought to be a useful disease model that reflects the pathology of endometriosis.

[0093]

Example 3: IL-33 Antagonists

Five types of human IL-33 antibodies (A10-1C04, A23-1A05, A25-2C02, A25-3H04 and A26-1F02) along with mouse sST2-Fc, which is a fusion protein of mouse ST2 and human IgG1 constant region, were prepared with recombinant CHO cells (WO 2015/099175). The amino acid sequences thereof are as shown in the table below, and when affinity of the five types of human IL-33 antibodies to human IL-33 protein (residue 112 to residue 270) (ATGen, ILC070) was

measured with KinExA, the values of K_d were 100.3 pM for A10-1C04, 195.3 pM for A23-1A05, 700 fM for A25-2C02, 7.7 pM for A25-3H04 and 5.3 pM for A26-1F02.

[Table 1]

IL-33 Antagonist	Light Chain Sequence	Heavy Chain Sequence
A10-1C04	SEQ ID NO: 7	SEQ ID NO: 8
A23-1A05	SEQ ID NO: 9	SEQ ID NO: 10
A25-2C02	SEQ ID NO: 11	SEQ ID NO: 12
A25-3H04	SEQ ID NO: 13	SEQ ID NO: 14
A26-1F02	SEQ ID NO: 15	SEQ ID NO: 16
Mouse sST2-Fc	SEQ ID NO: 6	

5 [0094]

Example 4: Effect of IL-33 Antagonist sST2-Fc on Growth of Ectopic Endometrial Tissue

Since IL-33 is involved in the proliferation of cystic lesions in an endometriosis model, endometriosis was indicated to be able to be treated by inhibiting IL-33. Endometriosis was therefore treated by administering IL-33 antagonist. The mouse sST2-Fc prepared in Example 3 was used for the IL-33 antagonist. Mouse sST2-Fc was administered intravenously over the course of 2 weeks every 3 days at the rate of 20 mg/kg following transplant of a uterine fragment using an endometriosis model in groups of 6 mice each prepared according to the method indicated in Example 1. A control Fc (InVivoMab Recombinant Human Fc-G1 (Bio X Cell, Cat. No. Be0096) was administered to control mice instead of the mouse sST2-Fc. The mice were euthanized and laparotomized following being treated using mouse sST2-Fc, cystic lesions that formed in the abdominal cavity were excised and the degree of adhesion of the cystic lesions following excision, the volume of the cystic lesions and blood vessels present in the cystic lesions were analyzed. As shown in FIG. 3, the volume of the cystic lesions in the mouse sST2-Fc dose group decreased significantly in comparison with the control Fc dose group. Accompanying this decrease in cystic lesion volume, adhesion of cystic lesions in the mouse sST2-Fc-dosed mice to the peritoneum and other tissue was inhibited at the time of excision in comparison with cystic lesions of the control mice. Cystic lesions in the mouse sST2-Fc-dosed mice demonstrated an apparent decrease in the number of blood vessels in comparison with cystic lesions of the control mice.

On the basis of the above results, endometriosis was able to be treated by administration of mouse sST2-Fc, and growth, adhesion (adhesion to various organs is a cause of pain) and angiogenesis of ectopic endometrial tissue of endometriosis were able to be inhibited.

[0095]

Example 5: Effect of IL-33 Antagonist sST2-Fc on Fibrosis of Ectopic Endometrial Tissue

The cystic lesions excised in Example 4 were fixed with paraformaldehyde followed by embedding in paraffin and preparing paraffin sections having a thickness of 8 μ m. Fibrotic tissue was stained blue using a staining solution of Mallory's aniline blue/orange stain G (Muto Pure Chemicals) in accordance with the protocol recommended by Muto Pure Chemicals. The degree of fibrosis was evaluated according to the depth of the blue color of azan staining based on a score of 1 (light) to 3 (dark). As shown in Table 2, fibrosis of the cystic lesions was inhibited in the mouse sST2-Fc dose group in comparison with the control Fc dose group. FIG. 4 depicts average stained images in each group (individual number D of the control Fc dose group and individual number C of the mouse sST2-Fc dose group).

[Table 2]

	A	B	C	D	E	F	G
Control Fc Dose Group	2	3	3	2	2	3	2.5
Mouse sST2-Fc Dose Group	1	2	1	3	3	1	1.8

On the basis of the above results, endometriosis is able to be treated by administration of mouse sST2-Fc and fibrosis of ectopic endometrial tissue of endometriosis can be inhibited.

[0096]

Example 6: Effect of Anti-IL-33 Monoclonal Antibody on Growth of Ectopic Endometrial Tissue

Cystic lesions were shown to increase due to administration of recombinant human IL-33 in a endometriosis model prepared in IL-33 KO mice (Example 2). The effect of the human anti-IL-33 monoclonal antibodies prepared in Example 3 (A10-1C04, A23-1A05, A25-2C02, A25-3H04 and A26-1F02) was investigated using this model. Human anti-IL-33 antibody was administered intravenously every week at the rate of 10 mg/kg after transplanting a uterine fragment using the IL-33-dosed endometriosis model prepared according to the method indicated in Example 2. Control antibody (fully human IgG1 isotype control PC grade (Eureka, Cat. No. ET901)) was administered to the mice of a control group instead of human anti-IL-33 antibody. The mice were euthanized and laparotomized after treating using the human anti-IL-33 antibody, cystic lesions that formed in the abdominal cavity were excised and the degree of adhesion of the cystic lesions following excision, the volume of the cystic lesions and blood vessels present in the cystic lesions were analyzed. As shown in FIG. 5 (showing the results for A10-1C04), the volume of the cystic lesions increased in the human IL-33 dose group in comparison with the PBS dose group, and the volume of the cystic lesions increased significantly even following administration of the control antibody. Increases in volume of the cystic lesions were inhibited significantly by administration of anti-IL-33 antibody. Accompanying a decrease in volume of the cystic lesions, adhesion of cystic lesions in the anti-IL-33 antibody-dosed mice to the

peritoneum and other tissue was inhibited at the time of excision in comparison with cystic lesions of the control mice. Cystic lesions in the mouse sST2-Fc-dosed mice demonstrated an apparent decrease in the number of blood vessels in comparison with cystic lesions of the control antibody-dosed mice. Cystic lesions anti-IL-33-dosed mice demonstrated an apparent decrease in the number of blood vessels in comparison with cystic lesions of the control mice.

On the basis of the above results, endometriosis is able to be treated by administration of anti-IL-33 antibody and the growth, adhesion (adhesion to various organs is a cause of pain) and angiogenesis of ectopic endometrial tissue of endometriosis are able to be inhibited.

[0097]

Example 7: Effect of Anti-IL-33 Monoclonal Antibody on Cell Proliferation of Ectopic Endometrial Tissue

The cystic lesions excised in Example 6 were fixed with paraformaldehyde followed by embedding in paraffin and preparing paraffin sections having a thickness of 8 μm . Immunohistostaining of the cell proliferation marker, Ki-67 antigen, was carried out using anti-Ki-67 antibody ("SP6", Abcam, ab16667) and Dako Envision+ Dual Link (Agilent, K4063) in accordance with the protocol recommended by Abcam in order to investigate the proliferation of cystic lesions. The Ki-67 positive rate in the cell nuclei per one microscopic field of a section was calculated. The Ki-67 positive rate at three locations per slide was also calculated and the average was determined. As shown in FIG. 6 (indicating the results for A10-1C04), administration of human IL-33 cause an increase in the percentage of Ki-67-positive cells serving as a cell proliferation marker in the cells of cystic lesions associated with endometriosis in comparison with the PBS dose group, and although the increase in the percentage of Ki-67-positive cells increased even following administration of control antibody, that increase was inhibited by administration of anti-IL-33 antibody.

On the basis of the above results, endometriosis is able to be treated by administration of anti-IL-33 antibody and cell proliferation of ectopic endometrial tissue of endometriosis can be inhibited.

[0098]

Example 8: Effect of Anti-IL-33 Monoclonal Antibody on Pain Associated with Endometriosis

Endometriosis and adenomyosis uteri can be treated by administering anti-IL-33 monoclonal antibody to endometriosis and adenomyosis uteri patients. Pain such as pelvic pain, dysmenorrheal pain or coital pain associated with endometriosis and adenomyosis uteri can be alleviated. QOL as related to difficulty in walking and coital pain associated with endometriosis and adenomyosis uteri can be improved.

INDUSTRIAL APPLICABILITY

[0099]

5 The therapeutic agent of the present invention having an anti-IL-33 antagonist as an active ingredient thereof can be used as a pharmaceutical composition for treating, preventing or alleviating endometriosis or adenomyosis uteri.

CLAIMS

[Claim 1]

A therapeutic agent for endometriosis or adenomyosis uteri comprising an IL-33 antagonist as an active ingredient.

[Claim 2]

The therapeutic agent according to claim 1, wherein said agent alleviates the pain of endometriosis or adenomyosis uteri.

[Claim 3]

The therapeutic agent according to claim 1 or 2, wherein said agent inhibits the growth of ectopic endometrial tissue (including cysts) in endometriosis or adenomyosis uteri.

[Claim 4]

The therapeutic agent according to any of claims 1 to 3, wherein said agent inhibits angiogenesis in ectopic endometrial tissue (including cysts) of endometriosis or adenomyosis uteri.

[Claim 5]

The therapeutic agent for endometriosis or adenomyosis uteri according to any of claims 1 to 4, wherein said agent inhibits fibrosis or cell proliferation in ectopic endometrial tissue (including cysts).

[Claim 6]

The therapeutic agent according to any of claims 1 to 5, wherein said agent inhibits adhesion of ectopic endometrial tissue (including cysts) in endometriosis to various organs.

[Claim 7]

The therapeutic agent for endometriosis or adenomyosis uteri according to any of claims 1 to 6, wherein the IL-33 antagonist is anti-IL-33 antibody, anti-IL-33 receptor antibody or soluble IL-33 receptor.

[Claim 8]

The therapeutic agent for endometriosis or adenomyosis uteri according to claim 7, wherein the IL-33 antibody is A10-1C04, A23-1A05, A25-2C02, A25-3H04 or A26-1F02.

[Claim 9]

The therapeutic agent for endometriosis or adenomyosis uteri according to claim 7, wherein the soluble IL-33 receptor is sST2-Fc.