DESCRIPTION

Title of Invention

TUMOR-TREATING PHARMACEUTICAL COMPOSITION

Technical Field

[0001] The present invention relates to a pharmaceutical composition for treating a tumor, which is used in the combination therapy of lenvatinib and (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide.

Background Art

[0002] Lenvatinib is an oral tyrosine kinase inhibitor having an angiogenesis inhibitory effect (Patent Literature 1) and targeting vascular endothelial growth factor receptors (VEGFRs) 1 to 3, fibroblast growth factor receptors (FGFRs) 1 to 4, rearranged during transfection (RET), KIT and platelet-derived growth factor receptor (PDGFR) α (Patent Literatures 2 to 5), and is known as a therapeutic agent for various tumors such as thyroid cancer, lung cancer, melanoma, endometrial cancer, renal cell carcinoma, glioma, hepatocellular carcinoma, and ovary cancer. The compound name of lenvatinib is 4-(3-chloro-4-(cyclopropylaminocarbonyl)aminophenoxy)-7-methoxy-6-quinolinecarboxamide.

[0003] (6S,9aS)-N-Benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide (hereinafter, also referred to as E7386) is known as a compound having a Wnt Pathway modulating effect (Patent Literature 6).

[0004] There is no previous report as to whether the combination therapy of lenvatinib and (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide exhibits any antitumor effect.

[0005] In general, a tumor therapeutic agent, when used alone, is often not effective for all patients. Accordingly, an attempt has been made so far to improve a treatment rate by using a plurality of tumor therapeutic agents in combination and achieving enhancement in antitumor effect or alleviation of adverse reactions (Patent Literatures 7 to 9).

Citation List

Patent Literature

[0006]

Patent Literature 1: U.S. Patent No. 7253286

Patent Literature 2: U.S. Patent Application Publication No. 2004-253205

Patent Literature 3: U.S. Patent Application Publication No. 2010-105031

Patent Literature 4: U.S. Patent Application Publication No. 2009-209580

Patent Literature 5: U.S. Patent Application Publication No. 2009-264464

Patent Literature 6: U.S. Patent No. 9174998

Patent Literature 7: International Publication No. WO 2009/140549

Patent Literature 8: U.S. Patent Application Publication No. 2004-259834

Patent Literature 9: U.S. Patent No. 6217866

Summary of Invention

Technical Problem

[0007] Under such circumstances, the further development of new combination therapy of tumor therapeutic agents is anticipated.

Solution to Problem

[0008] The present inventors have conducted diligent studies and consequently completed the present invention by finding that the combined administration of lenvatinib and (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide exhibits an unexpected antitumor effect.

[0009] Specifically, the present invention provides the following [1] to [33].

[1] A pharmaceutical composition comprising (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide, wherein (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide is administered in combination with lenvatinib or a pharmaceutically acceptable salt thereof.

[2] A pharmaceutical composition comprising lenvatinib or a pharmaceutically acceptable salt thereof, wherein lenvatinib or a pharmaceutically acceptable salt thereof is administered in combination with

(6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide.

[3] A pharmaceutical composition for treating a tumor, comprising (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide, wherein (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide is administered in combination with lenvatinib or a pharmaceutically acceptable salt thereof.

[4] A pharmaceutical composition for treating a tumor, comprising lenvatinib or a pharmaceutically acceptable salt thereof, wherein lenvatinib or a pharmaceutically acceptable salt thereof is administered in combination with (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide.

[5] A therapeutic agent for a tumor comprising (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide, wherein (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide is administered in combination with lenvatinib or a pharmaceutically acceptable salt thereof.

[6] A therapeutic agent for a tumor comprising lenvatinib or a pharmaceutically acceptable salt thereof, wherein lenvatinib or a pharmaceutically acceptable salt thereof is administered in combination with (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide.

[7] A method for treating tumor, comprising administering lenvatinib or a pharmaceutically acceptable salt thereof, and

(6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide to a patient in need thereof.

[8] Use of (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide for producing a pharmaceutical composition for treating a tumor, wherein (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide is administered in combination with lenvatinib or a pharmaceutically acceptable salt thereof.

[9] Use of lenvatinib or a pharmaceutically acceptable salt thereof for producing a pharmaceutical composition for treating a tumor, wherein lenvatinib or a pharmaceutically acceptable salt thereof is administered in combination with (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide.

[10] (6S,9aS)-N-Benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide for treating a tumor, wherein the (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide is administered in combination with lenvatinib or a pharmaceutically acceptable salt thereof.

[11] Lenvatinib or a pharmaceutically acceptable salt thereof for treating a tumor, wherein the lenvatinib or the pharmaceutically acceptable salt thereof is administered in combination with (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide.

[12] A kit comprising a formulation comprising lenvatinib or a pharmaceutically

acceptable salt thereof, and a formulation comprising (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide.

[13] The kit according to [12], wherein the kit is a kit for treating a tumor.

[14] A pharmaceutical composition comprising lenvatinib or a pharmaceutically acceptable salt thereof, and (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide.

[15] A pharmaceutical composition for treating a tumor, comprising lenvatinib or a pharmaceutically acceptable salt thereof, and (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide.

[16] A therapeutic agent for a tumor comprising lenvatinib or a pharmaceutically acceptable salt thereof, and (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide.

[17] Lenvatinib or a pharmaceutically acceptable salt thereof, and (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide for use in treating a tumor.

[18] (6S,9aS)-N-Benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide for use in treating a tumor in combination with lenvatinib or a pharmaceutically acceptable salt thereof.

[19] Lenvatinib or a pharmaceutically acceptable salt thereof for use in treating a tumor in combination with (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]tr

iazine-1(6H)-carboxamide.

[20] Use of lenvatinib or a pharmaceutically acceptable salt thereof, and (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide for producing a pharmaceutical composition for treating a tumor.

[21] The pharmaceutical composition or the therapeutic agent for a tumor, further comprising an excipient.

[22] The pharmaceutical composition, the therapeutic agent for a tumor, the treatment method, the use, the compound or the kit, wherein the lenvatinib or the pharmaceutically acceptable salt thereof is lenvatinib mesylate.

[23] The pharmaceutical composition, the therapeutic agent for a tumor, the treatment method, the use, the compound or the kit, wherein the lenvatinib or the pharmaceutically acceptable salt thereof, and the (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide are administered simultaneously, separately, continuously, or at time intervals.

[24] The pharmaceutical composition, the therapeutic agent for a tumor, the treatment method, the use, the compound or the kit, wherein the tumor is breast cancer, thyroid cancer, hepatocellular carcinoma, colorectal cancer, renal cell carcinoma, head and neck cancer, endometrial cancer or melanoma.

[25] The pharmaceutical composition, the therapeutic agent for a tumor, the treatment method, the use, the compound or the kit according to [24], wherein the tumor is breast cancer.

[26] The pharmaceutical composition, the therapeutic agent for a tumor, the treatment method, the use, the compound or the kit according to [24], wherein the tumor is thyroid cancer.

[27] The pharmaceutical composition, the therapeutic agent for a tumor, the treatment method, the use, the compound or the kit according to [26], wherein the thyroid cancer is anaplastic thyroid cancer.

[28] The pharmaceutical composition, the therapeutic agent for a tumor, the treatment method, the use, the compound or the kit according to [24], wherein the tumor is hepatocellular carcinoma.

[29] The pharmaceutical composition, the therapeutic agent for a tumor, the treatment method, the use, the compound or the kit according to [24], wherein the tumor is colorectal cancer.

[30] The pharmaceutical composition, the therapeutic agent for a tumor, the treatment method, the use, the compound or the kit according to [24], wherein the tumor is renal cell carcinoma.

[31] The pharmaceutical composition, the therapeutic agent for a tumor, the treatment method, the use, the compound or the kit according to [24], wherein the tumor is head and neck cancer.

[32] The pharmaceutical composition, the therapeutic agent for a tumor, the treatment method, the use, the compound or the kit according to [24], wherein the tumor is endometrial cancer.

[33] The pharmaceutical composition, the therapeutic agent for a tumor, the treatment method, the use, the compound or the kit according to [24], wherein the tumor is melanoma.

Advantageous Effects of Invention

[0010] The present invention provides a pharmaceutical composition for treating a tumor, which is used in the combination therapy of lenvatinib and (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide. This pharmaceutical composition for treating a tumor exhibits unexpected antitumor effects for patients in need thereof.

Brief Description of Drawings

[0011]

[Figure 1] Figure 1 is a graph showing the antitumor effect of combined use of 12.5 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in serial transplantation models of transgenic mouse (MMTV-Wnt-1) spontaneous breast cancer. In the graph, * and *** show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (*: $p < 0.05$, ***: $p < 0.001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[Figure 2] Figure 2 is a graph showing the antitumor effect of combined use of 25 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in serial transplantation models of transgenic mouse (MMTV-Wnt-1) spontaneous breast cancer. In the graph, **** shows that the

combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (****: $p < 0.0001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[Figure 3] Figure 3 is a graph showing the antitumor effect of combined use of 50 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in serial transplantation models of transgenic mouse (MMTV-Wnt-1) spontaneous breast cancer. In the graph, *** and **** show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (***: $p < 0.001$, ****: $p < 0.0001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[Figure 4] Figure 4 is a graph showing the antitumor effect of combined use of 25 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in mouse breast cancer 4T1 orthotopic transplantation models. In the graph, * and ** show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (*: $p < 0.05$, **: $p < 0.01$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[Figure 5] Figure 5 is a graph showing the antitumor effect of combined use of 25 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in human breast cancer MDA-MB-231 transplantation models. In the graph, * and *** show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (*: $p < 0.05$, ***: $p < 0.001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[Figure 6] Figure 6 is a graph showing the antitumor effect of combined use of 12.5 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in human melanoma cell line SEKI transplantation models. In the graph, * and ** show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (*: $p < 0.05$, **: $p < 0.01$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[Figure 7] Figure 7 is a graph showing the antitumor effect of combined use of 25 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in human melanoma cell line SEKI transplantation models. In the graph, * and *** show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (*: $p < 0.05$, ***: $p < 0.001$; repeated measures

ANOVA followed by Dunnett's type multiple comparison).

[Figure 8] Figure 8 is a graph showing the antitumor effect of combined use of 12.5 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in human anaplastic thyroid cancer cell line HTC/C3 transplantation models. In the graph, ** and *** show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (**: $p < 0.01$, ***: $p < 0.001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[Figure 9] Figure 9 is a graph showing the antitumor effect of combined use of 25 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in human anaplastic thyroid cancer cell line HTC/C3 transplantation models. In the graph, *** and **** show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (***: $p < 0.001$, ****: $p < 0.0001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[Figure 10] Figure 10 is a graph showing the antitumor effect of combined use of 50 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in human anaplastic thyroid cancer cell line HTC/C3 transplantation models. In the graph, ** and *** show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (**: $p < 0.01$, ***: $p < 0.001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[Figure 11] Figure 11 is a graph showing the antitumor effect of combined use of 12.5 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in human hepatocellular carcinoma line SNU398 transplantation models. In the graph, * and ** show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (*: $p < 0.05$, **: $p < 0.01$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[Figure 12] Figure 12 is a graph showing the antitumor effect of combined use of 25 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in human hepatocellular carcinoma line SNU398 transplantation models. In the graph, ** shows that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (**: $p < 0.01$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[Figure 13] Figure 13 is a graph showing the antitumor effect of combined use of 50 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in human hepatocellular carcinoma line SNU398

transplantation models. In the graph, **** shows that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (****: $p < 0.0001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[Figure 14] Figure 14 is a graph showing the antitumor effect of combined use of 50 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in human hepatocellular carcinoma line HepG2 transplantation models. In the graph, ** and **** show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (**: $p < 0.01$, ****: $p < 0.0001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[Figure 15] Figure 15 is a graph showing the antitumor effect of combined use of 50 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in human colorectal cancer line Colo-205 transplantation models. In the graph, ** and **** show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (**: $p < 0.01$, ****: $p < 0.0001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[Figure 16] Figure 16 is a graph showing the antitumor effect of combined use of 50 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in human renal cell carcinoma line A-498 subcutaneous transplantation models. In the graph, **** shows that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (****: $p < 0.0001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[Figure 17] Figure 17 is a 10× magnified photograph showing the microvessel suppressive effect of combined use of E7386 and lenvatinib mesylate in mouse breast cancer 4T1 orthotopic transplantation models by immunostaining in which CD31/α-SMA co-staining was performed. Figure 17(a) is a photograph of a control group, Figure 17(b) is a photograph of an E7386 alone administration group (25 mg/kg), Figure 17(c) is a photograph of a lenvatinib mesylate alone administration group (10 mg/kg), and Figure 17(d) is a photograph of an E7386 (25 mg/kg) and lenvatinib mesylate (10 mg/kg) combined administration group.

[Figure 18] Figure 18 is a 200× magnified photograph showing the pericyte coverage (coverage of blood vessels with vascular pericytes) suppressive effect of combined use of E7386 and lenvatinib mesylate in mouse breast cancer 4T1 orthotopic transplantation models

by immunostaining in which CD31/α-SMA co-staining was performed. Figure 18(a) is a photograph of a control group, Figure 18(b) is a photograph of an E7386 alone administration group (25 mg/kg), Figure 18(c) is a photograph of a lenvatinib mesylate alone administration group (10 mg/kg), and Figure 18(d) is a photograph of an E7386 (25 mg/kg) and lenvatinib mesylate (10 mg/kg) combined administration group. A microvessel stained with CD31 is indicated by black arrow. A CD31/α-SMA both positive blood vessel is indicated by open arrow.

[Figure 19] Figure 19 is a graph showing the microvessel suppressive effect of combined use of 25 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in mouse breast cancer 4T1 orthotopic transplantation models. In the graph, * and **** show that the combined use of E7386 and lenvatinib mesylate statistically significantly suppressed microvessels as compared with the case where each of them was administered alone (*: $p < 0.05$, ****: $p < 0.0001$; Dunnett's type multiple comparison).

[Figure 20] Figure 20 is a graph showing the pericyte coverage (coverage of blood vessels with vascular pericytes) suppressive effect of combined use of 25 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in mouse breast cancer 4T1 orthotopic transplantation models. In the graph, * and **** show that the combined use of E7386 and lenvatinib mesylate statistically significantly suppressed pericyte coverage as compared with the case where each of them was administered alone (*: $p < 0.05$, ****: $p < 0.0001$; Dunnett's type multiple comparison).

[Figure 21] Figure 21 is a graph showing the microvessel suppressive effect of combined use of 50 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in human hepatocellular carcinoma HepG2 subcutaneous transplantation models. In the graph, ** and **** show that the combined use of E7386 and lenvatinib mesylate statistically significantly suppressed microvessels as compared with the case where each of them was administered alone (**: $p < 0.01$, ****: $p < 0.0001$; Dunnett's type multiple comparison).

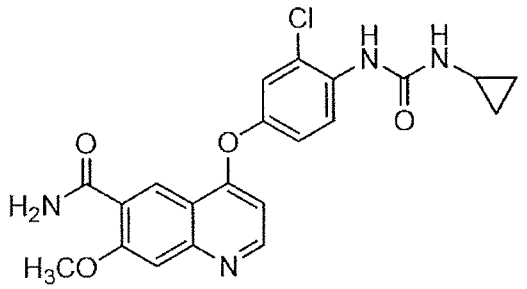
[Figure 22] Figure 22 is a graph showing the pericyte coverage (coverage of blood vessels with vascular pericytes) suppressive effect of combined use of 50 mg/kg E7386 and 10 mg/kg lenvatinib mesylate in human hepatocellular carcinoma HepG2 subcutaneous transplantation models. In the graph, **** shows that the combined use of E7386 and lenvatinib mesylate statistically significantly suppressed pericyte coverage as compared with the case where each of them was administered alone (****: $p < 0.0001$; Dunnett's type multiple comparison).

Description of Embodiments

[0012] Embodiments of the present invention are described below. The following embodiments are only examples for describing the present invention, and it is not intended to limit the present invention only to these embodiments. The present invention can be carried out in various modes without departing from the subject matter of the present invention.

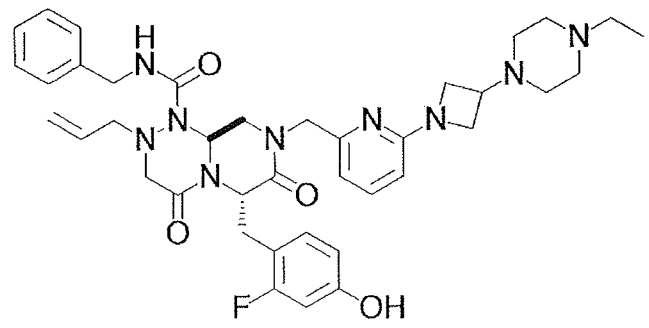
Note that the documents, publications, patent publications, and other patent literatures cited in the present description are incorporated herein by reference.

[0013] Lenvatinib refers to 4-(3-chloro-4-(cyclopropylaminocarbonyl)aminophenoxy)-7-methoxy-6-quinolinecarboxamide, and the structural formula thereof is shown in the following formula:



Lenvatinib or a pharmaceutically acceptable salt thereof can be produced by a method described in Patent Literature 1. One example of the pharmaceutically acceptable salt of lenvatinib is lenvatinib mesylate. Lenvatinib mesylate is also referred to as E7080 or Lenvima(R).

[0014] The structural formula of (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide is shown in the following formula.



(6S,9aS)-N-Benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1

-c][1,2,4]triazine-1(6H)-carboxamide can be produced by a method described in Patent Literature 6. (6S,9aS)-N-Benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide is also referred to as E7386.

[0015] Although the "pharmacologically acceptable salt" is not limited to a specific type of salt, examples thereof include salts with inorganic acids, salts with organic acids, salts with inorganic bases, salts with organic bases, and salts with acidic or basic amino acids.

[0016] Examples of salts with inorganic acids include salts with hydrochloric acid, hydrobromic acid, sulfuric acid, nitric acid, and phosphoric acid. Examples of salts with organic acids include salts with acetic acid, succinic acid, fumaric acid, maleic acid, tartaric acid, citric acid, lactic acid, stearic acid, benzoic acid, methanesulfonic acid (mesylic acid), ethanesulfonic acid, and p-toluenesulfonic acid.

[0017] Examples of salts with inorganic bases include alkali metal salts, such as sodium salt and potassium salt; alkaline earth metal salts, such as a calcium salt and a magnesium salt; an aluminum salt and an ammonium salt. Examples of salts with organic bases include salts with diethylamine, diethanolamine, meglumine, and N,N-dibenzylethylenediamine.

[0018] Examples of salts with acidic amino acids include salts with aspartic acid and glutamic acid. Examples of salts with basic amino acids include salts with arginine, lysine, and ornithine.

[0019] Examples of pharmacologically acceptable salts of lenvatinib include salts with organic acids, and one embodiment thereof is methanesulfonate (mesylate).

[0020] In the case where solvates and optical isomers of lenvatinib or (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide of the present invention are present, these solvates and optical isomers are included therein. Examples of solvates include hydrate and anhydrate. Examples of solvents include water, alcohols (e.g., methanol, ethanol, and n-propanol), and dimethylformamide.

[0021] Moreover, lenvatinib or (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide of the present invention may be crystalline or amorphous. In the

case where polymorphic crystals are present, a single crystal form or a mixture of any of these crystal forms may be used.

[0022] The dose of lenvatinib or a pharmacologically acceptable salt thereof can be suitably selected, depending on the degree of symptoms, the development of adverse effects, the age, sex, body weight, and sensitivity difference of the patient, administration route, administration period, administration interval, the type of pharmaceutical formulation, etc.

[0023] The dose of lenvatinib or a pharmacologically acceptable salt thereof is not particularly limited, but is generally, when orally administered to an adult (body weight: 60 kg) or an child, 0.1 to 500 mg, 0.5 to 300 mg, or 1 to 100 mg, per day, or is 0.1 to 500 mg/m^2 (body surface area, hereinafter the same), 0.5 to 300 mg/m^2, or 1.0 to 100 mg/m^2, per day. This dose can be generally administered once a day, or two to three times a day. If the patient has undergone excessive toxicity, it is necessary to reduce the dose. The dose and dosage schedule may be changed when one or more additional chemotherapeutic agents are used, in addition to the combination therapy of the present invention. The dosage schedule can be determined by the physician who is treating the specific patient.

[0024] The dose and dosage schedule of (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide can be changed according to the specific disease symptoms and the total symptoms of the patient.. The dose can be suitably reduced, depending on age, sex, symptoms, development of adverse effects, etc.

[0025] The dose of (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide is not particularly limited, but is generally 0.1 to 5000 mg, 0.5 to 3000 mg, or 1.0 to 1000 mg per day in the case of oral administration to an adult (body weight: 60 kg) or a child. This can usually be administered in one portion or in two to six divided portions per day or per a plurality of days. The dose and dosage schedule may be changed when one or more additional chemotherapeutic agents are used. The dosage schedule can be determined by the physician who is treating the specific patient.

[0026] The dose of lenvatinib or (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]tr

iazine-1(6H)-carboxamide in the combined administration of the present invention can generally be set equal to or lower than the dose when they are administered alone. The specific dose, administration route, administration frequency, administration cycle, etc., are suitably determined, in consideration of the age, sex, and symptoms of the patient, the development of adverse effects, etc.

[0027] The mode of administration of lenvatinib and (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide according to the present invention is not particularly limited, and lenvatinib and (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide can be administered in combination at the time of administration. For example, lenvatinib and (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide are administered to a patient simultaneously, separately, continuously, or at time intervals. Here, the term "simultaneously" means that the ingredients are each administered in the same period or exactly at the same time, or administered through the same route. The term "separately" means that the ingredients are each administered in different intervals or with different frequencies, or administered through different routes. The term "continuously" means that the ingredients are each administered through the same or different routes in an arbitrary order within a predetermined period. The term "at time intervals" means that the ingredients are each administered through the same or different routes at intervals for the respective ingredients. In the combined administration of lenvatinib and (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide, when lenvatinib is administered during one cycle of administration of (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide described above or during a period in which this cycle is repeated,

it is determined that lenvatinib and (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide are administered in combination. In one mode of administration for the combined administration of the present invention, lenvatinib and (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide are orally administered. Moreover, the combined administration of the present invention may be conducted simultaneously, separately, continuously, or at time intervals, together with the administration of a therapeutic agent for a tumor other than lenvatinib and (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide.

[0028] The pharmaceutical composition for treating a tumor of the present invention can be formulated by a method described in, for example, the Japanese Pharmacopoeia, 16th edition (JP), the United States pharmacopoeia (USP) or the European pharmacopoeia (EP).

[0029] The tumor targeted in the present invention is specifically, for example, breast cancer, thyroid cancer, hepatocellular carcinoma (HCC), colorectal cancer (CRC), renal cell carcinoma (RCC), head and neck cancer, endometrial cancer or melanoma, though not particularly limited to these. The tumor targeted in one aspect of the present invention is thyroid cancer. Also, the thyroid cancer targeted in one aspect of the present invention is anaplastic thyroid cancer (ATC). The tumor targeted in another aspect of the present invention is hepatocellular carcinoma.

Examples

[0030] Specific examples of the present invention are provided below; however, the present invention is not limited thereto.

[0031] [Example 1] Antitumor effect of combined use of E7386 and lenvatinib mesylate in serial transplantation model of transgenic mouse (MMTV-Wnt-1) spontaneous breast cancer

Spontaneous breast cancer of a transgenic mouse (MMTV-Wnt-1, The Jackson Laboratory) caused to locally express Wnt-1 in mammary gland epithelial cells was collected, transplanted in a mouse of background strain (C57BL/6J, Charles River

Laboratories Japan, Inc.) by using a trocar, and passaged. The tumor thus transplanted and passaged was excised when becoming approximately 1.5 g, and prepared into approximately 30 mg of a fragment, which was subcutaneously transplanted to the sides of the bodies of five mice (C57BL/6J) each of a control group, an E7386 12.5, 25 or 50 mg/kg alone administration group, a lenvatinib mesylate 10 mg/kg alone administration group, and a combined administration group of 12.5, 25 or 50 mg/kg E7386 and 10 mg/kg lenvatinib mesylate. After confirmation of engraftment of the tumor, E7386 (12.5, 25 or 50 mg/kg, b.d.s., 14 days, oral administration) and lenvatinib mesylate (10 mg/kg, q.d., 14 days, oral administration) were administered alone or in combination to the alone administration group or the combined administration group. For the administration, E7386 was dissolved in 0.1 mol/L hydrochloric acid, and lenvatinib mesylate was dissolved in 3 mmol/L hydrochloric acid. 0.1 mol/L hydrochloric acid (b.d.s., 14 days) was administered to the control group.

When the start day of administration was defined as day 1, the major axis and minor axis of tumor developed in each mouse were then measured at day 4, day 8, day 11, and day 15 by using Digimatic Caliper (Mitutoyo Corp.).

The tumor volume and the relative tumor volume (RTV) were calculated according to the following expressions.

Tumor volume (mm^3) = Tumor major axis (mm) × Tumor minor $axis^2$ (mm^2) / 2

Relative tumor volume (RTV) = Tumor volume at the measurement day / Tumor volume at the start day of administration

[0032] The results about RTV are shown in Table 1 and Figures 1, 2 and 3. Numbers in Table 1 denote mean ± standard deviation (SD) of RTV. As a result, combined use of E7386 and lenvatinib mesylate exhibited an excellent antitumor effect in the serial transplantation models of transgenic mouse (MMTV-Wnt-1) spontaneous breast cancer. *, *** and **** in Figures 1, 2 and 3 show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (*: $p < 0.05$, ***: $p < 0.001$, ****: $p < 0.0001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[0033] [Table 1]

Group	Day 4	Day 8	Day 11	Day 15
Control group	2.12±0.64	3.93±1.61	5.82±2.41	8.50±3.10
E7386 12.5 mg/kg group	1.34±0.25	1.20±0.40	1.70±0.67	2.12±0.65
E7386 25 mg/kg group	1.26±0.28	1.56±0.48	2.40±0.22	3.69±0.92
E7386 50 mg/kg group	0.93±0.23	1.05±0.26	1.34±0.35	1.59±1.03
Lenvatinib mesylate 10 mg/kg group	1.03±0.13	0.87±0.13	0.98±0.21	1.05±0.25
E7386 12.5 mg/kg + lenvatinib mesylate 10 mg/kg group	0.54±0.06	0.39±0.05	0.42±0.13	0.39±0.11
E7386 25 mg/kg + lenvatinib mesylate 10 mg/kg group	0.52±0.07	0.37±0.10	0.36±0.13	0.32±0.10
E7386 50 mg/kg + lenvatinib mesylate 10 mg/kg group	0.30±0.02	0.23±0.04	0.25±0.05	0.23±0.04

[0034] [Example 2] Antitumor effect of combined use of E7386 and lenvatinib mesylate in mouse breast cancer 4T1 orthotopic transplantation model

Mouse breast cancer 4T1 cells (ATCC) were cultured by using RPMI1640 medium (Sigma-Aldrich Co. LLC) containing 10% FBS in a 5% CO_2 incubator under conditions of 37°C. When the cells became an approximately 80% confluent state, the cells were recovered by using trypsin-EDTA. A suspension was prepared by adding Hank's balanced salt solution so as to be 1.0×10^7 cells/mL. 0.1 mL of the obtained cell suspension was transplanted to the right third mammary gland fat pads of five mice (C57BL/6J, Charles River Laboratories Japan, Inc.) each of a control group, an E7386 25 mg/kg alone administration group, a lenvatinib mesylate 10 mg/kg alone administration group, and a combined administration group of 25 mg/kg E7386 and 10 mg/kg lenvatinib mesylate. From 9 days after the transplantation, E7386 (25 mg/kg, b.d.s., 14 days, oral administration) and lenvatinib mesylate (10 mg/kg, q.d., 14 days, oral administration) were administered alone or in combination to the alone administration group or the combined administration group. For the administration, E7386 was dissolved in 0.1 mol/L hydrochloric acid, and lenvatinib mesylate was dissolved in 3 mmol/L hydrochloric acid. Any drug was not administered to the control group.

When the start day of administration was defined as day 1, the major axis and minor axis of tumor developed in each mouse were then measured at day 3, day 6, day 9, and day 14 by using Digimatic Caliper (Mitutoyo Corp.).

The tumor volume and the relative tumor volume (RTV) were calculated according to the following expressions.

Tumor volume (mm^3) = Tumor major axis (mm) × Tumor minor axis^2 (mm^2) / 2

Relative tumor volume (RTV) = Tumor volume at the measurement day / Tumor volume at the start day of administration

[0035] The results about RTV are shown in Table 2 and Figure 4. Numbers in Table 2 denote mean ± standard deviation (SD) of RTV. As a result, combined use of E7386 and lenvatinib mesylate exhibited an excellent antitumor effect in the mouse breast cancer 4T1 orthotopic transplantation models. * and ** in Figure 4 show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (*: $p < 0.05$, **: $p < 0.01$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[0036] [Table 2]

Group	Day 3	Day 6	Day 9	Day 14
Control group	1.71±0.25	2.30±0.41	3.42±1.48	5.14±2.53
Lenvatinib mesylate 10 mg/kg group	1.36±0.28	1.46±0.28	1.75±0.41	1.99±0.26
E7386 25 mg/kg group	1.59±0.38	1.75±0.42	2.17±0.76	2.32±0.68
E7386 25 mg/kg + lenvatinib mesylate 10 mg/kg group	1.06±0.15	0.81±0.13	0.83±0.13	0.99±0.21

[0037] [Example 3] Antitumor effect of combined use of E7386 and lenvatinib mesylate in human breast cancer MDA-MB-231 transplantation model

Human breast cancer MDA-MB-231 cells (ATCC) were cultured by using RPMI1640 medium (Sigma-Aldrich Co. LLC) containing 10% FBS in a 5% CO_2 incubator under conditions of 37°C. When the cells became an approximately 80% confluent state, the cells were recovered by using trypsin-EDTA. A suspension was prepared by adding Hank's balanced salt solution containing 50% Matrigel to the cells so as to be 10.0×10^7 cells/mL. 0.1 mL of the obtained cell suspension was subcutaneously transplanted to the sides of the bodies of five nude mice (CAnN.Cg-Foxn1^{nu}/CrlCrlj, Charles River Laboratories Japan, Inc.) each of a control group, an E7386 25 mg/kg alone administration group, a lenvatinib mesylate 10 mg/kg alone administration group, and a combined administration group of 25 mg/kg E7386 and 10 mg/kg lenvatinib mesylate. From 6 days after the transplantation, E7386 (25 mg/kg, b.d.s., 10 days, oral administration) and lenvatinib mesylate (10 mg/kg, q.d., 10 days, oral administration) were administered alone or in combination to the alone administration group or the combined administration group. For the administration, E7386 was dissolved in 0.1 mol/L hydrochloric acid, and lenvatinib

mesylate was dissolved in 3 mmol/L hydrochloric acid. Any drug was not administered to the control group.

When the start day of administration was defined as day 1, the major axis and minor axis of tumor developed in each mouse were then measured at day 4, day 7, and day 10 by using Digimatic Caliper (Mitutoyo Corp.).

The tumor volume and the relative tumor volume (RTV) were calculated according to the following expressions.

Tumor volume (mm^3) = Tumor major axis (mm) × Tumor minor $axis^2$ (mm^2) / 2

Relative tumor volume (RTV) = Tumor volume at the measurement day / Tumor volume at the start day of administration

[0038] The results about RTV are shown in Table 3 and Figure 5. Numbers in Table 3 denote mean ± standard deviation (SD) of RTV. As a result, combined use of E7386 and lenvatinib mesylate exhibited an excellent antitumor effect in the human breast cancer MDA-MB-231 transplantation models. * and *** in Figure 5 show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (*: $p < 0.05$, ***: $p < 0.001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[0039] [Table 3]

Group	Day 4	Day 7	Day 10
Control group	2.70±0.26	3.87±0.53	5.19±0.57
E7386 25 mg/kg group	2.34±0.11	3.19±0.38	4.49±0.51
Lenvatinib mesylate 10 mg/kg group	2.01±0.60	2.41±0.60	2.67±1.23
E7386 25 mg/kg + lenvatinib mesylate 10 mg/kg group	1.07±0.22	1.04±0.37	0.97±0.29

[0040] [Example 4] Antitumor effect of combined use of E7386 and lenvatinib mesylate in human melanoma cell line SEKI transplantation model

A human melanoma cell line SEKI (JCRB Cell Bank) was cultured by using RPMI1640 medium (Sigma-Aldrich Co. LLC) containing 10% FBS in a 5% CO_2 incubator under conditions of 37°C. When the cells became an approximately 80% confluent state, the cells were recovered by using trypsin-EDTA. A suspension was prepared by adding Hank's balanced salt solution containing 50% Matrigel to the cells so as to be 5.0×10^7 cells/mL. 0.1 mL of the obtained cell suspension was subcutaneously transplanted to the sides of the bodies of six nude mice (CAnN.Cg-Foxn1^{nu}/CrlCrlj, Charles River Laboratories

Japan, Inc.) each of a control group, an E7386 12.5 or 25 mg/kg alone administration group, a lenvatinib mesylate 10 mg/kg alone administration group, and a combined administration group of 12.5 or 25 mg/kg E7386 and 10 mg/kg lenvatinib mesylate. From 13 days after the transplantation, E7386 (12.5 or 25 mg/kg, b.d.s., 14 days, oral administration) and lenvatinib mesylate (10 mg/kg, q.d., 14 days, oral administration) were administered alone or in combination to the alone administration group or the combined administration group. For the administration, E7386 was dissolved in 0.1 mol/L hydrochloric acid, and lenvatinib mesylate was dissolved in 3 mmol/L hydrochloric acid. 0.1 mol/L hydrochloric acid (b.d.s., 14 days) was administered to the control group.

When the start day of administration was defined as day 1, the major axis and minor axis of tumor developed in each mouse were then measured at day 4, day 8, day 11, and day 15 by using Digimatic Caliper (Mitutoyo Corp.).

The tumor volume and the relative tumor volume (RTV) were calculated according to the following expressions.

Tumor volume (mm^3) = Tumor major axis (mm) × Tumor minor $axis^2$ (mm^2) / 2

Relative tumor volume (RTV) = Tumor volume at the measurement day / Tumor volume at the start day of administration

[0041] The results about RTV are shown in Table 4 and Figures 6 and 7. Numbers in Table 4 denote mean ± standard deviation (SD) of RTV. As a result, combined use of E7386 and lenvatinib mesylate exhibited an excellent antitumor effect in the human melanoma cell line SEKI transplantation models. *, ** and *** in Figures 6 and 7 show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[0042] [Table 4]

Group	Day 4	Day 8	Day 11	Day 15
Control group	1.87±0.12	3.32±0.31	4.96±0.71	7.10±1.02
E7386 12.5 mg/kg group	1.65±0.22	3.02±0.31	4.19±0.80	5.53±1.21
E7386 25 mg/kg group	1.56±0.21	2.94±0.22	4.35±0.36	5.90±1.34
Lenvatinib mesylate 10 mg/kg group	1.60±0.22	2.66±0.46	3.81±0.80	4.67±1.19
E7386 12.5 mg/kg + lenvatinib mesylate 10 mg/kg group	1.15±0.10	1.64±0.29	2.27±0.47	2.51±0.57
E7386 25 mg/kg + lenvatinib mesylate 10 mg/kg group	1.21±0.17	1.84±0.30	2.68±0.52	3.31±0.40

[0043] [Example 5] Antitumor effect of combined use of E7386 and lenvatinib mesylate in human anaplastic thyroid cancer cell line HTC/C3 transplantation model

A human anaplastic thyroid cancer cell line HTC/C3 (JCBR Cell Bank) was cultured by using D-MEM High Glucose medium (Wako Pure Chemical Industries, Ltd.) containing 10% FBS in a 5% CO_2 incubator under conditions of 37°C. When the cells became an approximately 80% confluent state, the cells were recovered by using trypsin-EDTA. A suspension was prepared by adding Hank's balanced salt solution containing 50% Matrigel to the cells so as to be 1.0×10^7 cells/mL. 0.1 mL of the obtained cell suspension was subcutaneously transplanted to the sides of the bodies of five nude mice (CAnN.Cg-Foxn1^{nu}/CrlCrlj, Charles River Laboratories Japan, Inc.) each of a control group, an E7386 12.5, 25 or 50 mg/kg alone administration group, a lenvatinib mesylate 10 mg/kg alone administration group, and a combined administration group of 12.5, 25 or 50 mg/kg E7386 and 10 mg/kg lenvatinib mesylate. From 11 days after the transplantation, E7386 (12.5, 25, or 50 mg/kg, b.d.s., 14 days, oral administration) and lenvatinib mesylate (10 mg/kg, q.d., 14 days, oral administration) were administered alone or in combination to the alone administration group or the combined administration group. For the administration, E7386 was dissolved in 0.1 mol/L hydrochloric acid, and lenvatinib mesylate was dissolved in 3 mmol/L hydrochloric acid. 0.1 mol/L hydrochloric acid (b.d.s., 14 days) was administered to the control group.

When the start day of administration was defined as day 1, the major axis and minor axis of tumor developed in each mouse were then measured at day 4, day 8, day 11, and day 15 by using Digimatic Caliper (Mitutoyo Corp.).

The tumor volume and the relative tumor volume (RTV) were calculated according to the following expressions.

Tumor volume (mm^3) = Tumor major axis (mm) × Tumor minor axis^2 (mm^2) / 2

Relative tumor volume (RTV) = Tumor volume at the measurement day / Tumor volume at the start day of administration

[0044] The results about RTV are shown in Table 5 and Figures 8, 9 and 10. Numbers in Table 5 denote mean ± standard deviation (SD) of RTV. As a result, combined use of E7386 and lenvatinib mesylate exhibited an excellent antitumor effect in the human anaplastic thyroid cancer cell line HTC/C3 transplantation models. **, *** and **** in Figures 8, 9 and 10 show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (**: $p < 0.01$, ***: $p < 0.001$, ****: $p < 0.0001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[0045] [Table 5]

Group	Day 4	Day 8	Day 11	Day 15
Control group	1.70±0.12	4.23±0.86	6.44±1.12	8.78±2.76
E7386 12.5 mg/kg group	1.68±0.13	4.02±0.40	6.27±0.93	8.58±2.48
E7386 25 mg/kg group	1.72±0.10	3.99±0.62	6.44±1.09	8.81±2.14
E7386 50 mg/kg group	1.74±0.09	4.00±0.66	5.85±1.42	7.83±2.28
Lenvatinib mesylate 10 mg/kg group	1.71±0.10	3.57±0.54	5.15±1.07	6.23±1.71
E7386 12.5 mg/kg + lenvatinib mesylate 10 mg/kg group	1.48±0.17	2.21±0.35	2.58±0.57	2.83±0.70
E7386 25 mg/kg + lenvatinib mesylate 10 mg/kg group	1.40±0.08	1.87±0.29	2.08±0.35	2.04±0.36
E7386 50 mg/kg + lenvatinib mesylate 10 mg/kg group	1.48±0.14	2.23±0.35	2.23±0.50	2.27±0.45

[0046] [Example 6] Antitumor effect of combined use of E7386 and lenvatinib mesylate in human hepatocellular carcinoma SNU398 transplantation model

Human hepatocellular carcinoma SNU398 (ATCC) is cultured by using RPMI1640 medium (Sigma-Aldrich Co. LLC) containing 10% FBS in a 5% CO_2 incubator under conditions of 37°C. When the cells become an approximately 80% confluent state, the cells are recovered by using trypsin-EDTA. A suspension is prepared by adding Hank's balanced salt solution containing 50% Matrigel to the cells so as to be 5.0×10^7 cells/mL. 0.1 mL of the obtained cell suspension is subcutaneously transplanted to the sides of the bodies of nude mice (CAnN.Cg-Foxn1^{nu}/CrlCrlj, Charles River Laboratories Japan, Inc.) each of a control group, an E7386 alone administration group, a lenvatinib mesylate alone administration group, and a combined administration group E7386 and lenvatinib mesylate.

After tumorigenesis, E7386 (oral administration) and lenvatinib mesylate (oral administration) are administered alone or in combination to the alone administration group or the combined administration group.

From the start day of administration, the major axis and minor axis of tumor developed in each mouse are measured on a regular basis by using Digimatic Caliper (Mitutoyo Corp.), and the tumor volume and the relative tumor volume (RTV) are calculated. From the results about RTV, the antitumor effect of combined use of E7386 and lenvatinib mesylate can be evaluated.

The tumor volume and the relative tumor volume (RTV) are calculated according to the following expressions.

Tumor volume (mm^3) = Tumor major axis (mm) × Tumor minor axis^2 (mm^2) / 2

Relative tumor volume (RTV) = Tumor volume at the measurement day / Tumor volume at the start day of administration

[0047] [Example 6-1] Antitumor effect of combined use of E7386 and lenvatinib mesylate in human hepatocellular carcinoma line SNU398 transplantation model

Human hepatocellular carcinoma line SNU398 cells (ATCC) were cultured by using RPMI1640 medium (Wako Pure Chemical Industries, Ltd.) containing 10% FBS in a 5% CO_2 incubator under conditions of 37°C. When the cells became an approximately 80% confluent state, the cells were recovered by using trypsin-EDTA. A suspension was prepared by adding Hank's balanced salt solution containing 50% Matrigel to the cells so as to be 5.0×10^7 cells/mL. 0.1 mL of the obtained cell suspension was subcutaneously transplanted to the sides of the bodies of eight nude mice (CAnN.Cg-Foxn1^{nu}/CrlCrlj, Charles River Laboratories Japan, Inc.) each of a control group, an E7386 50 mg/kg alone administration group, a lenvatinib mesylate 10 mg/kg alone administration group, and a combined administration group of 12.5, 25 or 50 mg/kg E7386 and 10 mg/kg lenvatinib mesylate. From 9 days after the transplantation, E7386 (12.5, 25, or 50 mg/kg, b.d.s., 14 days, oral administration) and lenvatinib mesylate (10 mg/kg, q.d., 14 days, oral administration) were administered alone or in combination to the alone administration group or the combined administration group. For the administration, E7386 was dissolved in 0.1 mol/L hydrochloric acid, and lenvatinib mesylate was dissolved in 3 mmol/L hydrochloric acid. Any drug was not administered to the control group.

When the start day of administration was defined as day 1, the major axis and minor axis of tumor developed in each mouse were then measured at day 6, day 9, day 12,

and day 15 by using Digimatic Caliper (Mitutoyo Corp.).

The tumor volume and the relative tumor volume (RTV) were calculated according to the following expressions.

Tumor volume (mm^3) = Tumor major axis (mm) × Tumor minor $axis^2$ (mm^2) / 2

Relative tumor volume (RTV) = Tumor volume at the measurement day / Tumor volume at the start day of administration

[0048] The results about RTV are shown in Table 6 and Figures 11, 12 and 13. Numbers in Table 6 denote mean ± standard deviation (SD) of RTV. As a result, combined use of E7386 and lenvatinib mesylate exhibited an excellent antitumor effect in the human hepatocellular carcinoma line SNU398 transplantation models. *, ** and **** in Figures 11, 12 and 13 show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (*: $p < 0.05$, **: $p < 0.01$, ****: $p < 0.0001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[0049] [Table 6]

Group	Day 6	Day 9	Day 12	Day 15
Control group	6.22±1.70	11.0±3.95	12.3±4.31	14.2±3.91
E7386 50 mg/kg group	3.74±0.75	6.31±1.74	7.33±0.89	10.1±1.03
Lenvatinib mesylate 10 mg/kg group	3.98±1.00	6.48±1.74	8.33±2.08	9.71±2.30
E7386 12.5 mg/kg group + lenvatinib mesylate 10 mg/kg group	2.98±0.59	4.07±1.16	6.12±2.34	7.41±2.39
E7386 25 mg/kg group + lenvatinib mesylate 10 mg/kg group	2.48±0.50	3.97±0.53	4.64±0.76	7.35±0.98
E7386 50 mg/kg group + lenvatinib mesylate 10 mg/kg group	2.06±0.29	2.97±0.61	3.85±0.43	5.50±1.33

[0050] [Example 7] Antitumor effect of combined use of E7386 and lenvatinib mesylate in human hepatocellular carcinoma line HepG2 subcutaneous transplantation model

Human hepatocellular carcinoma line HepG2 cells (JCRB Cell Bank) were cultured by using DMEM-Low glucose medium (Wako Pure Chemical Industries, Ltd.) containing 10% FBS in a 5% CO_2 incubator under conditions of 37°C. When the cells became an approximately 80% confluent state, the cells were recovered by using trypsin-EDTA. A suspension was prepared by adding phosphate-buffered saline containing 50% Matrigel to the cells so as to be 10.0×10^7 cells/mL. 0.1 mL of the obtained cell suspension was subcutaneously transplanted to the sides of the bodies of five nude mice

(CAnN.Cg-Foxn1^{nu}/CrlCrlj, Charles River Laboratories Japan, Inc.) each of a control group, an E7386 50 mg/kg alone administration group, a lenvatinib mesylate 10 mg/kg alone administration group, and a combined administration group of 50 mg/kg E7386 and 10 mg/kg lenvatinib mesylate. From 12 days after the transplantation, E7386 (50 mg/kg, b.d.s., 14 days, oral administration) and lenvatinib mesylate (10 mg/kg, q.d., 14 days, oral administration) were administered alone or in combination to the alone administration group or the combined administration group. For the administration, E7386 was dissolved in 0.1 mol/L hydrochloric acid, and lenvatinib mesylate was dissolved in 3 mmol/L hydrochloric acid. Any drug was not administered to the control group.

When the start day of administration was defined as day 1, the major axis and minor axis of tumor developed in each mouse were then measured at day 4, day 7, day 9, day 13, and day 15 by using Digimatic Caliper (Mitutoyo Corp.).

The tumor volume and the relative tumor volume (RTV) were calculated according to the following expressions.

Tumor volume (mm^3) = Tumor major axis (mm) × Tumor minor axis^2 (mm^2) / 2

Relative tumor volume (RTV) = Tumor volume at the measurement day / Tumor volume at the start day of administration

[0051] The results about RTV are shown in Table 7 and Figure 14. Numbers in Table 7 denote mean ± standard deviation (SD) of RTV. As a result, combined use of E7386 and lenvatinib mesylate exhibited an excellent antitumor effect in the human hepatocellular carcinoma line HepG2 transplantation models. ** and **** in Figure 14 show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (**: $p < 0.01$, ****: $p < 0.0001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[0052] [Table 7]

Group	Day 4	Day 7	Day 9	Day 13	Day 15
Control group	1.45±0.12	2.82±0.46	4.31±1.03	5.38±1.32	6.58±1.93
E7386 50 mg/kg group	1.45±0.23	3.05±0.57	3.96±0.53	5.60±1.02	6.23±1.39
Lenvatinib mesylate 10 mg/kg group	1.10±0.08	1.60±0.94	2.07±0.88	2.70±1.47	3.43±1.46
E7386 50 mg/kg group + lenvatinib mesylate 10 mg/kg group	0.74±0.18	0.81±0.41	0.91±0.47	1.44±0.56	1.97±0.98

[0053] [Example 8] Antitumor effect of combined use of E7386 and lenvatinib mesylate

in human colorectal cancer line Colo-205 transplantation model

Human colorectal cancer line Colo-205 cells (ATCC) were cultured by using RPMI1640 medium (Wako Pure Chemical Industries, Ltd.) containing 10% FBS in a 5% CO_2 incubator under conditions of 37°C. When the cells became an approximately 80% confluent state, the cells were recovered by using trypsin-EDTA. A suspension was prepared by adding Hank's balanced salt solution to the cells so as to be 5.0×10^7 cells/mL. 0.1 mL of the obtained cell suspension was subcutaneously transplanted to the sides of the bodies of five nude mice (CAnN.Cg-Foxn1^{nu}/CrlCrlj, Charles River Laboratories Japan, Inc.) each of a control group, an E7386 50 mg/kg alone administration group, a lenvatinib mesylate 10 mg/kg alone administration group, and a combined administration group of 50 mg/kg E7386 and 10 mg/kg lenvatinib mesylate. From 8 days after the transplantation, E7386 (50 mg/kg, q.d., 11 days, oral administration) and lenvatinib mesylate (10 mg/kg, q.d., 11 days, oral administration) were administered alone or in combination to the alone administration group or the combined administration group. For the administration, E7386 was dissolved in 0.1 mol/L hydrochloric acid, and lenvatinib mesylate was dissolved in 3 mmol/L hydrochloric acid. Any drug was not administered to the control group.

When the start day of administration was defined as day 1, the major axis and minor axis of tumor developed in each mouse were then measured at day 4, day 8, and day 12 by using Digimatic Caliper (Mitutoyo Corp.).

The tumor volume and the relative tumor volume (RTV) were calculated according to the following expressions.

Tumor volume (mm^3) = Tumor major axis (mm) × Tumor minor axis^2 (mm^2) / 2

Relative tumor volume (RTV) = Tumor volume at the measurement day / Tumor volume at the start day of administration

[0054] The results about RTV are shown in Table 8 and Figure 15. Numbers in Table 8 denote mean ± standard deviation (SD) of RTV. As a result, combined use of E7386 and lenvatinib mesylate exhibited an excellent antitumor effect in the human colorectal cancer line Colo-205 transplantation models. ** and **** in Figure 15 show that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (**: $p < 0.01$, ****: $p < 0.0001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[0055] [Table 8]

Group	Day 4	Day 8	Day 12
Control group	1.87±0.35	3.82±0.89	4.83±1.16
E7386 50 mg/kg group	1.98±0.24	3.87±0.74	4.94±1.41
Lenvatinib mesylate 10 mg/kg group	1.41±0.30	1.75±0.13	1.94±0.31
E7386 50 mg/kg group + lenvatinib mesylate 10 mg/kg group	0.80±0.18	0.71±0.20	0.77±0.10

[0056] [Example 9] Antitumor effect of combined use of E7386 and lenvatinib mesylate in human renal cell carcinoma line A-498 subcutaneous transplantation model

Human renal cell carcinoma line A-498 cells (ATCC) were cultured by using RPMI1640 medium (Wako Pure Chemical Industries, Ltd.) containing 10% FBS in a 5% CO_2 incubator under conditions of 37°C. When the cells became an approximately 100% confluent state, the cells were recovered by using trypsin-EDTA. A suspension was prepared by adding RPMI1640 medium containing 50% Matrigel to the cells so as to be 5.0 $\times 10^7$ cells/mL. 0.1 mL of the obtained cell suspension was subcutaneously transplanted to the sides of the bodies of six nude mice (CAnN.Cg-Foxn1^{nu}/CrlCrlj, Charles River Laboratories Japan, Inc.) each of a control group, an E7386 50 mg/kg alone administration group, a lenvatinib mesylate 10 mg/kg alone administration group, and a combined administration group of 50 mg/kg E7386 and 10 mg/kg lenvatinib mesylate. From 27 days after the transplantation, E7386 (50 mg/kg, q.d., 14 days, oral administration) and lenvatinib mesylate (10 mg/kg, q.d., 14 days, oral administration) were administered alone or in combination to the alone administration group or the combined administration group. For the administration, E7386 was dissolved in 0.1 mol/L hydrochloric acid, and lenvatinib mesylate was dissolved in 3 mmol/L hydrochloric acid. Any drug was not administered to the control group.

When the start day of administration was defined as day 1, the major axis and minor axis of tumor developed in each mouse were then measured at day 5, day 8, day 12, and day 15 by using Digimatic Caliper (Mitutoyo Corp.).

The tumor volume and the relative tumor volume (RTV) were calculated according to the following expressions.

Tumor volume (mm^3) = Tumor major axis (mm) × Tumor minor axis^2 (mm^2) / 2

Relative tumor volume (RTV) = Tumor volume at the measurement day / Tumor volume at the start day of administration

[0057] The results about RTV are shown in Table 9 and Figure 16. Numbers in Table 9

denote mean ± standard deviation (SD) of RTV. As a result, combined use of E7386 and lenvatinib mesylate exhibited an excellent antitumor effect in the human renal cell carcinoma line A-498 subcutaneous transplantation models. **** in Figure 16 shows that the combined use of E7386 and lenvatinib mesylate statistically significantly inhibited tumor growth as compared with the case where each of them was administered alone (****: $p < 0.0001$; repeated measures ANOVA followed by Dunnett's type multiple comparison).

[0058] [Table 9]

Group	Day 5	Day 8	Day 12	Day 15
Control group	1.41±0.14	1.69±0.13	2.11±0.09	2.51±0.16
E7386 50 mg/kg group	1.33±0.24	1.70±0.26	2.04±0.29	2.29±0.33
Lenvatinib mesylate 10 mg/kg group	1.08±0.18	1.35±0.25	1.21±0.18	1.20±0.21
E7386 50 mg/kg group + lenvatinib mesylate 10 mg/kg group	0.69±0.08	0.57±0.06	0.45±0.07	0.29±0.05

[0059] [Example 10] Antitumor effect of combined use of E7386 and lenvatinib mesylate in human head and neck cancer SCC15 transplantation model

Human head and neck cancer SCC15 cells (ATCC) are cultured by using RPMI1640 medium (Sigma-Aldrich Co. LLC) containing 10% FBS in a 5% CO_2 incubator under conditions of 37°C. When the cells become an approximately 80% confluent state, the cells are recovered by using trypsin-EDTA. A suspension is prepared by adding Hank's balanced salt solution containing 50% Matrigel to the cells so as to be 5.0×10^7 cells/mL. 0.1 mL of the obtained cell suspension is subcutaneously transplanted to the sides of the bodies of nude mice (CAnN.Cg-Foxn1^{nu}/CrlCrlj, Charles River Laboratories Japan, Inc.) each of a control group, an E7386 alone administration group, a lenvatinib mesylate alone administration group, and a combined administration group of E7386 and lenvatinib mesylate. After tumorigenesis, E7386 (oral administration) and lenvatinib mesylate (oral administration) are administered alone or in combination to the alone administration group or the combined administration group.

From the start day of administration, the major axis and minor axis of tumor developed in each mouse are measured on a regular basis by using Digimatic Caliper (Mitutoyo Corp.), and the tumor volume and the relative tumor volume (RTV) are calculated. From the results about RTV, the antitumor effect of combined use of E7386 and lenvatinib mesylate can be evaluated.

The tumor volume and the relative tumor volume (RTV) are calculated according

to the following expressions.

Tumor volume (mm^3) = Tumor major axis (mm) × Tumor minor $axis^2$ (mm^2) / 2

Relative tumor volume (RTV) = Tumor volume at the measurement day / Tumor volume at the start day of administration

[0060] [Example 11] Antitumor effect of combined use of E7386 and lenvatinib mesylate in human endometrial cancer HEC-151 transplantation model

Human endometrial cancer HEC-151 cells (JCRB Cell Bank) are cultured by using RPMI1640 medium (Sigma-Aldrich Co. LLC) containing 10% FBS in a 5% CO_2 incubator under conditions of 37°C. When the cells become an approximately 80% confluent state, the cells are recovered by using trypsin-EDTA. A suspension is prepared by adding Hank's balanced salt solution containing 50% Matrigel to the cells so as to be 5.0×10^7 cells/mL. 0.1 mL of the obtained cell suspension is subcutaneously transplanted to the sides of the bodies of nude mice (CAnN.Cg-Foxn1^{nu}/CrlCrlj, Charles River Laboratories Japan, Inc.) each of a control group, an E7386 alone administration group, a lenvatinib mesylate alone administration group, and a combined administration group of E7386 and lenvatinib mesylate. After tumorigenesis, E7386 (oral administration) and lenvatinib mesylate (oral administration) are administered alone or in combination to the alone administration group or the combined administration group.

From the start day of administration, the major axis and minor axis of tumor developed in each mouse are measured on a regular basis by using Digimatic Caliper (Mitutoyo Corp.), and the tumor volume and the relative tumor volume (RTV) are calculated. From the results about RTV, the antitumor effect of combined use of E7386 and lenvatinib mesylate can be evaluated.

The tumor volume and the relative tumor volume (RTV) are calculated according to the following expressions.

Tumor volume (mm^3) = Tumor major axis (mm) × Tumor minor $axis^2$ (mm^2) / 2

Relative tumor volume (RTV) = Tumor volume at the measurement day / Tumor volume at the start day of administration

[0061] [Example 12] Tumor vessel suppressive effect of combined use of E7386 and lenvatinib mesylate in mouse breast cancer 4T1 orthotopic transplantation model

Mouse breast cancer 4T1 cells (ATCC) were cultured by using RPMI1640 medium (Sigma-Aldrich Co. LLC) containing 10% FBS in a 5% CO_2 incubator under conditions of 37°C. When the cells became an approximately 80% confluent state, the cells

were recovered by using trypsin-EDTA. A suspension was prepared by adding Hank's balanced salt solution so as to be 1.0×10^7 cells/mL. 0.1 mL of the obtained cell suspension was transplanted to the right third mammary gland fat pads of five mice (C57BL/6J, Charles River Laboratories Japan, Inc.) each of a control group, an E7386 25 mg/kg alone administration group, a lenvatinib mesylate 10 mg/kg alone administration group, and a combined administration group of 25 mg/kg E7386 and 10 mg/kg lenvatinib mesylate. From 9 days after the transplantation, E7386 (25 mg/kg, b.d.s., 14 days, oral administration) and lenvatinib mesylate (10 mg/kg, q.d., 14 days, oral administration) were administered alone or in combination to the alone administration group or the combined administration group. For the administration, E7386 was dissolved in 0.1 mol/L hydrochloric acid, and lenvatinib mesylate was dissolved in 3 mmol/L hydrochloric acid. Any drug was not administered to the control group.

After the administration for 14 days, tumor tissues were collected from the mice, the formalin fixation of the tumor tissues was performed, and the tumor tissues were embedded in paraffin. Then, the paraffin-embedded tumor tissues were sliced at a thickness of 4 μm and placed on slide glass, and deparaffinization treatment was performed with xylene/ethanol. Immunostaining was performed by using an antibody (manufactured by Sigma-Aldrich Co. LLC) against α-smooth muscle actin (α-SMA), which is a marker for vascular pericytes, and an antibody (manufactured by Dianova GmbH) against CD31, which is a marker for vascular endothelial cells.

[0062] The preparations of CD31/α-SMA co-staining were converted to digital images in a slide scanner (Aperio, Leica Biosystems Nussloch GmbH), and microvessel density (MVD) was measured and analyzed as the amount of CD31-positive blood vessels per unit area (1 mm^2) in the whole tumor by using image analysis software (Aperio ImageScope ver 12.3.0.5056, Leica Biosystems Nussloch GmbH).

A 10× magnified immunostaining image (in a color photograph, indicated by brown (CD31) and red (α-SMA)) in which CD31/α-SMA co-staining was performed is shown in Figure 17. Figures 17(a), 17(b), 17(c) and 17(d) are the immunostaining images of the control group, the E7386 alone administration group, the lenvatinib mesylate alone administration group, and the combined administration group of E7386 and lenvatinib mesylate, respectively. As a result, for combined use of E7386 and lenvatinib mesylate, marked decrease in MVD was observed, as compared with the control group and the case where each of them was administered alone.

[0063] On a 200× magnified image, five regions of 0.2 mm × 0.2 mm square with high microvessel density per tumor section were determined as hot spots for vascular property analysis. PCI (pericyte coverage index), which is the amount of CD31/α-SMA both positive blood vessels relative to the amount of CD31-positive blood vessels, in the hot spots for analysis was measured and analyzed by using image analysis software (Aperio ImageScope ver 12.3.0.5056, Leica Biosystems Nussloch GmbH). PCI represents the ratio of blood vessels covered with vascular pericytes to all blood vessels. Mean PCI of the five hot spots for analysis was regarded as a typical value of the tumor section.

A 200× magnified immunostaining image (in a color photograph, indicated by brown (CD31) and red (α-SMA)) in which CD31/α-SMA co-staining was performed is shown in Figure 18. Figures 18(a), 18(b), 18(c) and 18(d) are the immunostaining images of the control group, the E7386 alone administration group, the lenvatinib mesylate alone administration group, and the combined administration group of E7386 and lenvatinib mesylate, respectively. A microvessel stained with CD31 is indicated by black arrow. A CD31/α-SMA both positive blood vessel is indicated by open arrow. As a result, for combined use of E7386 and lenvatinib mesylate, marked decrease in PCI was observed, as compared with the control group and the case where each of them was administered alone.

[0064] The results about MVD are shown in Figure 19. The graph shows a mean of five tumor sections of each administration group, and the error bar shows standard deviation. Combined use of E7386 and lenvatinib mesylate exhibited an excellent microvessel suppressive effect in the mouse breast cancer 4T1 orthotopic transplantation models. * and **** in Figure 19 show that the combined use of E7386 and lenvatinib mesylate statistically significantly suppressed microvessels as compared with the case where each of them was administered alone (*: $p < 0.05$, ****: $p < 0.0001$; Dunnett's type multiple comparison).

[0065] The results about PCI are shown in Figure 20. The graph shows a mean of five tumor sections of each administration group, and the error bar shows standard deviation. Combined use of E7386 and lenvatinib mesylate exhibited an excellent pericyte coverage (coverage of blood vessels with vascular pericytes) suppressive effect in the mouse breast cancer 4T1 orthotopic transplantation models. * and **** in Figure 20 show that the combined use of E7386 and lenvatinib mesylate statistically significantly suppressed pericyte coverage as compared with the case where each of them was administered alone (*: $p < 0.05$, ****: $p < 0.0001$; Dunnett's type multiple comparison).

[0066] [Example 13] Tumor vessel suppressive effect of combined use of E7386 and

lenvatinib mesylate in human hepatocellular carcinoma HepG2 subcutaneous transplantation model

0.1 mL of a cell suspension prepared by using human hepatocellular carcinoma line HepG2 cells (JCRB Cell Bank) as described in Example 7 above was subcutaneously transplanted to the sides of the bodies of five nude mice (CAnN.Cg-Foxn1^{nu}/CrlCrlj, Charles River Laboratories Japan, Inc.) each of a control group, an E7386 50 mg/kg alone administration group, a lenvatinib mesylate 10 mg/kg alone administration group, and a combined administration group of 50 mg/kg E7386 and 10 mg/kg lenvatinib mesylate. From 12 days after the transplantation, E7386 (50 mg/kg, q.d., 14 days, oral administration) and lenvatinib mesylate (10 mg/kg, q.d., 14 days, oral administration) were administered alone or in combination to the alone administration group or the combined administration group. For the administration, E7386 was dissolved in 0.1 mol/L hydrochloric acid, and lenvatinib mesylate was dissolved in 3 mmol/L hydrochloric acid. Any drug was not administered to the control group.

After the administration for 14 days, tumor tissues collected from the mice were divided and used as tumor samples for blood vessel analysis. The divided tumor tissues were subjected to formalin fixation and embedded in paraffin. Then, the paraffin-embedded tumor tissues were sliced at a thickness of 4 μm and placed on slide glass, and deparaffinization treatment was performed with xylene/ethanol. Immunostaining was performed by using an antibody (manufactured by Sigma-Aldrich Co. LLC) against α-smooth muscle actin (α-SMA), which is a marker for vascular pericytes, and an antibody (manufactured by Dianova GmbH) against CD31, which is a marker for vascular endothelial cells.

[0067] The preparations of CD31/α-SMA co-staining were converted to digital images in a slide scanner (Aperio, Leica Biosystems Nussloch GmbH), and microvessel density (MVD) was measured and analyzed as the amount of CD31-positive blood vessels per unit area (1 mm^2) in the whole tumor by using image analysis software (HALO v2.0.1145.38). As a result, for combined use of E7386 and lenvatinib mesylate, marked decrease in MVD was observed, as compared with the control group and the case where each of them was administered alone.

[0068] On a 200× magnified image, six regions of 0.5 mm × 0.5 mm square with high microvessel density per tumor section were determined as hot spots for vascular property analysis. PCI (pericyte coverage index), which is the amount of CD31/α-SMA both

positive blood vessels relative to the amount of CD31-positive blood vessels, in the hot spots for analysis was measured and analyzed by using image analysis software (HALO v2.0.1145.38). PCI represents the ratio (%) of blood vessels covered with vascular pericytes to all blood vessels. Mean PCI of the six hot spots for analysis was regarded as a typical value of the tumor section. As a result, PCI was markedly increased by the administration of lenvatinib mesylate alone, whereas the suppression of increase in PCI to a level equivalent to the control group by combined use of E7386 and lenvatinib mesylate was observed.

[0069] The results about MVD are shown in Figure 21. The graph was prepared by measuring a mean of five tumor sections of each administration group, and then calculating a ratio (%) with the value of the control group as a reference value. The error bar shows standard deviation. Combined use of E7386 and lenvatinib mesylate exhibited an excellent microvessel suppressive effect in the human hepatocellular carcinoma HepG2 subcutaneous transplantation models. ** and **** in Figure 21 show that the combined use of E7386 and lenvatinib mesylate statistically significantly suppressed microvessels as compared with the case where each of them was administered alone (**: $p < 0.01$, ****: $p < 0.0001$; Dunnett's type multiple comparison).

[0070] The results about PCI are shown in Figure 22. The graph shows a mean of five tumor sections of each administration group in PCI, and the error bar shows standard deviation. Combined use of E7386 and lenvatinib mesylate exhibited an excellent pericyte coverage (coverage of blood vessels with vascular pericytes) suppressive effect in the human hepatocellular carcinoma HepG2 subcutaneous transplantation models. **** in Figure 22 shows that the administration of lenvatinib mesylate alone statistically significantly increased pericyte coverage as compared with the control group, and the combined use of E7386 and lenvatinib mesylate statistically significantly suppressed pericyte coverage as compared with the case where lenvatinib mesylate was administered alone (****: $p < 0.001$; Dunnett's type multiple comparison).

CLAIMS

1. A pharmaceutical composition for treating a tumor, comprising (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide, wherein (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide is administered in combination with lenvatinib or a pharmaceutically acceptable salt thereof.

2. A pharmaceutical composition for treating a tumor, comprising lenvatinib or a pharmaceutically acceptable salt thereof, wherein lenvatinib or a pharmaceutically acceptable salt thereof is administered in combination with (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide.

3. The pharmaceutical composition according to claim 1 or 2, wherein the lenvatinib or the pharmaceutically acceptable salt thereof is lenvatinib mesylate.

4. The pharmaceutical composition according to any one of claims 1 to 3, further comprising an excipient.

5. The pharmaceutical composition according to any one of claims 1 to 4, wherein the lenvatinib or the pharmaceutically acceptable salt thereof, and the (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide are administered simultaneously, separately, continuously, or at time intervals.

6. The pharmaceutical composition according to any one of claims 1 to 5, wherein the tumor is breast cancer, thyroid cancer, hepatocellular carcinoma, colorectal cancer, renal cell carcinoma, head and neck cancer, endometrial cancer or melanoma.

7. The pharmaceutical composition according to claim 6, wherein the tumor is breast cancer.

8. The pharmaceutical composition according to claim 6, wherein the tumor is thyroid cancer.

9. The pharmaceutical composition according to claim 8, wherein the thyroid cancer

is anaplastic thyroid cancer.

10. The pharmaceutical composition according to claim 6, wherein the tumor is hepatocellular carcinoma.

11. The pharmaceutical composition according to claim 6, wherein the tumor is colorectal cancer.

12. The pharmaceutical composition according to claim 6, wherein the tumor is renal cell carcinoma.

13. The pharmaceutical composition according to claim 6, wherein the tumor is head and neck cancer.

14. The pharmaceutical composition according to claim 6, wherein the tumor is endometrial cancer.

15. The pharmaceutical composition according to claim 6, wherein the tumor is melanoma.

16. A therapeutic agent for a tumor comprising (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide, wherein (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide is administered in combination with lenvatinib or a pharmaceutically acceptable salt thereof.

17. A therapeutic agent for a tumor comprising lenvatinib or a pharmaceutically acceptable salt thereof, wherein lenvatinib or a pharmaceutically acceptable salt thereof is administered in combination with (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide.

18. A method for treating a tumor, comprising administering lenvatinib or a pharmaceutically acceptable salt thereof, and (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide to a patient in need thereof.

19. Use of

(6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide for producing a pharmaceutical composition for treating a tumor, wherein (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide is administered in combination with lenvatinib or a pharmaceutically acceptable salt thereof.

20. Use of lenvatinib or a pharmaceutically acceptable salt thereof for producing a pharmaceutical composition for treating a tumor, wherein lenvatinib or a pharmaceutically acceptable salt thereof is administered in combination with (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide.

21. (6S,9aS)-N-Benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide for use in the treatment of tumor in combination with lenvatinib or a pharmaceutically acceptable salt thereof.

22. Lenvatinib or a pharmaceutically acceptable salt thereof for use in the treatment of tumor in combination with (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide.

23. A pharmaceutical composition for treating a tumor, comprising lenvatinib or a pharmaceutically acceptable salt thereof, and (6S,9aS)-N-benzyl-8-({6-[3-(4-ethylpiperazin-1-yl)azetidin-1-yl]pyridin-2-yl}methyl)-6-(2-fluoro-4-hydroxybenzyl)-4,7-dioxo-2-(prop-2-en-1-yl)hexahydro-2H-pyrazino[2,1-c][1,2,4]triazine-1(6H)-carboxamide.