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DESCRIPTION

Technical Field

[0001] The present invention relates to an endogenous repair factor production accelerator which comprises one prostaglandin (hereinafter referred to as "PG") 12 agonist.

Background Art

[0002] Regeneration medical treatment is drawing attention as the regeneration therapy at the time of disorders of tissues and cells such as blood vessel, liver, kidney, lung, pancreas, bone, skeletal muscle cell, myocardial cell, peripheral and central nerve cells and the like. The self repair system includes a system which is attained by the cell division of mature cells (simple duplication system) like the regeneration of many parenchymal organs such as liver and kidney and a system mediated by the proliferation and differentiation induction of stem cells (precursor cells) (stem cell system) like the regeneration of hematopoietic cells. Presently, it is said that these two systems are present in the regeneration of many tissues and organs. For example, it is said that these two systems are present also in the angiogenesis (regeneration), and there are an angiogenesis system based on the growth of neighboring vascular endothelial cells, vascular smooth muscle cells and the like, effected by the release of various endogenous repair factors (e.g., vascular endothelial growth factor (VEGF), hepatocyte growth factor (HGF), various fibroblast growth factors (a/b FGF), transformation growth factor- β (TGF- β), platelet derived growth factor (PDGF), angiopoietin, hypoxia inducing factor (HTF), insulin-like growth factor (IGF), bone morphogenetic protein (BMP), connective tissue growth factor (CTGF), epidermal growth factor (EGF), etc., growth factors of their families, and the like) from (vascular) endothelial cells, (vascular) smooth muscle cells, fibroblasts, synovial cells, epithelial cells, platelets, monocytes, lymphocytes, macrophages and the like of the injured (neighboring) region, and a vasculogenesis system in which blood vessel is formed by the differentiation induction of vascular endothelial stem cells from bone marrow cells of a matured individual, effected by the release of various inflammatory cytokines (e.g., IL-1, IL-4, IL-8, TNF α , IFN α/γ , G-CSF, GM-CSF, NO (nitric monoxide), etc.), and various endogenous repair factors.

[0003] Regarding the presence of stem cells (precursor cells), they are present not only in blood vessels but also in many tissues such as hepatocyte, pancreatic (β) cell, myocardial cell, kidney, lung, bone, joint, nerve, fat, skin and the like, and are proliferated and differentiation-induced by various endogenous repair factors, various inflammatory cytokines and the like.

[0004] When production of these endogenous repair factors is accelerated, formation of collateral circulation passage is accelerated by the effect of angiogenesis on the ischemic region. Also, it is known that prevention and treatment (repairing regeneration) of various organ disorders are accelerated by the differentiation induction action from various tissue stem cells. For example, it is known that HGF has a cell growth acceleration action, a morphogenesis inducing action, a differentiation inducing action, a wandering acceleration action, anti-apoptosis action and the like (e.g., see Biochem. Biophys. Res. Commun., 239, 639-644 (1997), etc.). It is known that these endogenous repair factor production accelerations are effective for the prevention and/or treatment of, for example, liver diseases (e.g., fulminant hepatitis, acute hepatitis, hepatic cirrhosis, fatty liver, liver transplantation, etc.), kidney diseases (e.g., acute renal insufficiency, chronic renal insufficiency, etc.), lung diseases (e.g., acute pneumonia, pulmonary fibrosis, pulmonary hypertension, chronic obstructive pulmonary disease (COPD), asthma, etc.), pancreas diseases (e.g., diabetes mellitus, chronic pancreatitis, etc.), bone diseases (e.g., osteoarthritis, articular rheumatism, osteoporosis, bone fracture, periosteum injury, etc.), digestive organ diseases (e.g., gastric ulcer, duodenal ulcer, ulcerative colitis, Crohn disease, etc.), nerve degeneration diseases (e.g., stroke, Parkinson disease, Alzheimer disease, spinal canal stenosis, cerebrovascular accidents, moyamoya disease, etc.), diabetic complications (e.g., nerve disorder, skin ulcer, nephropathy, retinal disease, etc.), vascular endothelial cell diseases (e.g., restenosis after PTCA (percutaneous transluminal coronary angioplasty), arteriosclerosis, etc.), heart diseases (e.g., supraventricular tachyarrhythmia, congestive heart failure, coronary artery disease, sudden cardiomyopathy, dilated cardiomyopathy, etc.), dental diseases (e.g., periodontal disease, tooth extraction wound, oral wound, periodontal tissue disease, etc.), decubitus, glaucoma, alopecia and the like.

[0005] The regeneration therapy mediated by endogenous repair factors is drawing attention as an angiogenesis (regeneration) therapy and a tissue generation therapy at the time of the diseases of organs and tissues such as liver, pancreas, kidney, heart, central/ peripheral nerves, blood vessel, tooth, eye, periosteum, bone and the like. This is drawing attention particularly as a regeneration therapy of serious ischemic organ diseases having no therapeutic methods, and several methods are examined on arteriosclerosis obliterans (hereinafter referred to as "ASO"), Buerger disease, Raynaud disease, cardiovascular diseases (e.g., myocardial infarction, angina pectoris, etc.), diabetic neuropathy, spinal canal stenosis, ischemic brain disease (e.g.,

cerebrovascular accidents, cerebral infarction, etc.), pulmonary hypertension, bone fracture, or Alzheimer disease and the like.

[0006] For example, patients of obstructive peripheral blood vessel diseases typified by ASO and Buerger disease show intermittent claudication, pain during resting and ulcer and necrosis of the legs, and finally it becomes unavoidable to undergo amputation of the legs. However, at present, there is no therapeutic method effective for these serious ASO patients. Since intravenous injection of PGE 1 and a vasodilator or platelet agglutination inhibitor as an oral agent of cilostazol do not show their effects on serious ASO patients, an intravascular treatment (balloon dilation or Stent insertion) and revascularization cannot be carried out. Recently, a gene therapy in which a VEGF gene plasmid and an HGF gene plasmid are directly administered by intramuscular injection into skeletal muscles of ischemic regions of the legs of these patients (cf. Circulation, 97, 1114-1123 (1998) and Gene Therapy, 8, 181-189 (2001)) has been clinically applied, and its effect is drawing attention. In addition, slow release preparations of a growth factor protein (e.g., a gelatin inclusion sheet) have also been subjected to basal examinations (circulation, 106, Supple 2, II 350 (2002)).

[0007] On the other hand, an angiogenesis therapy in which vascular endothelial stem cells separated from bone marrow or peripheral blood of a patient are directly administered into the ischemic region of a leg by intramuscular injection is drawing attention and is carried out at several university hospitals which is also drawing attention (cf. THE LANCET, 360, 427-435 (1002)).

[0008] Introduction of these genes and stem cells directly into ischemic regions using a vascular catheter equipped with a low invasion needle became possible also in myocardial infarction and angina pectoris, and is under clinical application as an angiogenesis therapy. For example, it has been reported that ischemia is improved for unstable angina by injecting a VEGF gene plasmid directly into heart muscle (Circulation, 98, 2800-2804 (1998)). Also, it was considered that PDGF is concerned in the angiogenesis after stroke, because its increase was observed in nerve cell of the phenanbla (the tissue is not dead by infarction but cannot perform its function) region of infarct focus of a cerebral infarction patient (Stroke, 28, 564-573 (1997)). Gene therapy and the like using a vector to the brain via cerebrospinal fluid from cerebellomedullary cistern have also been attempted on the ischemic cerebrovascular accidents. These treatments are a therapeutic angiogenesis (regeneration) therapy which prompts development of collateral circulation passage to the ischemic region and is a tissue regeneration therapy by the differentiation induction of tissue stem cells. However, clinical application of these gene therapy and cell therapy have many problems in terms of ethics, safety (immunity, infection, cancer, etc.), flexibility, economy and the like.

[0009] As a reopening therapy at the time of blood vessel obstruction in ASO, myocardial infarction, angina pectoris, arteriosclerosis and the like, PTCA (percutaneous transluminal coronary angiopathy) has been carried out with good results. However, it is known that restenosis is induced by the injury of vascular endothelial cells around the obstruction due to forced vasodilation by balloon dilation, Stent indwelling and the like. As a method for preventing restenosis, a platelet agglutination inhibitor or the like is administered, but this is still an unsatisfactory state. Recently, drugs such as antibiotics and carcinostatic agents (rapamycin, sirolimus, etc.) and a Stent coated with a radioisotope preparation such as β rays have been developed with good results on the prevention of restenosis (N. Eng. J. Med, 346(23), 1769-1771 (2002)). However, these methods also have many problems from a long-term point of view. Accordingly, concern is directed toward a medicament which enhances platelet agglutination inhibitory action at topical injured regions of vascular endothelial cells and damage repairing action by endothelial cell growth.

[0010] On the other hand, prostaglandin (PG) is a natural physiologically active substance biosynthesized from PGH2 in a metabolic pathway in the living body, which is called arachidonic acid cascade. The biosynthesis enzymes from arachidonic acid to PGH2 are called cyclooxygenase (COX), and COX-1, COX-2 and COX-3 are known at present (Proc. Nail. Acad Sci., 99, 1371 (2002)). In addition, compounds which inhibit these enzymes are generally used as antipyretic, analgesic and anti-inflammatory agents and agents for preventing circulatory organ system diseases, as non-steroidal anti-inflammatory drug (NSAID). Particularly, COX-2 induced in inflammation regions is concerned in the biosynthesis of PGI2, PGE2 and the like. These biosynthesized PGs are concerned in the onset of pyrexia, pain and inflammation in the inflammation regions and healing thereof. That is, the PGs biosynthesized at the inflammation regions directly act as inflammation-causing agents, induce various inflammatory cytokines, evoke inflammation, and accelerate healing thereof.

[0011] On the other hand, it is known that patients who took NSAID for a prolonged period of time have significantly low mortality rate by large bowel cancer and lung cancer (N. Eng. J. Med., 328, 1313-1316 (1993)). It is said that this action has a cancer cell growth inhibitory action, because angiogenesis for cancer tissue growth is inhibited through the biosynthesis inhibition of PGI2, PGE2 and the like by NSAID. That is, an anti-angiogenesis therapy which controls growth and metastasis of tumors by inhibiting angiogenesis is drawing attention as a new strategy of cancer treatment. Also, it is known that a COX-2-selective inhibitor does not induce gastric ulcer when it is administered, but prolongs healing of gastric ulcer. There is a report stating that its cause is inhibition of angiogenesis action for repairing of injured tissues (Am. J. Med, 104, 43S-51S (1998)). In addition, selective COX-2 inhibitors control the angiogenesis accompanied by inflammation (Jpn. J. Pharmacol., 75, 105-114 (1997)).

[0012] It is known that PGI2 has a markedly strong platelet agglutination inhibitory action, as well as actions such as platelet adhesion, vasodilation and gastric acid secretion inhibition. In addition, PGE2 administration accelerates accumulation of inflammatory cells including monocyte and production of inflammatory cytokine (e.g., IL-1 (interleukin-1), IL-8, IL-6, IFN- α (interferon- α), TNF α (tumor necrosis factor α), and NO (nitric monoxide), e/c.), and acts as an inflammation-causing agent.

[0013] JP-A-6-87811 discloses in its specification that the oxime derivative represented by formula (I) which is described later or a non-toxic salt thereof, to be used in the present invention as a PGI2 agonist (IP agonist), is useful for the prevention and/or treatment of thrombosis, arteriosclerosis, ischemic heart disease, gastric ulcer, hypertension and the like, because it has platelet agglutination inhibition, platelet adhesion inhibition, vasodilation and gastric acid secretion inhibition actions, but it does not describe or suggest on the angiogenesis action by exerting vascular endothelial cell and vascular smooth muscle cell growth action based on the endogenous repair factor production acceleration action, and on the various cell and organ diseases (the above-described diseases to be prevented and treated (repair regeneration) by HGF) by differentiation induction of various stem cells caused by these endogenous repair factor production acceleration action and the like.

[0014] Also, it is reported in Diabetologia., 40, 1053-1061 (1997) that a PGI2 derivative Beraprost ((\pm)-(1R,2R,3aS,8bS)-2,3,3a,8b-terahydro-2-hydroxy-1-[(E)-(3S,4RS)-3-hydroxy-4-methyl-1-octen-6-ynyl]-1H-cyclopenta[b]benzofuran-3-butanoic acid sodium salt) increases HGF production in vascular endothelial cells *in vitro* and shows endothelial cell growth action, but there are no descriptions on the angiogenesis accelerating action by the topical administration of persistent preparation of Beraprost and on its usefulness for the prevention and treatment of various organ diseases.

[0015] In addition, PGE2 is known as a metabolic product in the arachidonic acid cascade, and it is known that its actions have various functions such as cell protection action, uterine contraction action, pain producing action, digestive organ peristalsis acceleration action, stimulation action, gastric acid secretion inhibition action, blood pressure reducing action, diuretic action and the like.

[0016] From the studies in recent years, it has been revealed that subtypes having respectively different roles are present in the PGE2 receptor. The subtypes known at present are roughly divided into four, and are respectively called EP1, EP2, EP3 and EP4 (J. Lipid Mediators Cell Signaling, 12, 379-391 (1995)). By examining their share of roles and thereby finding a compound which does not bind to other subtype receptors, it became possible to obtain a medicament having less side effects.

[0017] For example, JP-A-11-193268 discloses in its specification that a compound represented by formula (I-a), a non-toxic salt thereof, or a prodrug or cyclodextrin clathrate thereof, which is used in the present invention as an EP2 agonist, is useful in preventing and/or treating immune diseases (e.g., autoimmune disease, organ transplantation, etc.), asthma, osteogenesis abnormality, nerve cell death, hepatopathy, premature delivery, abortion, retinal nerve diseases such as glaucoma, and the like, but it does not describe or suggest on the endogenous repair factor releasing action, stem cell differentiation induction action and angiogenesis acceleration action.

[0018] For example, WO00/03980 discloses in its specification that a compound represented by formula (I-b), a non-toxic salt thereof, or a cyclodextrin clathrate thereof, which is used in the present invention as an EP4 agonist, is useful in preventing and/or treating diseases including immune diseases (amyotrophic lateral sclerosis (ALS), multiple sclerosis, Sjögren syndrome, rheumatoid arthritis, autoimmune diseases such as systemic lupus erythematosus, rejection after organ transplantation, etc.), asthma, osteogenesis abnormality, nerve cell death, lung disease, hepatopathy, acute hepatitis, glomerulonephritis, renal insufficiency, hypertension, myocardial ischemia, systemic inflammatory reaction syndrome, burn pain, sepsis, hemophagocytosis syndrome, macrophage activation syndrome, Still disease, Kawasaki disease, burn injury, systemic granuloma, neoplastic colitis, Crohn disease, hypercytokinemia at the time of dialysis, multiple organ failure, shock, sleep abnormality, platelet agglutination and the like, but it does not describe or suggest on the endogenous repair factor releasing action, stem cell differentiation induction action and angiogenesis acceleration action.

Disclosure of the Invention

[0019] Great concern has been directed toward the development of an endogenous repair factor production accelerator, a stem cell differentiation inducer (precursor cell differentiation inducer) and an angiogenesis accelerator, which are useful as preventive and therapeutic agents of (ischemic) organ diseases and have less side effects.

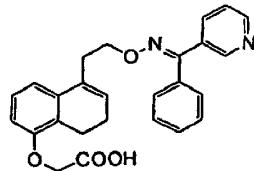
[0020] With the aim of finding an endogenous repair factor production accelerator, a stem cell differentiation inducer and an

angiogenesis accelerator, which are useful as preventive and therapeutic agents of (ischemic) organ diseases, the present inventors have conducted intensive studies and found as a result that a PGI2 agonist can achieve the object.

[0021] Also, the inventors have considered that when a PGI2 agonist, an EP2 agonist or an EP4 agonist could be topically administered to an ischemic region requiring angiogenesis or a injured region requiring tissue repair, it will become possible to produce an endogeneous repair factor, an inflammatory cytokine and the like in the periphery of the injured topical region, in addition to the vasodilation of the remaining blood vessels in the ischemic region and platelet agglutination inhibitory action, so that a medicament having less side effects in systemic administration could be created. In addition, it was considered that when it is possible to produce a pharmaceutical preparation for persistent release during a period until angiogenesis (regeneration) or tissue repair is effected in the ischemic region or periphery of the tissue injury topical region, a medicament having less side effects in systemic administration and with improved administration compliance of small administration frequency could be created.

[0022] For example, angiogenesis requires a period of generally from 1 week to 6 months, more preferably from 1 week to 8 weeks, and persistent release of the active ingredient is required in the ischemic region during the period. In addition, since PGI2 agonists, EP2 agonists and EP4 agonists show vasodilation action and platelet agglutination inhibitory action in addition to angiogenesis acceleration action and vascular stem cell differentiation induction action when production of various endogenous growth factors is accelerated, it was considered that they will show further strong preventive and/or therapeutic effect upon ischemic organ diseases when these actions are added.

[0023] Thus, the inventors have also found as a result of intensive studies that a persistent preparation of a PGI2 agonist, i.e., (E)-[5-[2-(1-phenyl-1-(3-pyridyl)methylideneaminoxy]ethyl]-7,8-dihydronaphthalen-1-yloxy]acetic acid (hereinafter referred occasionally to as "Compound 1") having the following structure:



or a salt thereof can achieve the above-described object.

[0024] The present invention is directed to a persistent microsphere preparation comprising a biodegradable polymer and (E)-[5-[2-(1-phenyl-1-(3-pyridyl)methylideneaminoxy]ethyl]-7,8-dihydronaphthalen-1-yloxy]acetic acid or salt thereof and a pharmaceutical composition and an agent comprising the microsphere preparation.

[0025] According to the present invention, the microsphere preparation is used as a vascular endothelial growth factor (VEGF) or a hepatocyte growth factor (HGF) production accelerator in preventing and/or treating a disease selected from myocardial infarction, angina pectoris, congestive heart failure and coronary artery disease.

[0026] Preferred embodiments of the present invention are defined in the subclaims.

[0027] All of pharmacologically acceptable salts are included in the salts of the (E)-[5-[2-(1-phenyl-1-(3-pyridyl)methylideneaminoxy]ethyl]-7,8-dihydronaphthalen-1-yloxy] acetic acid. It is preferable that the pharmacologically acceptable salts do not have toxicity and are soluble in water. Examples of the suitable salt of the above compounds include salts of alkali metals (potassium, sodium, lithium, etc.), salts of alkaline earth metals (calcium, magnesium, etc.), ammonium salts (tetramethylammonium salt, tetrabutylammonium salt, etc.), salts of organic amines (triethylamine, methylamine, dimethylamine, cyclopentylamine, benzylamine, phenethylamine, piperidine, monoethanolamine, diethanolamine, tris(hydroxymethyl)methylamine, lysine, arginine, N-methyl-D-glucamine, etc.), and acid addition salts (inorganic acid salts (hydrochloride, hydrobromide, hydroiodide, sulfate, phosphate, nitrate, etc.), organic acid salts (acetate, trifluoroacetate, lactate, tartarate, oxalate, fumarate, maleate, benzoate, citrate, methanesulfonate, ethanesulfonate, benzenesulfonate, toluenesulfonate, isethionate, glucuronate, gluconate, etc.). Also included in the salts of the compounds of the present invention are solvates, or solvates of alkali (alkaline earth) metal salts, ammonium salts, organic amine salts and acid addition salts of the compounds of the present invention. It is preferable that the solvates are nontoxic and soluble in water. Examples of appropriate solvate include solvates of water, alcohol system solvents (ethanol, etc.).

[0028] The compound used in the present invention is converted into pharmacologically acceptable salts by conventionally known methods.

[0029] Production methods of compound used in the present invention: (E)-[2-[1-phenyl-1-(3-pyridyl)methylideneaminoxy]ethyl]-7,8-dihydronaphthalen-1-yloxy]acetic acid (Compound 1) is described in Example 2(g) of JP-A-6-87811.

Toxicity:

[0030] Since toxicity of the active agent used in the present invention is very low, it is sufficiently safe for using as medicine.

Industrial Applicability

Application to pharmaceutical preparations:

[0031] Since Compound 1 used in the present invention has the angiogenesis accelerating action, it is for example useful as preventive and/or therapeutic agents for ischemic organ diseases (e.g., arteriosclerosis obliterans, Buerger disease, Raynaud disease, cardiovascular diseases (e.g., myocardial infarction, angina pectoris), diabetic neuropathy, spinal canal stenosis, ischemic brain disease (e.g., cerebrovascular accidents, cerebral infarction), pulmonary hypertension, bone fracture, Alzheimer disease). In addition, since Compound 1 used in the present invention has the endogenous repair factor production accelerating action, based on its action to induce differentiation from respective stem cells for repairing tissues, it is useful as preventive and/or therapeutic agents for various organ diseases (for example, liver diseases (e.g., fluminant hepatitis, acute hepatitis, hepatic cirrhosis, fatty liver, liver transplantation), kidney diseases (e.g., acute renal insufficiency, chronic renal insufficiency), lung diseases (e.g., acute pneumonia, pulmonary fibrosis, pulmonary hypertension, chronic obstructive pulmonary disease (COPD), asthma), pancreas diseases (e.g., diabetes mellitus, chronic pancreatitis), bone diseases (e.g., osteoarthritis, articular rheumatism, osteoporosis, bone fracture, periosteum injury), digestive organ diseases (e.g., gastric ulcer, duodenal ulcer, ulcerative colitis, Crohn disease), nerve degeneration diseases (e.g., stroke, Parkinson disease, Alzheimer disease, spinal canal stenosis, cerebrovascular accidents, moyamoya disease), diabetic complications (e.g., nerve disorder, skin ulcer, nephropathy, retinal disease,), vascular endothelial cell diseases (e.g., restenosis after PTCA (percutaneous transluminal coronary angiopathy), arteriosclerosis), heart diseases (e.g., supraventricular tachyarrhythmia, congestive heart failure, coronary artery disease, sudden cardiomyopathy, dilated cardiomyopathy), dental diseases (e.g., periodontal disease, tooth extraction wound, oral wound, periodontal tissue disease), decubitus, glaucoma, alopecia).

[0032] The agent of the present invention may be administered as a concomitant drug in combination with other agent for (1) complementing and/or reinforcing the preventive and/or therapeutic effect of the agent of the present invention, (2) improving kinetics and absorption of the agent of the present invention and reducing its dose, and/or (3) alleviating side effects of the agent of the present invention.

[0033] The concomitant drug of the agent of the present invention with other agent may be administered in the form of a combination drug in which both components are formulated in one pharmaceutical preparation, or administered as separate pharmaceutical preparations. When administered as the separate pharmaceutical preparations, it includes simultaneous administration and differential time administration. In addition, the differential time administration may be carried out by firstly administering the agent of the present invention and then administering the other agent, or by firstly administering the other agent and then administering the agent of the present invention, and the respective administration methods may be the same or different from each other.

[0034] The other agent may be a low molecular compound, a high molecular protein, polypeptide, polynucleotide (DNA, RNA or a gene), antisense, decoy or antibody, or a vaccine or a stem cell or the like separated from a tissue. Dose of the other agent can be optionally selected based on the clinically used dose. In addition, blending ratio of the agent of the present invention with the other agent can be optionally selected depending e.g. on the age and body weight of the subject to be administered, administration method, administration period, disease to be treated, symptoms and combination. For example, from 0.01 to 100 parts by mass of the other agent may be used based on 1 part by mass of the agent of the present invention. The other agent may be administered as an optional ratio of combination of one or two or more species optionally selected from the homologous group and heterogeneous group shown in the following.

[0035] The disease in which its preventive and/or therapeutic effect is exerted by the above-described concomitant drug is not particularly limited, and it may be any disease in which the preventive and/or therapeutic effect of the agent of the present

invention can be complemented and/or reinforced.

[0036] Examples of the other agent include an anti-thrombus agent, a circulation improving agent, a bronchial smooth muscle dilator, an anti-inflammatory drug, a local anesthetic, an analgesic, a bone cement, a joint lubricant, a prostaglandin derivative, an endogenous repair factor protein, an endogenous repair factor gene, various organ stem cells.

[0037] Examples of the anti-thrombus agent include heparin preparations (heparin sodium, heparin calcium, dalteparin sodium), oral anticoagulant (warfarin potassium), antithrombin agents (e.g. gabexate mesylate, nafamostat mesylate, argatroban), anti-platelet agglutination inhibitors (e.g. aspirin, dipyridamole, ticlopidine hydrochloride, beraprost sodium, cilostazol, ozagrel sodium, sarpogrelate hydrochloride, ethyl eicosapentanoate), thrombolytic agents (e.g. urokinase, tisokinase, alteplase, nateplase, monteplase, pamiteplase), factor Xa inhibitors, factor VIIa inhibitors.

[0038] Examples of the circulation improving agents include ifenprodil tartarate, aniracetam, donepezil hydrochloride, amantadine hydrochloride, nicergoline, ibudilast, a papaverine system, a nicotine system, a calcium antagonist, a β receptor agonist, an α receptor antagonist.

[0039] Examples of the bronchial smooth muscle dilator include β 2 stimulants (e.g., ephedrine hydrochloride, isiprenali sulfate, salbutamol sulfate, tulobuterol hydrochloride), theophylline drugs (e.g., diphophylline, aminophylline, choline theophylline), or anti-choline drugs (e.g., ipratropium bromide, flutropium bromide, oxytropium bromide).

[0040] Examples of the local anesthetic include a steroid preparation, procaine, cocaine hydrochloride, lidocaine hydrochloride, ropivacaine hydrochloride and the like.

[0041] Examples of the an analgesic include non-steroidal anti-inflammatory drugs (NSAID) such as aspirin, indometacin, diclofenac, meloxicam and celecoxib, opioid analgesic such as codein and morphine, pentazocine, buprenorphine hydrochloride, eptazocine hydrobromide.

[0042] Examples of the bone cement include calcium phosphate.

[0043] Examples of the joint lubricant include suvenyl.

[0044] Examples of the prostaglandin derivative include PGE1, PGE2 and PGI2 or prodrugs thereof, lipoPGE1, 6-oxoPGE1, 6-oxoPGE1 derivatives, omoprostil, limaprostil, enptostil, misoprostol.

[0045] Examples of the endogenous repair factor according to the "endogenous repair factor protein and endogenous repair factor gene" include vascular endothelial growth factor (VEGF), hepatocyte growth factor (HGF), various fibroblast growth factors (a/b FGF), transformation growth factor- β (TGF- β), platelet derived growth factor (PDGF), angiopoietin, hypoxia inducing factor (HIF), insulin-like growth factor (IGF), bone morphogenetic protein (BMP), connective tissue growth factor (CTGF) and epidermal growth factor (EGF), growth factors of their families.

[0046] In addition, not only the compounds so far found but also those which will be discovered in the future are also included in the other agents capable of complementing and/or reinforcing the preventive and/or therapeutic agents of the present invention, based on the above-described mechanism.

[0047] When the agent of the present invention, or the concomitant drug of the agent of the present invention with other agent, is used for the above-described purpose, it is generally administered systemically or topically in the oral or parenteral form.

[0048] Its dose varies depending e.g. on the age, body weight, symptoms, therapeutic effect, administration method, treating period, but is usually within the range of from 1 ng to 100 mg per adult per once, from once to several times a day by oral administration, or within the range of from 0.1 ng to 50 mg per adult per once, from once to several times a day, from once to several times a week, or from once to several times in 3 months by parenteral administration in the form of a persistent preparation, or continuously administered into a vein within the range of from 1 hour to 24 hours a day. Since the dose varies under various conditions as a matter of course as described above, there is a case in which a smaller dose than the above range is sufficient or a case which requires the administration exceeding the range.

[0049] When the agent of the present invention, or the concomitant drug of the agent of the present invention with other agent, is administered, it is used as solid preparations for internal use or liquid preparations for internal use for oral administration, or as

injections, subcutaneous or intramuscular injections, external preparations, suppositories, eye drops, inhalations, medical device-containing preparations and the like for parenteral administration.

[0050] The solid preparation for internal use for use in the oral administration includes tablets, pills, capsules, powders, granules. Hard capsules and soft capsules are included in the capsules.

[0051] In such a solid preparation for internal use, one or more active substances are used as such, or mixed e.g. with a filler (e.g. lactose, mannitol, glucose, microcrystalline cellulose, starch), a binder (e.g. hydroxypropylcellulose, polyvinyl pyrrolidone, magnesium aluminometasilicate), a disintegrating agent (e.g. calcium cellulose glycolate), a lubricant (e.g. magnesium stearate), a stabilizing agent, a solubilization assisting agent (e.g. glutamic acid, aspartic acid) and used by making the mixture into a pharmaceutical preparation. If necessary, this may be coated with a coating agent (e.g. sucrose, gelatin, hydroxypropylcellulose, hydroxypropylmethylcellulose phthalate), or coated with two or more layers. Further capsules of an absorbable substance such as gelatin are included.

[0052] The liquid preparation for internal use for use in the oral administration includes pharmaceutically acceptable solutions, suspensions, emulsions, syrups, elixirs. In such a liquid preparation, one or more active ingredient are dissolved, suspended or emulsified in a generally used diluent (e.g. purified water, ethanol, a mixed solution thereof.). In addition, this liquid preparation may contain a moistening agent, a suspending agent, an emulsifying agent, a sweetener, a flavor, an aromatic, a preservative.

[0053] Dosage forms for external use for use in parenteral administration include, for example, ointments, gels, creams, fomentations, adhesive preparations, liniments, sprays, inhalations, sprays, aerosols, eye drops, nasal drops. In addition, these may be sealed with a biodegradable polymer and used as medical devices (e.g. surgical suture, a bolt for use in bone fracture treatment). They contain one or more active ingredient and are prepared by a conventionally known method or based on a generally used formula.

[0054] The ointments are produced by a conventionally known method or based on a generally used formula. For example, they are prepared by suspending or melting one or more active ingredients in a base. The ointment base is selected from those which are conventionally known or generally used. For example, a single substance or a mixture of two or more substances are used, which are selected from higher fatty acids or higher fatty acid esters (e.g. adipic acid, myristic acid, palmitic acid, stearic acid, oleic acid, adipic acid ester, myristic acid ester, palmitic acid ester, stearic acid ester, oleic acid ester), waxes (e.g. beeswax, whale wax, ceresine), surfactants (e.g. polyoxyethylene alkyl ether phosphoric acid ester), higher alcohols (e.g. cetanol, stearyl alcohol, cetostearyl alcohol), silicon oil (e.g. dimethyl polysiloxane), hydrocarbons (e.g. hydrophilic vaseline, white vaseline, purified lanoline, liquid paraffin), glycols (e.g. ethylene glycol, diethylene glycol, propylene glycol, polyethylene glycol, macrogol), plant oil (e.g. castor oil, olive oil, sesame oil, turpentine oil), animal oil (e.g. mink oil, egg yolk oil, squalane, squalene), water, absorption accelerators and rash preventing agents. In addition, e.g. moisture keeping agents, preservatives, stabilizers, antioxidants, flavors may be contained.

[0055] The gels are produced by a conventionally known method or based on a generally used formula. For example, they are prepared by melting one or more active ingredients in a base. The gel base is selected from those which are conventionally known or generally used. For example, a single substance or a mixture of two or more substances are used, which are selected from lower alcohols (e.g. ethanol, isopropyl alcohol), gelling agents (e.g. carboxymethyl cellulose, hydroxyethyl cellulose, hydroxypropylcellulose, ethyl cellulose), neutralizing agents (e.g. triethanolamine, diisopropanolamine), surfactants (e.g. polyethylene glycol monostearate), gums, water, absorption accelerators and rash preventing agents. In addition, e.g. preservatives, antioxidants, flavors may be contained.

[0056] The creams are produced by a conventionally known method or based on a generally used formula. For example, they are prepared by melting or emulsifying one or more active ingredients in a base. The cream base is selected from those which are conventionally known or generally used. For example, a single substance or a mixture of two or more substances are used, which are selected from higher fatty acid esters, lower alcohols, hydrocarbons, polyhydric alcohols (e.g. propylene glycol, 1,3-butylene glycol), higher alcohols (e.g. 2-hexyldecanol, cetanol), emulsifiers (e.g. polyoxyethylene alkyl ethers, fatty acid esters), water, absorption accelerators and rash preventing agents. In addition, preservatives, antioxidants, flavors and the like may be contained.

[0057] The fomentations are produced by a conventionally known method or based on a generally used formula. For example, they are prepared by melting one or more active ingredients in a base and then spreading and coating the resulting kneaded material on a support. The fomentation base is selected from those which are conventionally known or generally used. For example, a single substance or a mixture of two or more substances are used, which are selected from thickeners (e.g. polyacrylic acid, polyvinyl pyrrolidone, acacia, starch, gelatin, methyl cellulose), moistening agents (e.g. urea, glycerol, propylene glycol),

fillers (e.g. kaolin, zinc oxide, talc, calcium, magnesium), water, solubilizing agents, tackifiers and rash preventing agents. In addition, e.g. preservatives, antioxidants, flavors may be contained.

[0058] The adhesive preparations are produced by a conventionally known method or based on a generally used formula. For example, they are prepared by melting one or more active ingredients in a base and then spreading and coating the resulting material on a support. The adhesive preparation base is selected from those which are conventionally known or generally used. For example, a single substance or a mixture of two or more substances are used, which are selected from polymer bases, oils and fats, higher fatty acids, tackifiers and rash preventing agents. In addition, e.g. preservatives, antioxidants, flavors may be contained.

[0059] The liniments are produced by a conventionally known method or based on a generally used formula. For example, they are prepared by dissolving, suspending or emulsifying one or more active ingredients in a single substance or two or more substances selected from e.g. water, alcohols (e.g. ethanol, polyethylene glycol), higher fatty acids, glycerol, soap, emulsifiers, suspending agents. In addition, e.g. preservatives, antioxidants, flavors may be contained.

[0060] In addition to the generally used diluents, the sprays and inhalations may contain stabilizers such as sodium hydrogen sulfite and buffer agents capable of giving tonicity, for example, tonicity agents such as sodium chloride, sodium citrate and citric acid. Production methods of sprays are illustratively described in, for example, US Patent No 2,868,691 and US Patent No. 3,095,355.

[0061] Solutions, suspensions, emulsions and solid injections which are used by dissolving or suspending in a solvent prior to use are included in the injections for parenteral administration. The injections are used by dissolving, suspending or emulsifying one or more active ingredients in a solvent. These injections may be injected e.g. into a vein, an artery, muscle, under the skin, into the brain, a joint, a bone and other topical regions of organs, or directly administered using a needle-equipped blood vessel catheter. As the solvent, for example, distilled water for injection, physiological saline, plant oil, alcohols such as propylene glycol, polyethylene glycol and ethanol, and combinations thereof are used. In addition, such injections may contain e.g. a stabilizer, a solubilization assisting agent (e.g. glutamic acid, aspartic acid, Polysorbate 80 (registered trade mark)), a suspending agent, an emulsifying agent, a soothing agent, a buffer agent, a preservative. These are produced by sterilizing at the final step or by an aseptic operation. In addition, it is possible to prepare an aseptic solid preparation, such as a freeze-dried preparation, and use it by dissolving in sterilized or aseptic distilled water for injection or other solvent prior to its use.

[0062] The eye drops for parenteral administration include an eye drop liquid, a suspension type eye drop liquid, an emulsion type eye drop liquid, a prior to use dissolution type eye drop liquid and an eye ointment.

[0063] These eye drops are produced in accordance with a conventionally known method. For example, they are used by dissolving, suspending or emulsifying one or more active ingredient in a solvent. As the solvent of eye drops, for examples, sterilized purified water, physiological saline, other aqueous solvent or non-aqueous solvent for injection (e.g., plant oil) and combinations thereof are used. If necessary, the eye drops may further contain substances optionally selected from e.g. tonicity agents (e.g. sodium chloride, concentrated glycerol), buffer agents (e.g. sodium phosphate, sodium acetate), surfactants (e.g. Polysorbate 80 (registered trade mark), polyoxyl 40 stearate, polyoxyethylene hardened castor oil), stabilizers (e.g. sodium citrate, sodium edetate), antiseptics (e.g. benzalkonium chloride, paraben).

[0064] These are produced by sterilizing at the final step or by an aseptic operation. In addition, it is possible to prepare an aseptic solid preparation, such as a freeze-dried preparation, and use it by dissolving in sterilized or aseptic distilled purified water or other solvent prior to its use.

[0065] As the inhalations for parenteral administration, aerosols, powders for inhalation or solutions for inhalation are included, and said solutions for inhalation may be in a form which is used by dissolving or suspending in water or other appropriate solvent prior to its use.

[0066] These inhalations are produced in accordance with conventionally known methods.

[0067] For example, in the case of solutions for inhalation, they are prepared by optionally selecting e.g. antiseptics (e.g. benzalkonium chloride, paraben), coloring agents, buffer agents (e.g. sodium phosphate, sodium acetate), tonicity agents (e.g. sodium chloride, concentrated glycerol), thickeners (e.g. carboxyvinyl polymer), absorption accelerators if necessary.

[0068] In the case of powders for inhalation, they are prepared by optionally selecting e.g. lubricants (e.g. stearic acid and a salt

thereof), binders (e.g. starch, dextrin), fillers (e.g. lactose, cellulose), coloring agents, antiseptics (e.g. benzalkonium chloride, paraben), absorption accelerators, if necessary.

[0069] When solutions for inhalation are administered, a sprayer (atomizer or nebulizer) is generally used, and an inhalation administering device for powders is generally used when powders for inhalation are used.

[0070] As other compositions for parenteral administration, e.g. suppositories for rectal administration, pessaries for vaginal administration are included, which contain one or more active ingredients and are formulated in the usual way.

Application to topical regions:

[0071] As the topical administration of according to the present invention, the administration method is not particularly limited, so long as the agent of the present invention or a concomitant drug of the agent of the present invention with other agent can be topically supplied to regions of a disease. Its examples include injections and embedding agents to be used in muscle, under the skin, and in the skin, blood vessel, heart muscle, alveoli, joint part, vertebra, bone part, tooth root part, injured organ, medical device-containing preparations in which the agent of the present invention or a concomitant drug of the agent of the present invention with other agent is contained in a medical device (e.g. stent, fixing bolt, fixer, thread), or coating agents coated with the same, solid preparations such as granules and powders, adhesive preparations, gels, ointments, films, preparation enclosed in a biodegradable polymer, or enclosed medical devices.

[0072] As the persistent preparation of the present invention, the pharmaceutical preparation is not limited, so long as the active ingredient can be persistently supplied to a region of a disease. Its examples include sustained release injections (e.g., microcapsule preparations, microsphere preparations, nanosphere preparations), embedding preparations (e.g., film preparations), ointments, coatings in which the active ingredient is contained or coated in a medical device (e.g. stent, fixing bolt, fixer, suture).

[0073] The microsphere preparations of the present invention are fine particle pharmaceutical composition with a biodegradable polymer, which contains an active ingredient as the active ingredient.

[0074] A bioabsorbable polymer is present in the sustained drug release system of the present invention, which is achieved by a natural polymer or a synthetic polymer. The mechanism for controlling the rate of sustained release therefrom includes a degradation controlling type, a dispersion controlling type, a membrane permeation controlling type.

[0075] Examples of the natural polymer as the bioabsorbable polymer of the present invention include plant-produced polysaccharides (e.g., cellulose, starch, alginic acid), animal-produced polysaccharides and proteins (e.g., chitin, chitosan, collagen, gelatin, albumin, glycosaminoglycan) and microorganism-produced polyesters and polysaccharides (e.g., poly-3-hydroxyalcanoate, hyaluronic acid).

[0076] Also, examples of the biodegradable polymer include fatty acid ester polymers or copolymers thereof, polyacrylic acid esters, polyhydroxybutyric acids, polyalkylene oxalates, polyortho esters, polycarbonate and polyamino acids, which can be used alone or as a mixture thereof. Examples of the fatty acid ester polymers or copolymers thereof include polylactic acid, polyglycolic acid, polycitric acid, polymalic acid, polyethylene succinate, polybutylene succinate, poly- ϵ -caprolactone, polybutylene terephthalate adipate or lactic acid-glycolic acid copolymer, which can be used alone or as a mixture thereof. In addition to these, poly α -cyano acrylic acid ester, poly- β -hydroxy butyric acid, polytrimethylene oxate, polyortho ester, polyortho carbonate, polyethylene carbonate, poly- γ -benzyl-glutamic acid, polyvinyl alcohol, polyester carbonate, polyacid anhydride, polycyano acrylate, polyphosphazine or poly-L-alanine can be used alone or as a mixture thereof. Preferred is polylactic acid, polyglycolic acid or a lactic acid-glycolic acid copolymer, and more preferred is a lactic acid-glycolic acid copolymer. acid copolymer.

[0077] Average molecular weight of these biodegradable high molecular weight polymers to be used in the present invention is preferably from about 2,000 to about 800,000, more preferably from about 5,000 to about 200,000. For example, in the case of polylactic acid, its weight average molecular weight is preferably from about 5,000 to about 100,000. It is more preferably from about 6,000 to about 50,000. Polylactic acid can be synthesized in accordance with the conventionally known production method. In the case of the lactic acid-glycolic acid copolymer, its compositional ratio of lactic acid and glycolic acid preferably from about 100/0 to about 50/50 (w/w), particularly preferably from about 90/10 to about 50/50 (w/w). Weight average molecular weight of the lactic acid-glycolic acid copolymer is preferably from about 5,000 to about 100,000. It is more preferably from about 10,000 to about 80,000. The lactic acid-glycolic acid copolymer can be synthesized in accordance with the conventionally known production

method. In addition, in order to control initial burst, basic amino acids (e.g., alginic acid) may be added.

[0078] According to the description, the weight average molecular weight is a polystyrene-based molecular weight measured by a gel permeation chromatography (GPC).

[0079] The above-described biodegradable high molecular weight polymer can be changed depending on the strength of pharmacological activity of the active ingredient and the drug release of interest, so long as the object of the present invention is attained, and for example, it is used in an amount of from about 0.2 to about 10,000 times (weight ratio), preferably from about 1 to about 1,000 times (weight ratio), more from about 1 to about 100 times (weight ratio), based on said physiologically active substance.

[0080] The microspheres of the present invention can be produced for example by a submerged drying method (e.g., o/w method, w/o method, w/o/w method), a phase separation method, a spray drying method, a supercritical fluid granulation method or a method corresponding thereto.

[0081] Specific production methods on the submerged drying (o/w method) and spray drying are described in the following.

1. (1) In the submerged drying method (o/w method), an organic solvent solution of a biodegradable polymer is firstly prepared. It is preferable that the organic solvent to be used in producing the microspheres of the present invention has a boiling point of 120°C or less. Examples of the organic solvent include halogenated hydrocarbons (e.g., dichloromethane, chloroform), aliphatic esters (e.g., ethyl acetate), ethers, aromatic hydrocarbons, ketones (e.g. acetone. Two or more of them may be used by mixing at an optional ratio. Desirable organic solvent is dichloromethane or acetonitrile. The organic solvent is preferably dichloromethane. Concentration of the biodegradable polymer in the organic solvent solution varies depending on e.g. the molecular weight of the biodegradable polymer, kind of the organic solvent, but is generally selected within the range of from about 0.01 to about 80% (v/w). It is preferably from about 0.1 to about 70% (v/w), more preferably from about 1 to about 60% (v/w).

An active ingredient is added to and dissolved in the thus obtained organic solvent solution of biodegradable polymer. Amount of this active ingredient to be added varies depending on e.g. the kind of agent, angiogenesis action, effect-persisting period of time, but is from about 0.001% to about 90% (w/w), preferably from about 0.01% to about 80% (w/w), more preferably from about 0.3% to 30% (w/w), as concentration of the biodegradable high molecular polymer in the organic solvent solution.

Next, the thus prepared organic solvent solution is further added to a water phase to form an o/w emulsion using e.g. a stirrer at emulsifier. The water phase volume in this case is selected generally from about 1 time to about 10,000 times of the oil phase volume. This is selected more preferably from about 2 times to about 5,000 times. This is selected particularly preferably from about 5 times to about 2,000 times. An emulsifying agent may be added to the water phase of the above-described outer phase. The emulsifying agent may be any agent which can generally form a stable o/w emulsion. Examples of the emulsifying agent include an anionic surfactant, a nonionic surfactant, a polyoxyethylcne castor oil derivative, polyvinyl pyrrolidone, polyvinyl alcohol, carboxymethylcellulose, lecithin, gelatin. These may be used in an optional combination. Concentration of the emulsifying agent in the outer water phase is preferably from about 0.001% to about 20% (w/w). It is more preferably from about 0.01% to about 10% (w/w). particularly preferably from about 0.05% to about 5% (w/w).

A generally used method is employed for the evaporation of solvent in the oil phase. The method is carried out under ordinary pressure or gradually reducing the pressure while stirring using e.g. a stirrer or magnetic stirrer, or using e.g. a rotary evaporator while adjusting the degree of vacuum. After fractionating the thus obtained microspheres by centrifugation or filtration, the free active ingredient, emulsifying agent and the like adhered to the microsphere surface are washed several times repeatedly with, for example, a surfactant solution or an alcohol, and the resulting microspheres are again dispersed in e.g. distilled water or a dispersion medium containing a filler (e.g. mannitol, sorbitol, lactose, etc.) and freeze-dried. As the above-described o/w method, microspheres may be produced by a method in which an active ingredient is dispersed in an organic solvent solution of biodegradable polymer, namely an s/o/w method.

2. (2) When microspheres are produced by a spray drying method, an organic solvent in which a biodegradable polymer and an active ingredient are dissolved, or an emulsion of the same, is sprayed into a drying chamber of a spray dryer device (spray dryer) using, a nozzle, and the organic solvent or water in the fine particle droplets is evaporated within a extremely short period of time to prepare microspheres. As the nozzle, there are e.g. a double fluid nozzle type, a pressure nozzle type or a rotary disc type.

[0082] In this case, for the purpose of preventing aggregation of microspheres, if necessary, it is effective to spray an organic

solvent or aqueous solution of an aggregation preventing agent (e.g. mannitol, lactose, gelatin) through another nozzle, simultaneously with the spraying of o/w emulsion. As thus obtained microspheres, more complete removal of water and solvent in the microspheres is carried out under a reduced pressure, with heating, if necessary.

[0083] The microspheres of the present invention can be made into various dosage forms of pharmaceutical preparation, for example, as such, or using a spherical, rod, needle, bolt, filamentous, pellet, film or cream-shaped pharmaceutical composition as the material substance.

[0084] In addition, using this pharmaceutical preparation, it can be administered as parenteral preparations for topical administration (e.g., injections and embedding agents to be used e.g. in muscle, under the skin, and in the skin, heart muscle, abdominal cavity, bronchus, blood vessel, alveoli, injured region of vascular endothelium, brain, marrow, inside of dura mater, outside of dura mater, joint part, vertebra, bone part, periodontal part, various organs, solid preparations such as granules and powders, liquid preparations such as suspensions, adhesive preparations, film preparations, ointments, medical device-containing preparations in which the active ingredient is contained in a medical device (e.g. stent, bolt, suture thread), coating agents coated with the same. In addition, it can be directly administered into, for example, an ischemic region of heart muscle using e.g. blood vessel catheter.

[0085] For example, when microspheres are made into injections, practical pharmaceutical preparations for injection can be obtained by making the microspheres into aqueous suspensions together with e.g. a dispersing agent, a preservative, a tonicity agent, a buffer agent, a pH adjusting agent. Also, they are made into injections which can be practically used as oily suspensions by dispersing together with a plant oil or its mixture with phospholipid such as lecithin, or a middle chain fatty acid triglyceride (e.g., Migliol 812).

[0086] Particle size of the microspheres, for example when used as suspension injections, may be within such a range that their dispersing degree and through-needle property are satisfied, and a range of from about 0.1 to about 300 μm as the average particle size can be exemplified. It is preferably within the range of from about 1 to 150 μm , more preferably a particle size of within the range of from about 2 to 100 μm . As described above, it is preferable that the pharmaceutical composition of the present invention is a suspension. It is preferable that the pharmaceutical composition of the present invention is in the form of fine particles. This is because the pharmaceutical composition does not give patients too excess pain when administered through a needle which is used for usual subcutaneous or intramuscular injection. The pharmaceutical composition of the present invention is particularly preferable as injections. When the microspheres are made into sterile preparations, e.g. a method in which the entire production steps are carried out under aseptic conditions, a method in which they are sterilized with gamma rays, a method in which an antiseptic is added can be employed, although not particularly limited.

[0087] The action of the active ingredient of the pharmaceutical composition of the present invention has a sustained release property, and the sustained release period varies depending on the kind, blending amount and the like of the biodegradable polymer, it has a sustained release period of generally from 1 week to 3 months, so that it can be used as a stem cell differentiation induction accelerator or an angiogenesis accelerator by accelerating production of various endogenous repair factors in (ischemic) organ disease regions.

[0088] Although dose of the pharmaceutical composition of the present invention varies depending on e.g. the kind and content of the active ingredient, dosage forms, persisting period of time of the drug release, the animal to be administered, it may be an effective amount of the active ingredient. For example, when the composition is used as microspheres in an ischemic region, it may be administered at a dose of from about 0.001 mg to 500 mg, preferably from about 0.01 mg to 50 mg, per once, as the active component per adult (50 kg in body weight), from once a day to once in 3 months.

[0089] In addition, for e.g. the coldness, numbness, intermittent claudication, pain at rest, skin ulcer on the limbs in the case of e.g. ASO, Buerger disease, diabetic neuropathy, it is preferable to carry out intramuscular administration of the agent of the present invention or its persistent preparation, for example, to the diseased region or the vicinity thereof continuously for a period of approximately from once a day to 4 weeks.

[0090] For e.g. myocardial infarction, angina pectoris, it is preferable to directly carry out intramuscular administration of the agent of the present invention or its persistent preparation, for example, to the ischemic heart muscle region or the vicinity thereof, and it is preferable to carry out the administration directly under thoracotomy or using e.g. a needle-equipped blood vessel catheter. As the administration period, it is preferable to carry out the intramuscular administration continuously, for example, for a period of approximately from once a day to 4 weeks.

[0091] In the case of e.g. osteoporosis, periodontal tissue damage; bone fracture, osteoarthritis, it is preferable to administer the

agent of the present invention or its persistent preparation alone, or by mixing it with e.g. a bone cement, a joint lubricant, a prosthetic tool topically to the diseased region or the vicinity thereof.

[0092] In the case e.g. of pulmonary hypertension or COPD, it is preferable to carry out inhalation of the agent of the present invention or its persistent preparation as solutions for inhalation or powders for inhalation.

Brief Description of the Drawings

[0093]

Fig. 1 shows a measured result of hollow organ formation acceleration action of Compound 1 ((E)-(5-(2-[1-phenyl-1-(3-pyridyl)methylideneaminoxy]ethyl)-7,8-dihydroronaphthalen-1-yloxy)acetic acid).

Fig. 2 shows a release test result of the microsphere preparation produced in Preparation Example 1.

Fig. 3 shows a release test result of the microsphere preparation produced in Preparation Example 2.

Fig. 4 shows a release test result of the microsphere preparation produced in Preparation Example 3.

Fig. 5 shows a measured result of hollow organ formation acceleration actions of Reference Compound 3 ((5Z,9β,11α,13E)-17,17-propano-11,16-dihydroxy-9-chloro-20-norprost-5,13-dienoic acid) and Reference Compound 4 ((11α,13E,15α)-9-oxo-11,15-dihydroxy-16-(3-methoxymethylphenyl)-17,18,19,20-tetranor-5-thiaprost-13-enoic acid).

Best Mode for Carrying out the Invention

[0094] Pharmacological tests are shown in the following as the examples of the present invention, but these are for thoroughly understanding the present invention and do not limit the scope of the present invention. In this connection, improvement of measuring accuracy and modification of measuring sensitivity were applied as follows to the measuring methods for evaluating the compounds of the present invention.

Example 1

Measurement of angiogenesis acceleration action (*in vitro*):

Test method:

[0095] An angiogenesis kit (manufactured by Kurabo; constituted from normal human umbilical cord vein vascular endothelial cells and normal human skin fibroblasts) was cultured for 3 hours, and then the culture medium (the medium for angiogenesis use attached to the angiogenesis kit was used as the culture medium and cultured at 37°C under a moist environment of 5% carbon dioxide-95% air, and a carbon dioxide incubator BNA-121D was used as the incubator) was changed and an agent to be tested was added to each well (0.5 ml/well). The medium exchange was carried out also on the 3rd, 6th and 8th days after commencement of the culturing and the fresh agent to be tested was added. The kind and concentration of the agent to be tested were untreated, solvent (DMSO) 0.1%, Compound 1 10⁻⁹, 10⁻⁸ and 10⁻⁷ mol/l, VEGF-A 0.1, 1 and 10 ng/ml and HGF 0.1, 1 and 10 ng/ml, and the culturing was carried out by using 3 wells for each concentration. Fixation was carried out 10 days after the commencement of culturing, and staining of hollow organ with anti-CD31 antibody was carried out by using a hollow organ staining kit (manufactured by Kurabo). As the evaluation, Chalkley Grid (a grid lens, manufactured by Kurabo) was mounted on the eyepiece of a microscope, and the hollow organ formation was evaluated by counting intersections of the randomly arranged points of Chalkley Grid with the formed hollow organ (by referring to the evaluation method of J. Pathol., 177, 275-283 (1995)). The counting was carried out at 12 positions per well, and the total was calculated.

[0096] As the agent to be tested, Compound 1 ((E)-(5-[2-[1-phenyl-1-(3-pyridyl)methylideneaminoxy]ethyl)-7,8-

dihydropthalen-1-yloxy]acetic acid) was dissolved in dimethyl sulfoxide (DMSO) to prepare 10^{-4} , 10^{-5} and 10^{-6} mol/l solutions which were then used by diluting 1/1000 time with the culture medium.

[0097] As the VEGF-A (vascular endothelial growth factor-A), the 2 μ g/ml solution of VEGF contained in the angiogenesis control reagent kit of Kurabo was diluted with the culture medium and used.

[0098] As the HGF (human hepatocyte growth factor), the 5 μ g/ml solution of HGF purchased from R & D System-Funakoshi was diluted with the culture medium and used.

Statistical analysis method:

[0099] The counts of hollow organ formation in the untreated wells were compared with those of the wells treated with respective concentrations of test samples by Dunnett's test-(two-sided test). The significance level was set to 5%.

[0100] In this connection, the data were shown by average value of 3 wells and standard deviation.

[0101] The test results are shown in Fig. 1.

Results:

[0102] Compound 1 accelerated hollow organ formation statistically significantly by 10^{-8} and 10^{-7} mol/l. In addition, the VEGF-A and HGF accelerated hollow organ formation at a concentration of 10 ng/ml. Based on the above results, it was revealed that Compound 1 has an angiogenesis accelerating effect having a strength equivalent to the positive control agents VEGF-A and HGF in a co-culture system of human vascular endothelial cells and human fibroblasts.

Example 2

Measurement of endogenous repair factor (HGF, VEGF) protein producing action (*in vitro*):

Test method:

[0103] An angiogenesis kit (manufactured by Kurabo; constituted from normal human umbilical cord vein vascular endothelial cells and normal human skin fibroblasts) was cultured for 3 hours, and then the culture medium (the medium for angiogenesis use attached to the angiogenesis kit was used as the culture medium and cultured at 37°C under a moist environment of 5% carbon dioxide-95% air, and a carbon dioxide incubator BNA-121D was used as the incubator) was changed and an agent to be tested was added to each well (0.5 ml/well). The agent to be tested were solvent (DMSO) 0.1% and Compound 1 10^{-7} mol/l, and the culturing was carried out by using 3 wells for each. Culture supernatants were collected before commencement of the culturing and 1, 2, 6, 24, 48 and 72 hours after the commencement. HGF and VEGF protein concentrations in the culture supernatants were measured by using an ELISA kit (R % D system-Funakoshi).

[0104] As the agent to be tested, Compound 1 ((E)-[5-[2-[1-phenyl-1-(3-pyridyl)methylideneaminoxy]ethyl]-7,8-dihydropthalen-1-yloxy]acetic acid) was dissolved in dimethyl sulfoxide (DMSO) to prepare 10^{-4} mol/l solution which was then used by diluting 1/1000 time with the culture medium.

Statistical analysis method:

[0105] Results of the solvent control wells were compared with those of the wells treated with the agent to be tested by Dunnett's test (two-sided test). The significance level was set to 5%.

[0106] In this connection, the data were shown by average value of 3 wells and standard deviation.

[0107] The test results after 72 hours of the culturing are shown in Table 1.

TABLE 1

Agent tested	HGF (pg/ml)	VEGF (pg/ml)
Solvent control (DMSO)	110 ± 16	2004 ± 76
Compound 1	518 ± 15***	3034 ± 30***

***: p < 0.001 vs. solvent control

Results:

[0108] Compound 1 accelerated production of HGF protein and VEGF protein statistically significantly in comparison with the solvent control, by 72 hours of - culturing at a concentration of 10^{-7} mol/l.

Example 3

Production of persistent preparations:

Preparation Example 1

[0109] A dichloromethane (1 ml) solution of 100 mg of a polylactic acid-glycolic acid copolymer (hereinafter referred to as "PLGA") (polylactic acid:glycolic acid = 1:1 (mol %), weight average molecular weight 40,000, PLGA5-1, manufactured by Mitsui Kagaku) and Compound 1 (5 mg) was prepared. An O/W emulsion was prepared by adding the solution prepared in the above to 300 ml of 0.1% polyvinyl alcohol (Nacalai Tesque) aqueous solution (pH 3.0, adjusted with 1 N hydrochloric acid) which was stirred at 5,000 rpm using TK Robomix (Tokushu Kiki, MARK II 2.5 type), and stirring the mixture at room temperature for 3 minutes. This O/W emulsion was stirred at room temperature for 2 hours to evaporate dichloromethane, and the oil phase was solidified and then centrifuged at 3,000 rpm for 10 minutes using a centrifuge (Hitachi, O5PR-22). The supernatant was discarded, and the residue was dispersed in distilled water for injection (35 ml) and then centrifuged at 3,000 rpm for 10 minutes using the centrifuge. The supernatant was discarded, and the residue was dispersed in 0.2% Tween 80 solution (35 ml) and then centrifuged at 3,000 rpm for 10 minutes using the centrifuge. The supernatant was discarded, and the residue was dispersed in distilled water for injection (35 ml) and then again centrifuged at 3,000 rpm for 10 minutes using the centrifuge. Finally discarding the supernatant, the precipitate was soaked in dry ice-methanol, frozen and then dried under a reduced pressure, thereby producing a microsphere preparation of Compound 1.

Preparation Example 2

[0110] A dichloromethane (1 ml) solution of 100 mg of a polylactic acid-glycolic acid copolymer (hereinafter referred to as "PLGA") (polylactic acid:glycolic acid = 1:1 (mol %), weight average molecular weight 20,000, PLGA5020, Wako Pure Chemical Industries) and Compound 1 (5 mg) was prepared. Thereafter, the same operation of Preparation Example 1 was carried out to produce a microsphere preparation of Compound 1.

Preparation Example 3

[0111] A dichloromethane (3 ml) solution of 100 mg of a polylactic acid-glycolic acid copolymer (to be referred to as PLGA hereinafter) (polylactic acid:glycolic acid = 1:1 (mol %), weight average molecular weight 40,000, PLGA5-1, manufactured by Mitsui Kagaku) and Compound 1 (5 mg) was prepared. Thereafter, the same operation of Preparation Example 1 was carried out

to produce a microsphere preparation of the Compound 1.

Preparation Test Example 1

Measurement of inclusion efficiency:

[0112] The microspheres produced in Preparation Examples 1, 2 and 3 (respectively about 10 mg) were mixed with an acetonitrile solution containing an appropriate internal standard and dissolved by carrying out an ultrasonic treatment. Compound I content of each of the solutions was measured by a high performance liquid chromatography, and inclusion efficiency of Compound 1 in the microsphere was calculated by the following formula.

$$\text{Inclusion efficiency (\%)} = (\text{content found}/\text{content calculated}) \times 100$$

[0113] As a result, the microsphere preparation of Preparation Example 1 showed an inclusion efficiency of 70.9%, the microsphere preparation of Preparation Example 2 showed an inclusion efficiency of 100% and the microsphere preparation of Preparation Example 3 showed an inclusion efficiency of 74.3%.

Preparation Test Example 2: *In vitro* release test:

[0114] Each of the microspheres preparations produced in Preparation Examples 1, 2 and 3 was added to 0.2% Tween 80 1/15 M phosphate buffer pH 6.8 to a concentration of 100 µg/ml as the agent and uniformly dispersed by ultrasonic treatment using Vortex. This was dispensed at 1 ml into containers and put into a 37°C constant temperature oven. The containers were periodically sampled out and centrifuged at 12,000 rpm for 5 minutes, and the residual amount of Compound 1 in microspheres of the pellet was measured by a high performance liquid chromatography (HPLC).

[0115] Results of the microsphere preparation produced in Preparation Example 1 are shown in Fig. 2, and results of the microsphere preparation produced in Preparation Example 2 in Fig. 3, and results of the microsphere preparation produced in Preparation Example 3 in Fig. 4.

[0116] In this connection, the residual ratio in Figs. 2, 3 and 4 means a ratio of Compound 1 remaining in microspheres to the initial.

[0117] As a result, the microsphere preparation of Preparation Example 1 released about 40% of the agent during 14 days, and the microsphere preparation of Preparation Example 2 released the whole amount during about 10 days. The microsphere preparation of Preparation Example 3 released about 60% during 28 days.

Example 4

Angiogenesis test (*in vivo* test) using rat leg ischemia (arteriosclerosis obliterans (ASO)) model:

[0118] Leg ischemia model was prepared by ligating rat left femoral artery. Blood flow in hind legs was measured by using Laser Doppler Imager (Moor Instruments) 2 weeks after the preparation, and the animals were divided into 6 groups (n = 5) in such a manner that the average value of blood flow became almost uniform.

[0119] Starting on the next day of the grouping, 0.1 ml/site, 2 sites, of the agent to be tested was administered by intramuscular injection into the left femoral adductor, for once a week, 4 times in total as a solution to be tested. One week after completion of the final administration, blood flows of hind legs were measured by using Laser Doppler Imager (Moor Instruments), and blood flows of the treated leg (left leg) and untreated leg (right leg) were compared and examined. The results of treated leg/untreated leg (%) are shown in Table 2.

[0120] In this connection, construction of the solution to be tested is as follows. Solvent (control) group: 0.2 w/v% Tween 80

solution (0.2 ml).

Polymer group:

[0121] The polylactic acid-glycolic acid copolymer used in Preparation Example 2 was suspended in 0.2 w/v% Tween 80 solution (0.2 ml). In this connection, amount of the polylactic acid-glycolic acid copolymer is identical to the amount contained in the Compound 1 MS (1 mg).

Compound 1 (1 mg) group:

[0122] Compound 1 (1 mg) was suspended in 0.2 w/v% Tween 80 solution (0.2 ml).

Compound 1 MS (0.01 mg) group:

[0123] The microsphere preparation produced in Preparation Example 2 containing 0.01 mg of Compound 1 was suspended in 0.2 w/v% Tween 80 solution (0.2 ml).

Compound 1 MS (0.1 mg) group:

[0124] The microsphere preparation produced in Preparation Example 2 containing 0.1 mg of Compound 1 was suspended in 0.2 w/v% Tween 80 solution (0.2 ml).

Compound 1 MS (mg) group:

[0125] The microsphere preparation produced in Preparation Example 2 containing 1 mg of Compound 1 was suspended in 0.2 w/v% Tween 80 solution (0.2 ml).

TABLE 2

Solution to be tested	Treated leg/untreated leg blood flow ratio (%)
Control	67.3 ± 5.1
Polymer	68.7 ± 4.1
Compound 1 (mg)	76.2 ± 2.8**##
Compound 1 MS (0.01 mg)	74.0 ± 7.1
Compound 1 MS (0.1 mg)	78.3 ± 4.6**##
Compound 1 MS (mg)	89.0 ± 4.4**##\$\$

**: significant difference from Control at p<0.01 (Student's t-test)
 #: significant difference from Polymer at p<0.01 (Student's t-test)
 \$\$: significant difference from Compound 1 (1 mg) at p<0.01 (Student's t-test)

Results:

[0126] Although significant recovery of blood flow against Control was found even by the administration of Compound 1 (1 mg) alone, further stronger blood flow improving effect than Compound 1 (1 mg) was observed by the administration of the microsphere (MS) preparation (Preparation Example 2) of Compound 1.

[0127] In comparison with the polymer group, dose-correlative blood flow improving effect was found in Compound 1 MS preparation, and significant blood flow improving effect action was found in Compound 1 MS (0.1 mg) and Compound 1 MS (1

mg).

Example 5

Angiogenesis test using rat leg ischemia (arteriosclerosis obliterans (ASO)) model; determination of minimum effective dose (*in vivo* test):

[0128] Leg ischemia model was prepared by ligating rat left femoral artery. Blood flow in hind legs was measured by using Laser Doppler Imager (Moor Instruments) 1 week after the preparation, and the animals were divided into 4 groups (n = 5) in such a manner that the average value of blood flow became almost uniform.

[0129] Starting on the next day of the grouping, 0.1 ml/site, 2 sites, of the agent to be tested was administered by intramuscular injection into the left femoral adductor (polymer group, Compound 1 MS group), for once a week, 4 times in total as a solution to be tested. One week after completion of the final administration, blood flows of hind legs were measured by using Laser Doppler Imager (Moor Instruments), and blood flows of the treated leg (left leg) and untreated leg (right leg) were compared and examined. The results of treated leg/untreated leg (%) are shown in Table 3.

[0130] In this connection, construction of the solution to be tested is as follows.

Polymer group:

[0131] The polylactic acid-glycolic acid copolymer used in Preparation Example 2 was suspended in 0.2 w/v% Tween 80 solution (0.2 ml). In this connection, amount of the polylactic acid-glycolic acid copolymer is identical to the amount contained in Compound 1 MS (0.1 mg).

Compound 1 MS (0.03 mg) group:

[0132] The microsphere preparation produced in Preparation Example 2 containing 0.03 mg of Compound 1 was suspended in 0.2 w/v% Tween 80 solution (0.2 ml).

Compound 1 MS (0.1 mg) group:

[0133] The microsphere preparation produced in Preparation Example 2 containing 0.1 mg of Compound 1 was suspended in 0.2 w/v% Tween 80 solution (0.2 ml).

Compound 1 MS (0.3 mg) group:

[0134] The microsphere preparation produced in Preparation Example 2 containing 0.3 mg of Compound 1 was suspended in 0.2 w/v% Tween 80 solution (0.2 ml).

TABLE 3

Solution to be tested	Treated leg/untreated leg blood flow ratio (%)
Polymer	57.3 ± 4.5
Compound 1 MS (0.03 mg)	65.1 ± 3.7*
Compound 1 MS (0.1 mg)	68.4 ± 3.2**
Compound 1 MS (0.3 mg)	72.7 ± 4.6**

*: p<0.05 vs. Polymer (Student's t-test)
**: p<0.01 vs. Polymer (Student's t-test)

Results:

[0135] In comparison with the polymer group, dose-correlative blood flow improving effect was found in the microsphere (MS) preparation of Compound 1, and significant blood flow improving effect action was found in Compound 1 MS (0.03 mg). This, since significant blood flow improving effect action was not found in Compound 1 MS (0.01 mg) in Example 4, it was suggested that the minimum effective dose is 0.03 mg.

Example 6**Angiogenesis test using rat leg ischemia (arteriosclerosis obliterans (ASO)) model; usefulness of topical administration (*in vivo* test):**

[0136] Leg ischemia model was prepared by ligating rat left femoral artery. Blood flow in hind legs was measured by using Laser Doppler Imager (Moor Instruments) 1 week after the preparation, and the animals were divided into 4 groups ($n = 5$) in such a manner that the average value of blood flow became almost uniform.

[0137] Starting on the next day of the grouping, 0.1 ml/site, 2 sites, of the agent to be tested was administered by intramuscular injection into ischemic regions of the left femoral adductor (polymer group, Compound 1 group, Compound 1 MS group) and normal region of the right shoulder upper arm (Compound 1 MS group), for once a week, 4 times in total as a solution to be tested. One week after completion of the final administration, blood flows of hind legs were measured by using Laser Doppler Imager (Moor Instruments), and blood flows of the treated leg (left leg) and untreated leg (right leg) were compared and examined. The results of treated leg/untreated leg (%) are shown in Table 4.

[0138] In this connection, construction of the solution to be tested is as follows.

Polymer group:

[0139] The polylactic acid-glycolic acid copolymer used in Preparation Example 2 was suspended in 0.2 w/v% Tween 80 solution (0.2 ml). In this connection, amount of the polylactic acid-glycolic acid copolymer is identical to the amount contained in Compound 1 MS (1 mg).

Compound 1 (0.1 mg) group:

[0140] Compound 1 (0.1 mg) was suspended in 0.2 w/v% Tween 80 solution (0.2 ml).

Compound 1 MS (0.1 mg) group:

[0141] The microsphere preparation produced in Preparation Example 2 containing 0.1 mg of Compound 1 was suspended in 0.2 w/v% Tween 80 solution (0.2 ml).

TABLE 4

Solution to be tested	Treated leg/untreated leg blood flow ratio (%)
Polymer a)	57.3 \pm 4.5
Compound 1 (0.1 mg) a)	60.5 \pm 3.1
Compound 1 MS (0.1 mg) b)	56.9 \pm 5.6
Compound 1 MS (0.1 mg) a)	68.4 \pm 3.2*

a): Intramuscular administration into the ischemic left femoral part
 b): Intramuscular administration into right normal upper arm
 **: p<0.01 vs. Polymer (Student's t-test)

Results:

[0142] Although significant increase in the blood flow was not found by the intramuscular administration of Compound 1 MS (0.1 mg) into the right normal upper arm, significant increase in the blood flow was found by the intramuscular administration of the same dose into the ischemic left femoral part. Based on this, it was suggested that efficacy of Compound 1 is not mediated by blood flow, but its topical administration into ischemic regions is important. In addition, since significant blood flow increasing action was not observed by the topical administration of Compound 1 into ischemic region, efficacy of the persistent preparation (MS) was suggested.

Example 7

Angiogenesis test using rat leg ischemia (arteriosclerosis obliterans (ASO)) model; vasodilation action and angiogenesis acceleration action (*in vivo* test):

[0143] Leg ischemia model was prepared by ligating rat left femoral artery. Blood flow in hind legs was measured by using Laser Doppler Imager (Moor Instruments) 1 week after the preparation, and the animals were divided into 2 groups (n = 5) in such a manner that the average value of blood flow became almost uniform.

[0144] Starting on the next day of the grouping, the solution to be tested was administered by intramuscular injection into the left femoral adductor (polymer group, Compound 1 MS group) for once a week, 4 times in total. Blood flows of hind legs were measured 3 days after the second administration (on the 10th day after grouping) and after 1 week and 2 weeks from the completion of the final administration, by using Laser Doppler Imager (Moor Instruments), and blood flows of the treated leg (left leg) and untreated leg (right leg) were compared and examined. The results of treated leg/untreated leg (%) are shown in Table 5.

[0145] In this connection, construction of the solution to be tested is as follows.

Polymer group:

[0146] The polylactic acid-glycolic acid copolymer used in Preparation Example 2 was suspended in 0.2 w/v% Tween 80 solution (0.2 ml). In this connection, amount of the polylactic acid-glycolic acid copolymer is identical to the amount contained in Compound 1 MS (0.3 mg).

Compound 1 MS (0.3 mg) group:

[0147] The microsphere preparation produced in Preparation Example 2 containing 0.3 mg of Compound 1 was suspended in 0.2 w/v% Tween 80 solution (0.2 ml).

TABLE 5

Solution to be tested	Treated leg/untreated leg blood flow ratio (%)			
	Before 1st administration	After 3 days of 2nd administration	After 1 week of 4th administration	After 2 weeks of 4th administration
Polymer	36.7 ± 4.2	49.8 ± 5.8	57.3 ± 4.5	61.3 ± 2.5
Compound 1 MS (0.3 mg)	36.6 ± 4.3	59.9 ± 3.7*	72.7 ± 4.6*	72.4 ± 5.7**

*: p<0.05 vs. Polymer (Student's t-test)
**: p<0.01 vs. Polymer (Student's t-test)

Results:

[0148] In comparison with the polymer-administered group, a significant blood flow increase of about 10% was observed at the ischemic region by Compound 1 MS (0.3 mg) even on the 10th day after the 1st administration (3 days after the 2nd administration). Since a period of about 4 weeks is necessary for angiogenesis and Compound 1 is under release at the ischemic topical region 3 days after the 2nd administration, it was suggested that this improving effect is a blood flow increasing effect by direct actions such as vasodilation action and platelet agglutination inhibitory action of slow-released Compound 1. In addition, a significant blood flow increase action of about 11% was also observed after 1 week and 2 weeks of the final administration. It was considered based on this that release of Compound 1 from the microsphere preparation was completely disappeared after one week of the final administration, and it was suggested that this effect is not the direct actions of Compound 1 (vasodilation action, platelet agglutination inhibitory action, etc.), but an effect by the angiogenesis action.

Example 8

Angiogenesis test (*in vivo* test) using mouse sponge transplantation model:

[0149] Under anesthesia, dorsal part of a mouse was incised and a discus urethane sponge (about 5 mm in thickness and 13 mm in diameter) was embedded therein. Administration of the agent was carried out by topically administering it directly into the sponge once a day for a total of 14 times starting on the day of the sponge transplantation model preparation, or on the operation-completed day and 7th day thereafter. On the 15th day after the sponge transplantation, the sponge containing granulation tissue was extracted and observed with the naked eye, and then its wet mass was measured. In addition, this was mixed with distilled water of 4 times larger amount than the wet mass, homogenized and centrifuged, and then the supernatant was subjected to the measurement of the hemoglobin content using Hemoglobin β -Test Wako (manufactured by Wako Pure Chemical Industries). Results of measurement of the total hemoglobin content in the extracted sponges are shown in Table 6.

[0150] In this connection, construction of the solution to be tested is as follows.

Polymer group:

[0151] The polylactic acid-glycolic acid copolymer used in Preparation Example 2 was suspended in 0.2 w/v% Tween 80 solution (0.05 ml). In this connection, amount of the polylactic acid-glycolic acid copolymer is identical to the amount contained in Compound 1 MS (200 μ g).

Compound 1 (20 μ g) group:

[0152] Compound 1 (20 μ g) was suspended in 0.2 w/v% Tween 80 solution (0.05 ml).

Compound 1 (40 μ g) group:

[0153] Compound 1 (40 μ g) was suspended in 0.2 w/v% Tween 80 solution (0.05 ml).

Compound 1 (200 μ g) group:

[0154] Compound 1 (200 μ g) was suspended in 0.2 w/v% Tween 80 solution (0.05 ml).

Compound 1 MS (200 µg) group:

[0155] The microsphere preparation produced in Preparation Example 2 containing 200 µg of Compound 1 was suspended in 0.2 w/v% Tween 80 solution (0.05 ml).

Compound 1 MS (400 µg) group:

[0156] The microsphere preparation produced in Preparation Example 2 containing 400 µg of Compound 1 was suspended in 0.2 w/v% Tween 80 solution (0.05 ml).

Reference Compound 3 (20 µg) group:

[0157] Reference Compound 3 (20 µg) was suspended in 0.2 w/v% Tween 80 solution (0.05 ml).

TABLE 6

Solution to be tested	Sponge wet weight (g)	Hemoglobin content (mg/g wet tissue)
Polymer b)	0.4542 ± 0.0303	1.973 ± 0.564
Compound 1 (20 µg) a)	0.3843 ± 0.0681	2.403 ± 0.533
Compound 1 (40 µg) a)	0.5136 ± 0.0938	3.010 ± 0.808
Compound 1 (200 µg) b)	0.4123 ± 0.0320	1.964 ± 0.289
Compound 1 MS (200 µg) b)	0.5317 ± 0.1413	3.523 ± 0.482**
Compound 1 MS (400 µg) b)	0.5655 ± 0.1130	4.822 ± 1.218**
Reference Compound 3 (20 µg) a)	0.5193 ± 0.0792	4.588 ± 0.488**

a): once a day, 14 days of repeated administration

b): two administrations at 7 day intervals

**: p<0.01 vs. Polymer (Dunnett's test)

Results:

[0158] Formation of granulation was found in the sponges administered with Compound 1 MS (200 µg) (two administrations at 7 day intervals) and Compound 1 MS(400 µg) (two administrations at 7 day intervals), and they turned pale red, red or dark brown. In addition, when hemoglobin concentration in the granulation tissue formed in each sponge was measured, significant increase in the concentration of hemoglobin in comparison with the polymer group was observed so that the angiogenesis effect was confirmed. On the other hand, in the case of Compound 1 (20 µg) (14 days of repeated administration) and Compound 1 (40 µg) (14 days of repeated administration), hemoglobin concentration in the granulation tissue formed in each sponge showed an increasing tendency, but is not a significant increase. Also, hemoglobin concentration in the granulation tissue formed in the sponge did not increase in the case of Compound 1 (200 µg) (two administrations at 7 day intervals). Based on this, it was found that the slow release preparation of Compound 1 (Compound 1 MS) is particularly useful in inducing angiogenesis. Also, formation of granulation was found in the sponge administered with Reference Compound 3(20 µg) (14 days of repeated administration), and they turned pale red, red or dark brown. In addition, when hemoglobin concentration in the granulation tissue formed in the sponge was measured, significant increase in the concentration of hemoglobin in comparison with the polymer group was observed so that the angiogenesis effect was confirmed.

Example 9 (Reference)**Measurement of angiogenesis acceleration action (*in vitro*):**

Test method:

[0159] An angiogenesis kit (manufactured by Kurabo; constituted from normal human umbilical cord vein vascular endothelial cells and normal human skin fibroblasts) was cultured for 3 hours, and then the culture medium (the medium for angiogenesis use attached to the angiogenesis kit was used as the culture medium and cultured at 37°C under a moist environment of 5% carbon dioxide-95% air, and a carbon dioxide incubator BNA-121D was used as the incubator) was changed and an agent to be tested was added to each well (0.5 ml/well). The medium exchange was carried out also on the 3rd, 6th and 8th days after commencement of the culturing and the fresh agent to be tested was added. The kind and concentration of the agent to be tested were untreated; DMSO: 0.1%; α -CD: 0.0118, 0.118 and 1.18 mg/ml; PGE2- α CD: 1, 10 and 100 nmol/l; Reference Compound 3 (EP2 agonist), Reference Compound 4 (EP4 agonist), EP1 agonist and EP3 agonist: 1, 10 and 100 nmol/l, VEGF: 0.1, 1 and 10 ng/ml; and HGF: 0.1, 1 and 10 ng/ml, and culturing was carried out by using 3 wells for each concentration. Fixation was carried out 10 days after the commencement of culturing, and staining of hollow organ with anti-CD31 antibody was carried out by using a hollow organ staining kit (manufactured by Kurabo). As the evaluation, Chalkley Grid (a grid lens, Kurabo) was mounted on the eyepiece of a microscope, and the hollow organ formation was evaluated by counting intersections of the randomly arranged points of Chalkley Grid with the formed hollow organ (by referring to the evaluation method of J. Pathol., 177, 275-283 (1995)). The counting was carried out at 12 positions per well, and the total was calculated.

[0160] In this connection, Reference Compound 3 as an EP2 agonist ((5Z,9 β ,11 α ,13E)-17,17-propano-11,16-dihydroxy-9-chloro-20-norprost-5,13-dienoic acid) was dissolved in dimethyl sulfoxide (DMSO) to prepare 10^{-4} , 10^{-5} and 10^{-6} mol/l solutions which were then used by diluting 1/1000 time with the culture medium.

[0161] Reference Compound 4 as an EP4 agonist ((11 α ,13E,15 α)-9-oxo-11,15-dihydroxy-16-(3-methoxymethylphenyl)-17,18,19,20-tetranor-5-thiaprost-13-enoic acid) was dissolved in dimethyl sulfoxide (DMSO) to prepare 10^{-4} , 10^{-5} and 10^{-6} mol/l solutions which were then used by diluting 1/1000 time with the culture medium.

[0162] The EP1 agonist ((13E)-(11 α ,15S,17S)-2,5-ethano-6,9-dioxo-11,15-dihydroxy-17,20-dimethylprost-13-enoic acid; the compound described in Example 1 in the specification of JP-A-11-322709) was dissolved in dimethyl sulfoxide (DMSO) to prepare 10^{-4} , 10^{-5} and 10^{-6} mol/l solutions which were then used by diluting 1/1000 time with the culture medium.

[0163] The EP3 agonist (11 α ,15 α -dimethoxy-9-oxoprost-5Z,13E-dienoic acid; the compound described in Example 1 in the specification of WO98/34916) was dissolved in dimethyl sulfoxide (DMSO) to prepare 10^{-4} , 10^{-5} and 10^{-6} mol/l solutions which were then used by diluting 1/1000 time with the culture medium.

[0164] The PGE2- α CD was dissolved in distilled water for injection to prepare 10^{-4} , 10^{-5} and 10^{-6} mol/l solutions which were then used by diluting 1/1000 time with the culture medium.

[0165] As the VEGF (vascular endothelial growth factor), the 2 μ g/ml solution of VEGF contained in the angiogenesis control reagent kit of Kurabo was diluted with the culture medium and used.

[0166] As the HGF (human hepatocyte growth factor), the 5 μ g/ml solution of HGF purchased from R & D System-Funakoshi was diluted with the culture medium and used.

Statistical analysis method:

[0167] The counts of hollow organ formation in the untreated wells were compared with those of the wells treated with respective concentrations of test samples by Dunnett's test (two-sided test). The significance level was set to 5%.

[0168] In this connection, the data were shown by average value of 3 wells and standard deviation.

[0169] The test results are shown in Fig. 5.

Results:

[0170] The PGE2- α CD, Reference Compound 3 (EP2 agonist) and Reference Compound 4 (EP4 agonist) significantly accelerated hollow organ formation at concentrations of 10 nmol/l and 100 nmol/l. In addition, the VEGF and HGF accelerated hollow organ formation at a concentration of 10 ng/ml. However, the EP1 agonist, EP3 agonist and α -CD did not exert influence upon hollow organ formation.

Example 10 (Reference)

Measurement of endogenous repair factor releasing action (*in vitro*):

Test method:

[0171] An angiogenesis kit (manufactured by Kurabo; constituted from normal human umbilical cord vein vascular endothelial cells and normal human skin fibroblasts) was cultured for 3 hours, and then the culture medium (the medium for angiogenesis use attached to the angiogenesis kit was used as the culture medium and cultured at 37°C under a moist environment of 5% carbon dioxide-95% air, and a carbon dioxide incubator BNA-121D was used as the incubator) was changed and an agent to be tested was added to each well (0.5 ml/well). HGF and VEGF concentrations in the culture supernatants were measured 3 days after the commencement of the culturing. Kinds and concentrations of the agent to be tested were untreated; DMSO: 0.1%; PGE1- α CD: 100 nmol/l; PGE2- α CD: 100 nmol/l; and Reference Compound 3 (EP2 agonist) and Reference Compound 4 (EP4 agonist): 100 nmol/l, and the culturing was carried out by using 3 wells for each concentration. The HGF and VEGF concentrations were measured by using an ELISA kit (R % D system-Funakoshi).

[0172] In this connection, Reference Compound 3 as an EP2 agonist ((5Z,9 β ,11 α ,13E)-17,17-propano-11,16-dihydroxy-9-chloro-20-norprost-5,13-dienoic acid) was dissolved in dimethyl sulfoxide (DMSO) to prepare a 10^{-4} mol/l solution which was then used by diluting 1/1000 time with the culture medium.

[0173] Reference Compound 4 as an EP4 agonist ((11 α ,13E,15 α)-9-oxo-11,15-dihydroxy-16-(3-methoxymethylphenyl)-17,18,19,20-tetranor-5-thiaprostan-13-enoic acid) was dissolved in dimethyl sulfoxide (DMSO) to prepare a 10^{-4} mol/l solution which was then used by diluting 1/1000 time with the culture medium.

[0174] The PGE1- α CD and PGE2- α CD were dissolved in distilled water for injection to prepare 10^{-4} mol/l solutions which were then used by diluting 1/1000 time with the culture medium.

Statistical analysis method:

[0175] HGF and VEGF concentrations in the supernatants of the solvent control group were compared with those of the agent-treated groups by Dunnett's test (two-sided test). The significance level was set to 5%.

[0176] In this connection, the data were shown by average value of 3 wells and standard deviation.

[0177] The test results after 72 hours of the culturing are shown in Table 7.

TABLE 7

Agent tested	HGF (pg/ml)	VEGF (pg/ml)
Untreated	110 \pm 16	2004 \pm 76
PGE1- α CD	2043 \pm 77***	2710 \pm 50***
PGE2- α CD	1735 \pm 95***	3032 \pm 165****
EP2 agonist (Reference Compound 3)	1865 \pm 48***	2762 \pm 51***
EP4 agonist (Reference Compound 4)	379 \pm 12***	2936 \pm 69***

*** p<0.001 vs. untreated (Dunnett's test)

Results:

[0178] The PGE1- α CD, PGE2- α CD, Reference Compound 3 (EP2 agonist) and Reference Compound 4 (EP4 agonist) significantly increased HGF and VEGF concentrations in supernatants at a concentration of 100 nmol/l.

REFERENCES CITED IN THE DESCRIPTION

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MIKROSFÆRER, DER OMFATTER ONO-1301

PATENTKRAV

1. Persistent mikrosfærefremstilling, der omfatter en biologisk nedbrydelig polymer og (E)-[5-[2-(1-phenyl-1-(3-pyridyl)methylidenaminoxy)ethyl]-7,8-dihydronaphthalen-1-yloxy]-eddikesyre eller salt deraf.
- 5 2. Persistent mikrosfærefremstilling ifølge krav 1, hvor den biologisk nedbrydelige polymer er en mælkesyre-glycolsyrecopolymer.
3. Persistent mikrosfærefremstilling ifølge krav 1 eller 2 til anvendelse som en vaskular endothelial vækstfaktor- (VEGF) eller en hepatocytvækstfaktor- (HGF) produktionsaccelerator til forebyggelse og/eller behandling af en sygdom, der er udvalgt fra myokardieinfarkt, angina pectoris, kongestiv hjertesvigt og
- 10 10 koronar hjertesygdom.
4. Persistent mikrosfærefremstilling til anvendelse ifølge krav 3, hvor sygdommen er myokardieinfarkt.
5. Persistent mikrosfærefremstilling til anvendelse ifølge krav 3, hvor sygdommen er kongestiv hjertesvigt.
- 15 6. Farmaceutisk sammensætning, der omfatter en persistent mikrosfærefremstilling ifølge krav 1 eller 2.
7. Farmaceutisk sammensætning ifølge krav 6 til anvendelse til forebyggelse og/eller behandling af en sygdom, der er udvalgt fra myokardieinfarkt, angina pectoris, kongestiv hjertesvigt og koronar hjertesygdom.
- 20 8. Farmaceutisk sammensætning til anvendelse ifølge krav 7, hvor sygdommen er myokardieinfarkt.
9. Farmaceutisk sammensætning til anvendelse ifølge krav 7, hvor sygdommen er kongestiv hjertesvigt.
10. Middel, der omfatter den persistente mikrosfærefremstilling ifølge krav 1 eller 2.
11. Middel ifølge krav 10 til anvendelse til forebyggelse og/eller behandling af en sygdom, der er
- 25 udvalgt fra myokardieinfarkt, angina pectoris, kongestiv hjertesvigt og koronar hjertesygdom.
12. Middel til anvendelse ifølge krav 11, hvor sygdommen er myokardieinfarkt.
13. Middel til anvendelse ifølge krav 11, hvor sygdommen er kongestiv hjertesvigt.

DRAWINGS

FIG. 1

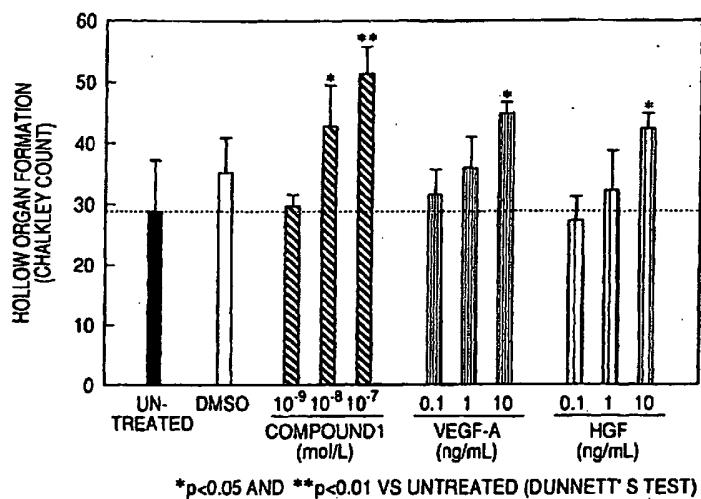


FIG. 2

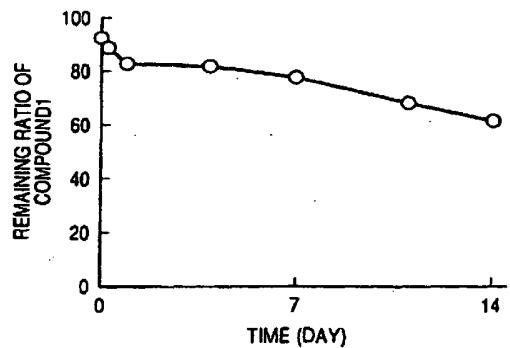


FIG. 3

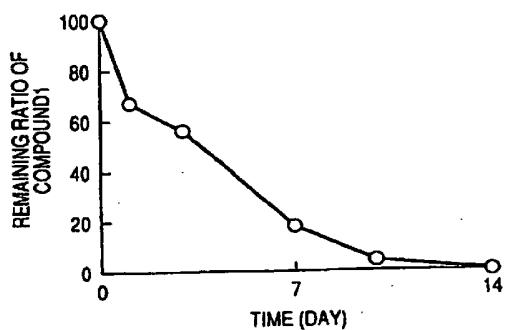


FIG. 4

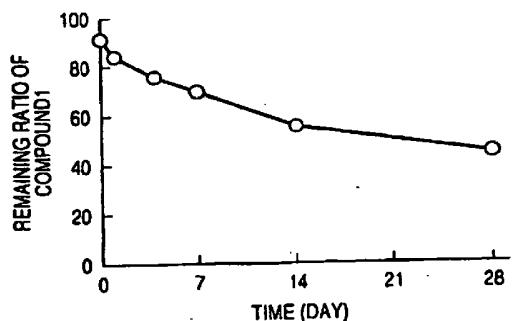


FIG. 5

