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(54) **Title:**
METHODS FOR USE OF A SPECIFIC ANTI-ANGIOGENIC ADENOVIRAL AGENT

(57) **Abstract:**
Anti-angiogenic adenovirus vectors, and therapeutic use thereof are provided, and more particularly, but not exclusively, clinical protocols for treatment of solid tumors in patients with an Ad5-PPE-1-3X-fas-chimera adenovirus vector.

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(54) **Title**: METHODS FOR USE OF A SPECIFIC ANTI-ANGIOGENIC ADENOVIRAL AGENT

(57) **Abstract**: Anti-angiogenic adenovirus vectors, and therapeutic use thereof are provided, and more particularly, but not exclusively, clinical protocols for treatment of solid tumors in patients with an Ad5-PPE-1-3X-fas-chimera adenovirus vector.

METHODS FOR USE OF A SPECIFIC ANTI-ANGIOGENIC ADENOVIRAL AGENT

FIELD AND BACKGROUND OF THE INVENTION

The present invention, in some embodiments thereof, relates to anti-angiogenic adenovirus vectors, and therapeutic use thereof, and more particularly, but not exclusively, to clinical protocols for treatment of solid tumors in patients with an Ad5-PPE-1-3X-fas-chimera adenovirus vector.

Angiogenesis is a process of new blood vessel formation by sprouting from pre-existing neighboring vessels. This process is common and major feature of several pathologies. Among these are diseases in which excessive angiogenesis is a part of the pathology and thus is a target of therapy, most significantly, cancer. Angiogenesis occurs in tumors and permits their growth, invasion and metastatic proliferation. In 1971, Folkman proposed that tumor growth and metastases are angiogenesis dependent, and suggested that inhibiting angiogenesis may be a strategy to arrest tumor growth.

There are several molecules involved in angiogenesis, from cell surface molecules to transcription factors to growth factors. Hypoxia is an important environmental factor that leads to neovascularization, inducing release of several pro-angiogenic cytokines, including vascular endothelial growth factors (VEGF) and their receptors, members of the angiopoietin family, basic fibroblast growth factor, and endothelin-1 (ET-1). These factors mediate induction of angiogenesis through control of activation, proliferation and migration of endothelial cells.

Recombinant forms of endogenous inhibitors of angiogenesis have been tested for the treatment of cancer, however the potential pharmacokinetic, biotechnological and economic drawbacks of chronic delivery of these recombinant inhibitors have led scientists to develop other approaches. The development of the anti-VEGF monoclonal antibody bevacizumab has validated anti-angiogenic targeting as a complementary therapeutic modality to chemotherapy. Several small molecule inhibitors, including second-generation multi-targeted tyrosine kinase inhibitors, have also shown promise as antiangiogenic agents for cancer.

The drawbacks of chronic delivery of recombinant inhibitors, antibodies, and small molecules, as well as the limited activity manifested when these drugs are administered as monotherapy have led to the development of anti-angiogenic gene therapies. Gene therapy is an emerging modality for treating inherited and acquired human diseases. However, a number of obstacles have impeded development of successful gene therapy, including duration of expression, induction of the immune response, cytotoxicity of the vectors and tissue specificity.

Two general strategies for anti-cancer gene therapy have proposed: tumor directed or systemic gene therapy. The lack of success in targeting gene therapy products to cancerous cells or their environment by systemic treatments, and the danger of significant anti-drug or anti-vector immunity has caused most therapies to be administered to the tumor itself, despite the advantages of systemic administration. "Adenoviral vaccines", designed to induce immunity to a recombinant antigen or epitope expressed in the patient's body, have been tried but produce mostly disappointing results. Thus, elaborate, potentially dangerous and costly strategies for eluding pathological host immune responses to systemic and repeated administration of therapeutic recombinant adenoviral vectors have been proposed, including immunosuppression, oral tolerization to vector antigens and genetic modification of the vectors (see Bangari et al, Current Gene Therapy 2006;6: 215-226).

United States Patent 5,747,340 teaches use of a murine endothelial cell-specific promoter which shows selectivity towards angiogenic cells, and therapeutic applications thereof.

International Application WO/2008/132729 discloses a non-replicating adenovirus vector (Ad5, E1 deleted), containing a modified murine pre-proendothelin promoter (PPE-1-3X) and a fas-chimera transgene [Fas and human tumor necrosis factor (TNF) receptor] which has been developed, in which the modified murine promoter (PPE-1-3X), is able to restrict expression of the fas chimera transgene to angiogenic blood vessels, leading to targeted apoptosis of these vessels.

Endothelial-specific gene therapy with the PPE-1-3X promoter does not increase the specificity of viral interactions with the host (e.g. transfection) but restricts the expression of the transgene to those tissues that endogenously recognize the modified promoter – angiogenic endothelial cells. The chimeric receptor can trigger the Fas pathway by binding TNFα, which is less toxic in non-tumoral tissues than using the Fas/Fas ligand mechanism, which is highly expressed in non-tumoral normal tissues such as the liver. Further, TNFα was found to be abundant in the microenvironment of tumors adding to the specificity of the transgene activity in the tumor and its surroundings.

Preliminary studies have shown that a single systemic injection of a PPE-1-3X-fas chimera results in transgene expression restricted to the tumor-bearing organ, causing tumor growth retardation, necrosis of the blood vessels in the metastatic tumor mass and reduction in tumor burden in B16 melanoma and Lewis lung carcinoma mice models.

However, an effective procedure for administration of a therapeutic amount of a recombinant anti-angiogenic adenovirus vector in the clinical setting is still lacking. As such, there is a great need for defining the parameters of clinically viable protocols for anti-angiogenic-adenoviral treatment of conditions associated with neovascularization, such as cancer, without the disadvantages of the current methods as described herein.

SUMMARY OF THE INVENTION

According to an aspect of some embodiments of the present invention there is provided a method of treating a solid tumor in a subject in need thereof, the method comprising administering to the subject a therapeutically effective amount of a non-replicating adenovirus vector, the vector comprises a polynucleotide which comprises a fas-chimera transgene transcriptionally linked to a murine pre-proendothelin promoter, wherein the therapeutically effective amount is at least $1X10^8$ virus particles.

According to an aspect of some embodiments of the present invention there is provided a method of treating a solid tumor in a subject in need thereof, the method comprising administering to the subject a therapeutically effective amount of a non-replicating adenovirus vector which comprises a polynucleotide comprising a fas-chimera transgene transcriptionally linked to a murine pre-proendothelin promoter, the adenovirus vector comprising a nucleic acid sequence as set forth in SEQ ID NOs: 9 or 10.

According to an aspect of some embodiments of the present invention there is provided a method of treating a solid tumor in a subject in need thereof, the method comprising administering to the subject, in at least two separate doses, a therapeutically effective amount of a non-replicating adenovirus vector which comprises a polynucleotide comprising a fas-chimera transgene transcriptionally linked to a murine pre-proendothelin promoter, wherein the time between administration of the first dose and the at least a second dose is sufficient for anti-Ad5 antibody formation in the subject.

According to an aspect of some embodiments of the present invention there is provided a method of treating a solid tumor in a subject in need thereof, the method comprising administering to the subject a single intravenous dose of $3X10^{12}$ or $1X10^{13}$ virus particles of a non-replicating adenovirus vector comprising a polynucleotide having a nucleotide sequence as set forth in SEQ ID NOs: 9 or 10.

According to an aspect of some embodiments of the present invention there is provided a method of treating a thyroid cancer in a subject in need thereof, the method comprising administering to the subject a single intravenous dose of $3X10^{12}$ or $1X10^{13}$ virus particles of a non-replicating adenovirus vector comprising a polynucleotide having a nucleotide sequence as set forth in SEQ ID NOs: 9 or 10.

According to an aspect of some embodiments of the present invention there is provided a method of treating a neuroendocrine cancer in a subject in need thereof, the method comprising administering to the subject a single intravenous dose of $3X10^{12}$ or $1X10^{12}$ virus particles of a non-replicating adenovirus vector comprising a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 9 or 10.

According to some embodiments of the present invention administering the dose of adenovirus vector inhibits angiogenesis of the tumor.

According to some embodiments of the present invention administering the dose of adenovirus inhibits growth of the tumor.

According to an aspect of some embodiments of the present invention there is provided a method for administering a therapeutically effective amount of a therapeutic composition comprising an adenoviral vector to a subject in need thereof comprising administering the composition to the subject at least twice, wherein the administration does not induce a dose-dependent increase in antibodies against the adenoviral vector in the subject.

According to an aspect of some embodiments of the present invention there is provided a kit for treating a solid tumor in a subject in need thereof, comprising a unit dosage of virus particles of a non-replicating adenovirus vector comprising a polynucleotide having a nucleotide sequence as set forth in SEQ ID NOs: 9 or 10, wherein the non-replicating adenovirus vector is formulated for intravenous administration, and instructions for administration of the adenovirus.

According to some embodiments of the present invention the unit dosage comprises about $3X10^{12}$ virus particles, at least about $1X10^{8}$ to about $1X10^{16}$ virus particles, at least about $1X10^{11}$ to about $1X10^{13}$ virus particles, optionally at least about $3X10^{12}$ virus particles.

According to some embodiments of the present invention the fas-chimera transgene comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 3.

According to yet other embodiments of the present invention the fas-chimera transgene comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 2.

According to still other embodiments of the present invention the fas-chimera transgene comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 4.

According to some embodiments of the present invention the murine pre-pro endothelin promoter comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 6.

According to some embodiments of the present invention the murine pre-pro endothelin promoter comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 7.

According to yet other embodiments of the present invention the murine pre-pro endothelin promoter comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 8.

According to yet other embodiments of the present invention the murine pre-pro endothelin promoter comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 5.

According to still other embodiments of the present invention the murine prepro-endothelin promoter comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 12.

According to some embodiments of the present invention the murine pre-pro endothelin promoter comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 13.

According to some embodiments of the present invention the non-replicating adenovirus vector is an adenovirus 5 vector.

According to yet other embodiments of the present invention the adenovirus 5 vector comprises a nucleic acid sequence as set forth in SEQ ID NOs: 9 or 10.

According to some embodiments of the present invention the solid tumor is a cancerous tumor.

According to still other embodiments of the present invention the solid tumor is a primary tumor.

According to yet other embodiments of the present invention the solid tumor is a metastatic tumor.

According to some embodiments the solid tumor is a thyroid tumor.

According to some embodiments the solid tumor is a neuroendocrine tumor.

According to some embodiments administering the dose of adenovirus vector inhibits angiogenesis of the tumor.

According to some embodiments administering the dose of the adenovirus vector inhibits growth of the tumor.

According to some embodiments the adenovirus is detected in the blood of the subject at least about 4 days post administration.

According to some embodiments an amount of serum anti-adenovirus antibodies is increased following the administering, and the adenovirus is detected in the blood of the subject at least about 21 days post administration.

According to some embodiments of the present invention the adenovirus vector is administered systemically.

According to still other embodiments of the present invention the vector is administered systemically by a route selected from the group consisting of intra-articular administration, intravenous administration, intraperitoneal administration, subcutaneous administration, infusion, oral administration, rectal administration, nasal administration and inhalation.

According to still other embodiments of the present invention administering the adenovirus vector is in at least two separate systemic doses.

According to some embodiments of the present invention the administering of the adenovirus vector is in a first dose and at least a second additional dose, wherein the first dose is sufficient to induce anti-Ad5 antibodies in the subject, and wherein the time between administration of the first dose and the at least a second dose is sufficient for anti-Ad5 antibody formation in the subject

According to some embodiments of the present invention the subject is further receiving a chemotherapeutic agent as well as treatment with the virus particles of said non-replicating adenovirus vector.

According to some embodiments of the present invention the chemotherapeutic agent is administered prior to, concomitantly with, or following treatment with said virus particles.

According to some embodiments of the present invention the chemotherapeutic agent is sunitinib.

Unless otherwise defined, all technical and/or scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the invention pertains. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of embodiments of the invention, exemplary methods and/or materials are described below. In case of conflict, the patent specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and are not intended to be necessarily limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

Some embodiments of the invention are herein described, by way of example only, with reference to the accompanying drawings and images. With specific reference now to the drawings and images in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of embodiments of the invention. In this regard, the description taken with the drawings makes apparent to those skilled in the art how embodiments of the invention may be practiced.

In the drawings:

FIG. 1A-1D is a graph with photos illustrating inhibition of metastatic disease by systemic administration of Ad5-PPE-1-3X fas-chimera adenovirus vector in the Lewis Lung Cancer model. FIGs. 1A-1C are photos of exemplary lungs from control (saline) and Ad5-PPE-1-3X fas-chimera adenovirus vector treated mice. Note the strong, dose dependent inhibition of metastatic development by the Ad5-PPE-1-3X fas-chimera adenovirus vector, as reflected in both the gross morphology and weight of the excised lungs (FIG. 1C);

FIG. 2 is a histogram showing the pre-treatment titer of pre-treatment neutralizing anti-Ad5 antibodies in the serum of patients in cohort 6 ($3X10^{12}$ vp), as a function of their disease progression at day 28 post administration of Ad5-PPE-1-3X fas-chimera adenovirus vector. Note the lack of correlation between progressive disease (blue), stable disease (red) and antibody titer (Y-axis);

FIGs. 3A and 3B are histograms showing the pre-treatment titer of neutralizing anti-Ad5 antibodies in the serum of patients, as a function of their disease progression at day 56 post administration of Ad5-PPE-1-3X fas-chimera adenovirus vector. Figure 3A represents values for cohort 6. Figure 3B represents the values for cohorts 6 and 7. Note the lack of correlation between progressive disease (blue), stable disease (red) and the baseline titer of neutralizing antibodies;

FIG. 4 is a baseline (pre-dose) cervical CT scan of a subject with advanced papillary thyroid cancer who received a single dose ($3X10^{12}$ virus particles) of Ad5-PPE-1-3X fas-chimera adenovirus vector, demonstrating a paratracheal metastasis causing partial obstruction of the trachea (red arrows);

FIG. 5 is a follow-up cervical CT of the same subject as described in FIG. 4, 6 months post-administration of Ad5-PPE-1-3X fas-chimera adenovirus vector, demonstrating regression of the metastatic lesion (red arrows) with central liquefaction (blue arrow);

FIGs. 6A-6C are abdominal CT scans illustrating regression of a metastatic lesion following administration of a single dose of Ad5-PPE-1-3X fas-chimera adenovirus vector ($3X10^{12}$ virus particles) in a subject with advanced neuroendocrine cancer. FIG. 6A is an abdominal CT scan showing the metastatic lesion (circled) in the liver at 21 days post-administration. FIG. 6B is an abdominal CT scan showing significant regression of the lesion (circled) in the liver at 50 days post-administration. FIG. 6C is an abdominal CT scan showing even greater regression of the lesion (circled) in the liver at 112 days post-administration;

FIGs. 7A-7C are abdominal CT scans illustrating regression of a metastatic lesion following administration of a single dose of Ad5-PPE-1-3X fas-chimera adenovirus vector ($3X10^{12}$ virus particles) as described in FIGs. 6A-6C. FIGs. 7A-7C are CT scans from the same series, same subject as in FIGs. 6A-6C, showing the same lesion from a different orientation (CT slice at a different level);

FIG. 8 is a graph illustrating the disease response of individual patients in cohorts 1-5, measured at days 0, 28 and 56, and expressed as percent change in RECIST scores, relative to those observed on day 0. Greater increase in RECIST scores is typically indicative of progressive disease (solid line = stable disease, dotted line = progressive disease);

FIG. 9 is a graph illustrating the disease response of individual patients in cohorts 6 and 7, measured at days 0, 28 and 56, and expressed as percent change in RECIST scores, relative to those observed on day 0. Greater increase in RECIST scores is typically indicative of progressive disease (solid line = stable disease, dotted line = progressive disease). Note the trend to lesser change in RECIST scores among cohorts 6 and 7;

FIGs. 10A and 10B is a timeline showing the effects of administration of a single dose of Ad5-PPE-1-3X fas-chimera adenovirus vector ($3X10^{12}$ virus particles) on disease progression in two thyroid cancer patients(see Example II herein). Figure 10A depicts the survival of a patient with refractory metastatic papillary thyroid cancer, receiving two doses the Ad5-PPE-1-3X fas-chimera adenovirus vector nearly two years apart, and has remained progression-free for most of that time. Figure 10B shows the progression free survival of a patient with medullary thyroid cancer, who remained stable and progression free when monitored at 120 days after receiving a single dose of the Ad5-PPE-1-3X fas-chimera adenovirus vector. SD=stable disease. PD= progressive disease. PR= partial response;

FIG. 11 is a graph illustrating the humoral immune response to a single administration of the Ad5-PPE-1-3X fas-chimera adenovirus, in cohorts 1 to 7 (cohort 1=diamond ♦; cohort 2= square ■; cohort 3= triangle ▲; cohort 4= "X"; cohort 5= star;

cohort 6= circle •; cohort 7= vertical line |). Individual patients' anti-Adenovirus 5 IgG levels were assayed (as detailed in Example II) at day 0 (administration), and days 7, 14, 21 and 28 post infusion. Note the plateau of the immune response as early as day 7 in some cohorts (e.g. 1, 3, 4) and later in others (e.g. cohorts 2, 5, 6, 7);

FIGs. 12A and 12B show the pharmacokinetics of the Ad5-PPE-1-3X fas-chimera adenovirus vector, following intravenous adminstration. FIG. 12A is a graph depicting the pharmacokinetics of the Ad5-PPE-1-3X fas-chimera adenovirus vector in blood, from administration to day 56, post-infusion. Whole blood samples of patients receiving 10^{10} (♦, solid black line), $3X10^{10}$ (■, dotted black line), 10^{11} (▲, dashed black line), $3X10^{11}$ (X, solid grey line), 10^{12} (■, dotted grey line) and $3X10^{12}$ (•, dashed grey line) Ad5-PPE-1-3X fas-chimera adenovirus particles were analyzed by RT-PCR at indicated timepoints for adenovirus 5 DNA. Adenovirus levels were reduced by at least two orders of magnitude, or undetectable by day 56. FIG 12B represents the average levels of adenovirus particles, analyzed by RT-PCR, in whole blood sampled at the end of the infusion with the virus vector;

FIGs. 13A and 13B illustrate the effects of combined Ad5-PPE-1-3X fas-chimera adenovirus vector and sunitinib on the Lewis Lung metastatic cancer model. Mice with induced lung metastases received either the Ad5-PPE-1-3X fas-chimera adenovirus vector or oral sunitinib, in the indicated dosages, or a combination of the two therapies. Control mice received empty (sham) virus vehicles. Lung metastases were evaluated according to the tumor mass in grams (tumor burden) at 22 days post- primary tumor removal. Figure 13 A is a histogram of the values in Figure 13B. Note the enhanced effect of the combination therapy at 80 mg/kg sunitinib, and 10^9 Ad5-PPE-1-3X fas-chimera virus particles.

Unless otherwise defined, all technical and/or scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the invention pertains. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of embodiments of the invention, exemplary methods and/or materials are described below. In case of conflict, the patent specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and are not intended to be necessarily limiting.

DESCRIPTION OF SPECIFIC EMBODIMENTS OF THE INVENTION

The present invention, in some embodiments thereof, relates to anti-angiogenic adenovirus vectors, and therapeutic use thereof, and more particularly, but not exclusively, to clinical protocols for treatment of solid tumors in patients with an Ad5-PPE-1-3X-fas-chimera adenovirus vector.

Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not necessarily limited in its application to the details set forth in the following description or exemplified by the Examples. The invention is capable of other embodiments or of being practiced or carried out in various ways.

Angiogenesis is required for the development of neoplastic and hyperproliferative growths. Gene therapy for anti-angiogenic therapy in conditions associated with neovascularization, such as cancer, has been investigated, however, despite promising results in *in-vitro* experiments and in animal models, there has been little success with anti-angiogenic gene therapy in the clinical setting, likely due to obstacles including duration of expression of the transferred gene, induction of host immune response, cytotoxicity of the vectors and tissue specificity of expression.

The present inventors have developed a clinically safe and effective procedure for administration of a therapeutic recombinant adenovirus vector comprising a cytotoxic fas-chimera effector sequence under transcriptional control of an angiogenic endothelial-specific modified murine pre-pro endothelin promoter, which can be used for treatment of a variety of cancers and other hyperproliferative, neovascular-dependent diseases, for example, for solid tumors.

Thus, according to one aspect of the present invention, there is provided a method of treating a solid tumor in a subject in need thereof, the method comprising administering to the subject a therapeutically effective amount of a non-replicating adenovirus vector, said vector comprises a polynucleotide which comprises a fas-chimera transgene transcriptionally linked to a murine pre-proendothelin promoter, wherein said therapeutically effective amount is at least $1X10^8$ virus particles, thereby treating the solid tumor.

As used herein, the phrases "cancer", "malignancy", "solid tumor" or "hyperproliferative disorder" are used as synonymous terms and refer to any of a number of diseases that are characterized by uncontrolled, abnormal proliferation of cells, the ability of affected cells to spread locally or through the bloodstream and lymphatic system to other parts of the body (i.e., metastasize) as well as any of a number of characteristic structural and/or molecular features. A "cancerous" or "malignant cell" or "solid tumor cell" is understood as a cell having specific structural properties, lacking differentiation and being capable of invasion and metastasis. "Cancer" refers to all types of cancer or neoplasm or malignant tumors found in mammals, including carcinomas and sarcomas. Examples are cancers of the breast, lung, non-small cell lung, stomach, brain, head and neck, medulloblastoma, bone, liver, colon, genitourinary, bladder, urinary, kidney, testes, uterus, ovary, cervix, prostate, melanoma, mesothelioma, sarcoma, (see DeVita, et al., (eds.), 2001, Cancer Principles and Practice of Oncology, 6th. Ed., Lippincott Williams & Wilkins, Philadelphia, Pa.; this reference is herein incorporated by reference in its entirety for all purposes).

"Cancer-associated" refers to the relationship of a nucleic acid and its expression, or lack thereof, or a protein and its level or activity, or lack thereof, to the onset of malignancy in a subject cell. For example, cancer can be associated with expression of a particular gene that is not expressed, or is expressed at a lower level, in a normal healthy cell. Conversely, a cancer-associated gene can be one that is not expressed in a malignant cell (or in a cell undergoing transformation), or is expressed at a lower level in the malignant cell than it is expressed in a normal healthy cell.

"Hyperproliferative disease" refers to any disease or disorder in which the cells proliferate more rapidly than normal tissue growth. Thus, a hyperproliferating cell is a cell that is proliferating more rapidly than normal cells.

"Neovascularization" and "angiogenesis" refer to the growth of new blood vessels. Pathological angiogenesis or neovascularization refers to unbalanced new blood vessel growth, including non-self-limiting endothelial and periendothelial cell-proliferation. "Angiogenic diseases" are conditions of unregulated angiogenesis, for example, cancer, ocular neovascularization, arthritis, diabetes, skin diseases, chronic inflammatory diseases such as rheumatoid arthritis, psoriasis and synovitis.

"Advanced cancer" means cancer that is no longer localized to the primary tumor site, or a cancer that is Stage III or IV according to the American Joint Committee on Cancer (AJCC).

"Well tolerated" refers to the absence of adverse changes in health status that occur as a result of the treatment and would affect treatment decisions.

"Metastatic" refers to tumor cells, e.g., human solid tumor or thyroid malignancy, that are able to establish secondary tumor lesions in the lungs, liver, bone or brain of immune deficient mice upon injection into the mammary fat pad and/or the circulation of the immune deficient mouse.

A "solid tumor" includes, but is not limited to, sarcoma, melanoma, carcinoma, or other solid tumor cancer. "Sarcoma" refers to a tumor which is made up of a substance like the embryonic connective tissue and is generally composed of closely packed cells embedded in a fibrillar or homogeneous substance. Sarcomas include, but are not limited to, chondrosarcoma, fibrosarcoma, lymphosarcoma, melanosarcoma, myxosarcoma, osteosarcoma, Abemethy's sarcoma, adipose sarcoma, liposarcoma, alveolar soft part sarcoma, ameloblastic sarcoma, botryoid sarcoma, chloroma sarcoma, chorio carcinoma, embryonal sarcoma, Wilms' tumor sarcoma, endometrial sarcoma, stromal sarcoma, Ewing's sarcoma, fascial sarcoma, fibroblastic sarcoma, giant cell sarcoma, granulocytic sarcoma, Hodgkin's sarcoma, idiopathic multiple pigmented hemorrhagic sarcoma, immunoblastic sarcoma of B cells, lymphoma, immunoblastic sarcoma of T-cells, Jensen's sarcoma, Kaposi's sarcoma, Kupffer cell sarcoma, angiosarcoma, leukosarcoma, malignant mesenchymoma sarcoma, parosteal sarcoma, reticulocytic sarcoma, Rous sarcoma, serocystic sarcoma, synovial sarcoma, and telangiectaltic sarcoma.

"Melanoma" refers to a tumor arising from the melanocytic system of the skin and other organs. Melanomas include, for example, acral-lentiginous melanoma, amelanotic melanoma, benign juvenile melanoma, Cloudman's melanoma, S91 melanoma, Harding-Passey melanoma, juvenile melanoma, lentigo maligna melanoma, malignant melanoma, metastatic melanoma, nodular melanoma, subungal melanoma, and superficial spreading melanoma.

"Carcinoma" refers to a malignant new growth made up of epithelial cells tending to infiltrate the surrounding tissues and give rise to metastases. Exemplary carcinomas include, for example, acinar carcinoma, acinous carcinoma, adenocystic carcinoma, adenoid cystic carcinoma, carcinoma adenomatosum, carcinoma of adrenal cortex, alveolar carcinoma, alveolar cell carcinoma, basal cell carcinoma, carcinoma basocellulare, basaloid carcinoma, basosquamous cell carcinoma, bronchioalveolar carcinoma, bronchiolar carcinoma, bronchogenic carcinoma, cerebriform carcinoma, cholangiocellular carcinoma, chorionic carcinoma, colloid carcinoma, comedo carcinoma, corpus carcinoma, cribriform carcinoma, carcinoma en cuirasse, carcinoma cutaneum, cylindrical carcinoma, cylindrical cell carcinoma, duct carcinoma, carcinoma durum, embryonal carcinoma, encephaloid carcinoma, epiermoid carcinoma, carcinoma epitheliale adenoides, exophytic carcinoma, carcinoma ex ulcere, carcinoma fibrosum, gelatiniform carcinoma, gelatinous carcinoma, giant cell carcinoma, carcinoma gigantocellulare, glandular carcinoma, granulosa cell carcinoma, hair-matrix carcinoma, hematoid carcinoma, hepatocellular carcinoma, Hurthle cell carcinoma, hyaline carcinoma, hypemephroid carcinoma, infantile embryonal carcinoma, carcinoma in situ, intraepidermal carcinoma, intraepithelial carcinoma, Krompecher's carcinoma, Kulchitzky-cell carcinoma, large-cell carcinoma, lenticular carcinoma, carcinoma lenticulare, lipomatous carcinoma, lymphoepithelial carcinoma, carcinoma medullare, medullary carcinoma, melanotic carcinoma, carcinoma molle, mucinous carcinoma, carcinoma muciparum, carcinoma mucocellulare, mucoepidernoid carcinoma, carcinoma mucosum, mucous carcinoma, carcinoma myxomatodes, naspharyngeal carcinoma, oat cell carcinoma, carcinoma ossificans, osteoid carcinoma, papillary carcinoma, periportal carcinoma, preinvasive carcinoma, prickle cell carcinoma, pultaceous carcinoma, renal cell carcinoma of kidney, reserve cell carcinoma, carcinoma sarcomatodes, schneiderian carcinoma, scirrhous carcinoma, carcinoma scroti, signet-ring cell carcinoma, carcinoma simplex, small-cell carcinoma, solanoid carcinoma, spheroidal cell carcinoma, spindle cell carcinoma, carcinoma spongiosum, squamous carcinoma, squamous cell carcinoma, string carcinoma, carcinoma telangiectaticum, carcinoma telangiectodes, transitional cell carcinoma, carcinoma tuberosum, tuberous carcinoma, verrucous carcinoma, and carcinoma viflosum.

Additional cancers include, for example, Leukemia, Hodgkin's Disease, Non-Hodgkin's Lymphoma, multiple myeloma, neuroblastoma, breast cancer, ovarian cancer, lung cancer, rhabdomyosarcoma, primary thrombocytosis, primary macroglobulinemia, small-cell lung tumors, primary brain tumors, stomach cancer, colon cancer, malignant pancreatic insulanoma, malignant carcinoid, urinary bladder cancer, premalignant skin lesions, testicular cancer, lymphomas, thyroid cancer, papillary thyroid cancer, neuroblastoma, neuroendocrine cancer, esophageal cancer, genitourinary tract cancer, malignant hypercalcemia, cervical cancer, endometrial cancer, adrenal cortical cancer, and prostate cancer.

The present inventors have shown that systemic administration of the Ad5-PPE-1-3X-fas-c adenoviral vector was correlated with a reduction in tumor mass and prolonged stable disease in a patient suffering from metastatic papillary thyroid cancer (see Example II and FIGs. 4 and 5 that follow). Thus, according to one aspect of some embodiments of the present invention there is provided a method for treating a thyroid cancer in a patient in need thereof, the method comprising administering to the subject a single or multiple intravenous dose(s) of $3X10^{12}$ or 10^{13} virus particles of a non-replicating adenovirus vector comprising a polynucleotide having a nucleotide sequence as set forth in SEQ ID NOs: 9 or 10. Disease progression in thyroid cancer can be assessed or monitored by methods including, but not limited to, radiographic analysis of tumor mass and density (e.g. RECIST criteria), measurement of thyroid and thyroid-associated hormone levels, thyroglobulin levels, and the like.

The present inventors have shown that systemic administration of the Ad5-PPE-1-3X-fas-c adenoviral vector was correlated with a reduction in a metastatic hepatic lesion and prolonged stable disease in a patient suffering from metastatic neuroendocrine cancer (see Example II and FIGs. 6A-6C, 7A- 7C that follow). Thus, according to one aspect of some embodiments of the present invention there is provided a method for treating a neuroendocrine cancer in a patient in need thereof, the method comprising administering to the subject a single or multiple intravenous dose(s) of $3X10^{12}$ or 10^{13} virus particles of a non-replicating adenovirus vector comprising a polynucleotide having a nucleotide sequence as set forth in SEQ ID NOs: 9 or 10. Methods for assessing or monitoring disease progression in neuroendocrine cancer include radiographic analysis of tumor mass and density (e.g. RECIST criteria), measurement of liver enzyme levels (where the tumor is a liver metastasis), and the like.

The method of the present invention as claimed has been indicated effective in treating other cancers. Thus, according to further aspects of some embodiments of the present invention there is provided a method for treating an ovarian cancer, a non small cell lung cancer and/or a renal cell carcinoma in a patient in need thereof, the method comprising administering to the subject a single or multiple intravenous dose(s) of

$3X10^{12}$ or 10^{13} virus particles of a non-replicating adenovirus vector comprising a polynucleotide having a nucleotide sequence as set forth in SEQ ID NOs: 9 or 10. Methods for assessing or monitoring disease progression in these cancers include radiographic analysis of tumor mass and density (e.g. RECIST criteria), measurement of organ function (e.g. kidney function in renal cell carcinoma), measurement of specific biomarkers, endocrine function, and the like.

Contemplated subjects to be treated include mammals – e.g. humans. According to one embodiment the subject has received a prior treatment for the solid tumor (e.g. radiotherapy and/or chemotherapy) and the malignant tumor has relapsed. According to another embodiment, the subject has not received a prior treatment for the malignant tumor.

The phrase "viral vector" refers to a replication-competent or replication-deficient viral particle which is capable of transferring nucleic acid molecules into a host.

The present inventors contemplate use of Replication Defective Vectors and Replication Defective Vector-Producing Packaging Cells. Examples of such vectors are adenoviral vectors, AAV vectors and retroviral vectors and others described in Shir et al, Cellular and Molecular Neurobiology, Vol. 21, No. 6, December 2001, the contents of which are incorporated herein by reference.

The term "virus" refers to any of the obligate intracellular parasites having no protein-synthesizing or energy-generating mechanism. The viral genome may be RNA or DNA contained with a coated structure of protein of a lipid membrane. Examples of viruses useful in the practice of the present invention include baculoviridiae, parvoviridiae, picornoviridiae, herepesviridiae, poxviridiae, adenoviridiae, picotrnaviridiae. The term recombinant virus includes chimeric (or even multimeric) viruses, i.e. vectors constructed using complementary coding sequences from more than one viral subtype. (See, e.g. Feng, et al. Nature Biotechnology 15:866-870) The term "adenovirus" is synonymous with the term "adenoviral vector" and refers to viruses of the genus adenoviridiae. The term adenoviridiae refers collectively to animal adenoviruses of the genus mastadenovirus including but no limited to human, bovine, ovine, equine, canine, porcine, murine and simian adenovirus subgenera. In particular, human adenoviruses includes the A-F subgenera as well as the individual serotypes thereof the individual serotypes and A-F subgenera including but not limited to human adenovirus types 1, 2, 3, 4, 4a, 5, 6, 7, 8, 9, 10, 11 (Ad11A and Ad 11P), 12, 13, 14, 15, 16, 17, 18, 19, 19a, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 34a, 35, 35p, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, and 91. The term bovine adenoviruses includes but is not limited to bovine adenovirus types 1, 2, 3, 4, 7, and 10. The term canine adenoviruses includes but is not limited to canine types 1 (strains CLL, Glaxo, RI261, Utrect, Toronto 26-61) and 2. The term equine adenoviruses includes but is not limited to equine types 1 and 2. The term porcine adenoviruses includes but is not limited to porcine types 3 and 4. In one embodiment of the invention, the adenovirus is derived from the human adenovirus serotypes 2 or 5. For purposes of this invention, adenovirus vectors can be replication-competent or replication deficient in a target cell. In some embodiments, the adenovirus vectors are conditionally or selectively replicating adenoviruses, wherein a gene[s] required for viral replication is [are] operatively linked to a cell and/or context-specific promoter. Examples of selectively replicating or conditionally replicating viral vectors are known in the art (see, for example, US 7,691,370). In one embodiment, the adenovirus vector is a conditionally replicating adenovirus wherein the E1 gene is under transcriptional control of the pre-proendothelin promoter PPE-1 (PPE-1, SEQ ID NO: 13). In another embodiment, the adenovirus vector is a conditionally replicating or selectively replicating adenovirus wherein the E1 gene is under transcriptional control of the modified pre-proendothelin promoter PPE-1-3X (PPE-1-3X, SEQ ID NO: 12). In some embodiments, adenovirus vectors suitable for use with the present invention include all adenovirus serotypes having hexon protein structure. Viral vectors suitable for therapeutic use include adenoviral vectors, retrovirusal vectors, AAV, herpesvirus vectors and the like. Engineering and production of viral vectors is well known in the art, as described in detail in, for example, US Patent No: 7,732,129 or 6,649,158, which are incorporated herein by reference, in their entirety. In specific embodiments, the adenovirus is a C-type adenovirus (Ad5, Ad2), a B-type adenovirus (Ad3, Ad16, Ad21, Ad35, Ad50), an E-type adenovirus (Ad4) or an F-type adenovirus (Ad41).

As used herein, the phrase adenoviral vector refers to a vector in which, among the nucleic acid molecules in the viral particle, sequences necessary to function as a viral vector are based on the adenoviral genome.

According to one embodiment the adenoviral vector is a non-replicating serotype 5 (Ad5) adenoviral vector.

According to another embodiment, the adenoviral vector comprises a sequence as set forth in SEQ ID NO: 1 or SEQ ID NO: 11.

It will be appreciated that the present invention also contemplates use of oncolytic viruses which reproduce themselves in cancer cells and subsequently kill the initially infected cells by lysis. Such viruses proceed to infect adjacent cells thus repeating the cycle. Contemplated examples of oncolytic viruses include, but are not limited to Herpes Simplex Virus, conditionally replicative Ads (CRAds) and reoviruses.

Two major strategies for development of CRAd vectors have been developed, mainly focusing on the genetic engineering of the early 1 (E1) genes to restrict virus replication to target cells and to spare normal tissue. Genetic complementation-type (type 1) CRAds, such as Ad524, have a mutation in the immediately early (E1A) or early (E1B) adenoviral region, which is complemented in tumor cells but not in normal cells. In trans complementation-type (type 2) CRAds, virus replication is controlled via a tumor/tissue-specific promoter.

Reovirus is a naturally occurring oncolytic virus that requires activated Ras signaling pathways of tumor cells for its replication. Ras pathways are activated in most malignant tumors via upstream signaling by receptor tyrosine kinases.

As mentioned the viral vectors of this aspect of the present invention comprise a cytotoxic fas-chimera effector sequence under transcriptional control of an angiogenic endothelial-specific modified murine pre-pro endothelin promoter.

Typically, such viral vectors are constructed using genetic recombination technology – i.e. recombinant viral vectors.

The Fas-chimera (Fas-c) polypeptide, is a previously described fusion of two "death receptors", constructed from the extracellular region of TNFR1 (SEQ ID NO: 2) and the trans-membrane and intracellular regions of Fas (SEQ ID NO: 3) [Boldin MP et al. J Biol Chem (1995) 270(14):7795-8; the contents of which are incorporated herein by reference].

According to one embodiment the Fas-c is encoded by a polynucleotide as set forth in SEQ ID NO: 4.

It will be appreciated that the present invention also contemplates use of a viral construct (e.g. an adenoviral construct) comprising an endothelial/periendothelial cell-specific promoter operatively linked to other cytotoxic polypeptides for the treatment of solid tumors.

Such polypeptides, include but are not limited to suicide polypeptides such as p53 and egr-1-TNF-alpha, cytotoxic pro-drug/enzymes for drug susceptibility therapy such as ganciclovir/thymidine kinase and 5-fluorocytosine/cytosine deaminase, and antimetastatic polypeptides such as 5 E1A.

The term "promoter" as used herein refers to a DNA sequence which directs transcription of a polynucleotide sequence operatively linked thereto in the cell in a constitutive or inducible manner. The promoter may also comprise enhancer elements which stimulate transcription from the linked promoter.

The pre-pro endothelial promoter as used herein refers to the preproendothelin-1 (PPE-1) promoter, of mammalian origin. In one embodiment, the pre-proendothelin 1 promoter is a murine pre-pro endothelin 1 promoter (PPE-1, SEQ ID NO: 13) and modifications thereof. It will be appreciated that other endothelial specific promoters can be used with the present invention, for example, the TIE-1 promoter, the TIE-2 promoter, the Endoglin promoter, the von Willerband promoter, the KDR/flk-1 promoter, The FLT-1 promoter, the Egr-1 promoter, the ICAM-1 promoter, the VCAM-1 promoter, the PECAM-1 promoter and the aortic carboxypeptidase-like protein (ACLP) promoter.

According to one embodiment the promoter comprises at least one copy of an enhancer element that confers endothelial cell specific transcriptional activity. According to one embodiment the enhancer element is naturally found positioned between the –364 bp and –320 bp of the murine PPE-1 promoter (as set forth in SEQ ID NO: 6). In one embodiment, the promoter comprises at least two and more preferably three of the above described enhancer elements. According to a specific embodiment, the promoter comprises two of the above described enhancer elements on one strand of the promoter DNA and one of the above described enhancer element on the complementary strand of the promoter DNA.

In yet another embodiment, the promoter comprises a modified enhancer element as set forth in SEQ ID NO: 8, optionally in combination with other enhancer elements. Thus, according to this embodiment, the promoter comprises a sequence as set forth in SEQ ID NO: 7.

According to another embodiment, the promoter further comprises at least one hypoxia response element – e.g. comprising a sequence as set forth in SEQ ID NO: 5.

An exemplary promoter which can be used in the context of the present invention comprises a sequence as set forth in SEQ ID NO: 12. This sequence comprises SEQ ID NO: 5 and SEQ ID NO: 7 (which itself comprises two copies of SEQ ID NO: 6 either side of one copy of SEQ ID NO: 8).

According to a particular embodiment of this aspect of the present invention, the viral vector consists of a sequence as set forth in SEQ ID NOs: 9 or 10.

The Ad5-PPE-1-3X-fas-c sequence, as set forth in SEQ ID NO: 9 or 10 comprises a sequence which is an anti-sense copy of SEQ ID NO: 7, located at nucleic acid coordinates 894- 1036, a sequence which is a single antisense copy of SEQ ID NO: 8 located at nucleotide coordinates 951-997; a sequence which is a first antisense copy of SEQ ID NO: 6 located at nucleotide coordinates 907-950; a sequence which is a second antisense copy of SEQ ID NO: 6 located at nucleotide coordinates 993-1036; and a third copy of SEQ ID NO: 6 in the sense orientation at position 823-866.

In some embodiments of the invention, the viral vector comprises additional polynucleotide sequences capable of enhancing or inhibiting transcriptional activity of an endothelial specific promoter. According to an aspect of some embodiments of the invention, the additional polynucleotide sequence includes an isolated polynucleotide comprising at least 6 nucleotides of element X of a pre-proendothelin (PPE-1) promoter, the element X having a wild type sequence as set forth by SEQ ID NO:6, wherein the at least 6 nucleotides comprise at least 2 consecutive sequences derived from SEQ ID NO:6, each of the at least 2 consecutive sequences comprises at least 3 nucleotides, at least one of the at least 3 nucleotide being positioned next to at least one nucleotide position in SEQ ID NO:6, the at least one nucleotide position in SEQ ID NO:6 is selected from the group consisting of:

(i) at least one nucleotide of wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC);

(ii) at least one nucleotide of wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG);

(iii) at least one nucleotide of wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC);

(iv) at least one nucleotide of wild type M6 sequence set forth by SEQ ID NO: 17 (GGGTG);

(v) at least one nucleotide of wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT);

(vi) at least one nucleotide of wild type M1 sequence set forth by SEQ ID NO: 20 (GTACT); and

(v) at least one nucleotide of wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT);

wherein the at least one nucleotide position is mutated as compared to SEQ ID NO:6 by at least one nucleotide substitution, at least one nucleotide deletion and/or at least one nucleotide insertion, with the proviso that a mutation of the at least one nucleotide position does not result in nucleotides GGTA at position 21-24 of SEQ ID NO:6 and/or in nucleotides CATG at position 29-32 of SEQ ID NO:6, such that when the isolated polynucleotide is integrated into the PPE-1 promoter and placed upstream of a reporter gene (e.g., luciferase coding sequence) the expression level of the reporter gene is upregulated or downregulated as compared to when SEQ ID NO:6 is similarly integrated into the PPE-1 promoter and placed upstream of the reporter gene coding sequence.

According to some embodiments of the invention, the isolated polynucleotide is not naturally occurring in a genome or a whole chromosome sequence of an organism.

As used herein the phrase “naturally occurring” refers to as found in nature, without any man-made modifications.

As described above, the at least 6 nucleotides of element X comprise at least 2 consecutive sequences derived from SEQ ID NO:6.

As used herein the phrase “consecutive sequence derived from SEQ ID NO:6 ” refers to a nucleic acid sequence (a polynucleotide) in which the nucleotides appear in the same order as in the nucleic acid sequence of SEQ ID NO:6 from which they are derived. It should be noted that the order of nucleotides is determined by the chemical bond (phosphodiester bond) formed between a 3'-OH of a preceding nucleotide and the 5'-phosphate of the following nucleotide.

According to some embodiments of the invention, each of the at least 2 consecutive sequences comprises at least 3 nucleotides, e.g., 3 nucleotides, 4 nucleotides, 5 nucleotides, 6 nucleotides, 7 nucleotides, 8 nucleotides, 9 nucleotides, 10 nucleotides, 11 nucleotides, 12 nucleotides, 13 nucleotides, 14 nucleotides, 15 nucleotides, 16 nucleotides, 17 nucleotides, 18 nucleotides, 19 nucleotides, 20 nucleotides, 21 nucleotides, 22 nucleotides, 23 nucleotides, 24 nucleotides, 25 nucleotides, 26 nucleotides, 27 nucleotides, 28 nucleotides, 29 nucleotides, 30 nucleotide, 31 nucleotides, 32 nucleotides, 33 nucleotides, 34 nucleotides, 35 nucleotides, 36 nucleotides, 37 nucleotides, 38 nucleotides, 39 nucleotides, 40 nucleotides, 41 nucleotides of SEQ ID NO:6.

As described, the isolated polynucleotide comprises at least 2 consecutive sequences derived from SEQ ID NO:6. According to some embodiments of the invention, the isolated polynucleotide comprises 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 or 14 consecutive sequences derived from SEQ ID NO:6.

As used herein the phrase “wild type” with respect to a nucleotide sequence refers to the nucleic acid sequence as appears in SEQ ID NO:6. Examples include, but are not limited to wild type M4 sequence (SEQ ID NO: 15), wild type M5 sequence (SEQ ID NO: 16), wild type M8 (SEQ ID NO:19), wild type M6 sequence (SEQ ID NO:17), wild type M7 sequence (SEQ ID NO:18), wild type M1 (SEQ ID NO:20) and wild type M3 sequence (SEQ ID NO:21).

According to some embodiments of the invention, the mutation is an insertion of at least one nucleotide in a nucleotide position with respect to SEQ ID NO:6. According to some embodiments of the invention, the insertion includes at least 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 nucleotides, e.g., at least about 15, at least about 20, at least about 25, at least about 30, at least about 35, at least about 40, at least about 45, at least about 50, at least about 55, at least about 60, at least about 65, at least about 70, at least about 75, at least about 80, at least about 85, at least about 90, at least about 95, at least about 100, at least about 200, at least about 300, or more nucleotides.

It should be noted that the sequence which is inserted by the mutation can be derived from any source (e.g., species, tissue or cell type), and is not limited to the source of the sequence of element X.

According to some embodiments of the invention, the mutation is a combination of any of the mutation types described above, *i.e.*, substitution, insertion and deletion. For example, while one nucleotide position in SEQ ID NO:6 can be subject to a substitution mutation, another nucleotide position in SEQ ID NO:6 can be subject to a deletion or insertion. Additionally or alternatively, while one nucleotide position in SEQ ID NO:6 can be subject to a deletion mutation, another nucleotide position in SEQ ID NO:6 can be subject to a substitution or insertion. Additionally or alternatively, while one nucleotide position in SEQ ID NO:6 can be subject to an insertion mutation, another nucleotide position in SEQ ID NO:6 can be subject to a substitution or deletion. It should be noted that various other combinations are possible.

According to specific embodiments of the invention, the mutation in the isolated polynucleotide of the invention does not result in nucleotides GGTA at position 21-24 of SEQ ID NO:6 and/or in nucleotides CATG at position 29-32 of SEQ ID NO:6.

As used herein the phrase "integrated into the PPE-1 promoter" refers to a nucleotide sequence (the isolated polynucleotide) which is covalently conjugated within the PPE-1 promoter sequence.

According to some embodiments of the invention, the isolated polynucleotide further comprises at least one copy of a nucleic acid sequence selected from the group consisting of:

(i) wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC),

(ii) wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG),

(iii) wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC),

(iv) wild type M6 sequence set forth by SEQ ID NO: 17 (GGGTG),

(v) wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT);

(vi) wild type M1 sequence set forth by SEQ ID NO: 20 (GTACT), and

(vii) wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT).

According to some embodiments of the invention, the isolated polynucleotide is integrated into (within), downstream of, or upstream of any known (or unknown) promoter sequence to thereby regulate (e.g., increase, decrease, modulate tissue-specificity, modulate inductive or constitutive expression) the transcriptional promoting activity of the promoter.

According to some embodiments of the invention, the isolated polynucleotide is for increasing expression of a heterologous polynucleotide operably linked thereto in endothelial cells. Such a polynucleotide can include wild type sequences of M4 and/or M5 in the presence or absence of additional sequences from element X, and/or in the presence of other mutated sequences from element X.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC).

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG).

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC) and at least one copy of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG).

According to some embodiments of the invention, the at least one nucleotide position which is mutated as compared to SEQ ID NO:6 is at least one nucleotide of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC). It should be noted that such an isolated polynucleotide may further include a wild type M6 sequence (SEQ ID NO:17) and/or a wild type M7 sequence (SEQ ID NO:18)

Non-limiting examples of isolated polynucleotides which include at least one copy of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC) and a mutation in at least one nucleotide of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:55-62.

Non-limiting examples of isolated polynucleotides which include at least one copy of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG) and a mutation in at least one nucleotide of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs: 63-66.

Non-limiting examples of isolated polynucleotides which include at least one copy of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), at least one copy of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG) and a mutation in at least one nucleotide of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs: 67-70.

According to some embodiments of the invention, the isolated polynucleotide further comprising at least one copy of wild type M1 sequence set forth by SEQ ID NO: 20 (GTACT).

Non-limiting examples of isolated polynucleotides which include at least one copy of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), at least one copy of the wild type M1 sequence set forth by SEQ ID NO: 20 (GTACT), and a mutation in at least one nucleotide of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs: 71-105.

Non-limiting examples of isolated polynucleotides which include at least one copy of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M1 sequence set forth by SEQ ID NO: 20 (GTACT) and a mutation in at least one nucleotide of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs: 106-136.

Non-limiting examples of isolated polynucleotides which include at least one copy of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), at least one copy of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M1 sequence set forth by SEQ ID NO: 20 (GTACT) and a mutation in at least one nucleotide of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:137-152.

According to some embodiments of the invention, the isolated polynucleotide reduces expression of a heterologous polynucleotide operably linked thereto in endothelial cells. Such a polynucleotide can include mutations in M4 and/or M5 in the presence or absence of additional sequences from element X, and/or in the presence of other mutated sequences from element X.

According to some embodiments of the invention, the at least one nucleotide position which is mutated as compared to SEQ ID NO:6 is at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC).

Non-limiting examples of isolated polynucleotides which includes a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO:46 (CATTC) are provided in SEQ ID NOs:153-162.

According to some embodiments of the invention, the at least one nucleotide position which is mutated as compared to SEQ ID NO:6 is at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG).

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG) are provided in SEQ ID NOs:163-171.

According to some embodiments of the invention, the at least one nucleotide position which is mutated as compared to SEQ ID NO:6 is at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC) and at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG).

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC) and a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG) are provided in SEQ ID NOs:172-180.

According to some embodiments of the invention, the isolated polynucleotide is for increasing expression of a heterologous polynucleotide operably linked thereto in cells other than endothelial cells. Such a polynucleotide can include mutations in M4 and/or M5 and wild type sequences of M6 and/or M7, in the presence or absence of additional sequences from element X, and/or in the presence of other mutated sequences from element X.

According to some embodiments of the invention, the isolated polynucleotide comprises a mutation in M4 (SEQ ID NO: 15) and/or in M5 (SEQ ID NO: 16) and at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and/or at least one copy of wild type M7 set forth by SEQ ID NO:18.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC) and at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) are provided in SEQ ID NOs:181-182.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG) and at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) are provided in SEQ ID NOs:183-189.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG) and at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) are provided in SEQ ID NOs:190-191.

According to some embodiments of the invention, the isolated polynucleotide further comprises at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT).

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC) and at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) are provided in SEQ ID NOs:192-195.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG) and at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) are provided in SEQ ID NOs:196-198.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG) and at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) are provided in SEQ ID NOs:199-202.

According to some embodiments of the invention, the isolated polynucleotide further comprises at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT).

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) are provided in SEQ ID NOs:203-205.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16

(CAATG), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) are provided in SEQ ID NOs:206-207.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) are provided in SEQ ID NOs:208-209.

According to some embodiments of the invention, the isolated polynucleotide reduces expression in cells of a heterologous polynucleotide operably linked thereto. Such a polynucleotide can include mutations in M4, M5, M6 and/or M7, in the presence or absence of additional sequences from element X, and/or in the presence of other mutated sequences from element X.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one mutation in wild type M4 (SEQ ID NO: 15) and/or in wild type M5 (SEQ ID NO:47) and in wild type M6 set forth by SEQ ID NO: 17 (GGGTG).

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC) and a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) are provided in SEQ ID NOs:210-213.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG) and a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) are provided in SEQ ID NOs:214-222.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), and a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) are provided in SEQ ID NOs:223-231.

According to some embodiments of the invention, the isolated polynucleotide further comprises at least one mutation in wild type M7 set forth by SEQ ID NO: 18 (ACTTT).

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC) and a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT) are provided in SEQ ID NOs:232-236.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG) and a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT) are provided in SEQ ID NOs:237-240.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), and a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT) are provided in SEQ ID NOs:241-248.

According to some embodiments of the invention, the isolated polynucleotide further comprises at least one mutation in wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and at least one mutation in wild type M7 set forth by SEQ ID NO: 18 (ACTTT).

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT) are provided in SEQ ID NOs:249-258.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT) are provided in SEQ ID NOs:259-264.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT) are provided in SEQ ID NOs:265-270.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) with additional wild type or mutated sequences derived from element X (SEQ ID NO:6).

Non-limiting examples of isolated polynucleotides which includes a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:271-279.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:280-287.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:288-291.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:294-298.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:299-301.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:302-303.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:304-308.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:309-311.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:312-315.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NO:316.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16

(CAATG), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NO:317.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NO:318.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:319-327.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:328-333.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:334-337.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide position of the wild type M7 set forth by

SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:338-344.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:345-348.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:349-354.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:355-361.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:362-365.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) are provided in SEQ ID NOs:366-369.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) with additional wild type or mutated sequences derived from element X (SEQ ID NO:6).

Non-limiting examples of isolated polynucleotides which includes a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:378-384.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:628-634.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:370-377.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:385-390.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:391-396.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:397-401.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:402-409.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:410-417.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:418-423.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:424-425.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:538-540.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NO:426.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:427-435.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:436-444.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:445-451.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:452-458.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:459-465.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NO:466.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:467-471.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:472-477.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:478-483.

According to some embodiments of the invention, the isolated polynucleotide further comprises at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) with additional wild type or mutated sequences derived from element X (SEQ ID NO:6).

Non-limiting examples of isolated polynucleotides which includes a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:484-495.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:496-507.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:508-515.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:516-519.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:520-523.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC), and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:524-525.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:526-529.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:530-533.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:534-535.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT)are provided in SEQ ID NOs:536-537.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT) at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:538-539.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), at least one copy of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), at least one copy of the wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NO:540.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:541-547.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:548-554.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:555-559.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:560-566.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:567-573.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:574-578.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:579-583.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:584-588.

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of the wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC), a mutation in at least one nucleotide of the wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG), a mutation in at least one nucleotide position of the wild type M6 set forth by SEQ ID NO: 17 (GGGTG), a mutation in at least one nucleotide position of the wild type M7 set forth by SEQ ID NO: 18 (ACTTT), at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) are provided in SEQ ID NOs:589-592.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of wild type M3 sequence (SEQ ID NO: 21) and at least one copy of wild type M8 sequence (SEQ ID NO: 19) , with at least one mutation in wild type M6 (SEQ ID NO: 17) and/or in wild type M7 (SEQ ID NO:50).

Non-limiting examples of isolated polynucleotides which include at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT), with a mutation in at least one nucleotide of the wild type M6 sequence (SEQ ID NO: 17) , and/or a mutation in at least one nucleotide of the wild type M7 (SEQ ID NO: 18) are provided in SEQ ID NOs:593-600.

The present inventors have envisaged that an isolated polynucleotide which includes the wild type M8 sequence (SEQ ID NO: 19) and/or the wild type M3 (SEQ ID NO: 21) sequence in addition to tissue specific enhancers (e.g., wild type M4 and/or wild type M5), and/or induced enhancers (e.g., developmentally related- or stress related-enhancers) is expected to exert a more specific regulatory effect by suppressing expression in non-target cells or under non-induced conditions.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and an endothelial specific enhancer sequence.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of wild type M4 sequence set forth by SEQ ID NO: 15.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of wild type M5 sequence set forth by SEQ ID NO:16.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of the wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC), at least one copy of wild type M4 sequence set forth by SEQ ID NO: 15 and at least one copy of wild type M5 sequence set forth by SEQ ID NO:16.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) and an endothelial specific enhancer sequence.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) and at least one copy of wild type M4 sequence set forth by SEQ ID NO: 15.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT) and at least one copy of wild type M5 sequence set forth by SEQ ID NO:16.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT), at least one copy of wild type M4 sequence set forth by SEQ ID NO: 15 and at least one copy of wild type M5 sequence set forth by SEQ ID NO:16.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT), at least one copy of wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and an endothelial specific enhancer sequence.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT), at least one copy of wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of wild type M4 sequence set forth by SEQ ID NO: 15.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT), at least one copy of wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one copy of wild type M5 sequence set forth by SEQ ID NO: 16.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT), at least one copy of wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC), at least one copy of wild type M4 sequence set forth by SEQ ID NO: 15 and at least one copy of wild type M5 sequence set forth by SEQ ID NO: 16.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of the wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT), at least one copy of wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC) and at least one enhancer element such as wild type M6 (SEQ ID NO: 17) and/or wild type M7 sequence (SEQ ID NO:18).

According to some embodiments of the invention, the isolated polynucleotide includes at least one copy of wild type M8 with additional flanking sequences such as at least one copy of a wild type M8 sequence (SEQ ID NO:19), at least one copy of wild type M7 (SEQ ID NO: 18) and/or wild type M9 sequence (SEQ ID NO: 14, CTGGA); and/or the isolated polynucleotide includes at least one copy of wild type M8 and at least one mutation in M7, with or without M9 (SEQ ID NO: 22). Such polynucleotides can be used as a non-specific repressor.

According to some embodiments of the invention, the isolated polynucleotide is for increasing expression of a heterologous polynucleotide operably linked thereto in cells/tissues.

According to some embodiments of the invention, the isolated polynucleotide comprises at least one copy of wild type M6 sequence set forth by SEQ ID NO: 17 (GGGTG) and/or at least one copy of wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT).

According to some embodiments of the invention, the isolated polynucleotide includes at least one copy of wild type M6 (SEQ ID NO: 17) and a mutation in at least one nucleotide of wild type M8 (SEQ ID NO: 19).

Non-limiting examples of isolated polynucleotide which include at least one copy of wild type M6 (SEQ ID NO: 17) and a mutation in at least one nucleotide of the wild type M8 (SEQ ID NO: 19) are provided in SEQ ID NOs:23-26.

According to some embodiments of the invention, the isolated polynucleotide includes at least one copy of wild type M7 (SEQ ID NO: 18) and a mutation in at least one nucleotide of wild type M8 (SEQ ID NO: 19).

Non-limiting examples of isolated polynucleotide which include at least one copy of wild type M7 (SEQ ID NO: 18) and a mutation in at least one nucleotide of the wild type M8 (SEQ ID NO: 19) are provided in SEQ ID NOs:27-28.

According to some embodiments of the invention, the isolated polynucleotide includes at least one copy of wild type M6 (SEQ ID NO: 17), at least one copy of wild type M7 (SEQ ID NO: 18) and a mutation in at least one nucleotide of wild type M8 (SEQ ID NO: 19).

According to some embodiments of the invention, the isolated polynucleotide includes at least one copy of wild type M1 (SEQ ID NO: 20) and a mutation in at least one nucleotide of wild type M8 (SEQ ID NO: 19).

Non-limiting examples of isolated polynucleotide which include at least one copy of wild type M1 (SEQ ID NO: 20) and a mutation in at least one nucleotide of the wild type M8 (SEQ ID NO: 19) are provided in SEQ ID NOs:43-54 and 601-632.

According to some embodiments of the invention, the isolated polynucleotide includes at least one copy of wild type M1 (SEQ ID NO: 20), at least one copy of wild type M6 (SEQ ID NO: 17) and/or at least one copy of wild type M7 (SEQ ID NO: 18) and a mutation in at least one nucleotide of wild type M8 (SEQ ID NO: 19).

Non-limiting examples of isolated polynucleotides which include a mutation in at least one nucleotide of wild type M8 (SEQ ID NO: 19) and at least one copy of wild type M1 (SEQ ID NO: 20) , wild type M6 (SEQ ID NO: 17) and/or wild type M7 (SEQ ID NO: 18) are provided in SEQ ID NOs:29-42.

Additional examples of regulatory isolated polynucleotides which can be used according to some embodiments of the invention are provided (; SEQ ID NOs: 633-644) in the Examples section which follows.

According to an aspect of some embodiments of the invention, there is provided an isolated polynucleotide comprising a nucleic acid sequence which comprises a first polynucleotide comprising the pre-proendothelin (PPE-1) promoter set forth by SEQ ID NO:13 and a second polynucleotide comprising at least one copy of a nucleic acid sequence selected from the group consisting of:

(i) wild type M4 sequence set forth by SEQ ID NO: 15 (CATTC),

(ii) wild type M5 sequence set forth by SEQ ID NO: 16 (CAATG),

(iii) wild type M8 sequence set forth by SEQ ID NO: 19 (GCTTC),

(iv) wild type M6 sequence set forth by SEQ ID NO: 17 (GGGTG),

(v) wild type M7 sequence set forth by SEQ ID NO: 18 (ACTTT);

(vi) wild type M1 sequence set forth by SEQ ID NO: 20 (GTACT), and

(vii) wild type M3 sequence set forth by SEQ ID NO: 21 (CTTTT);

with the proviso that the second polynucleotide is not SEQ ID NO:6 (element X), and wherein the isolated polynucleotide is not SEQ ID NO:12 (PPE-1-3X).

According to some embodiments of the invention, each of the wild type M4, M5, M8, M6, M7 and/or M1 sequences is placed in a head to tail (5'→3') orientation with respect to the PPE-1 promoter set forth by SEQ ID NO:13.

According to some embodiments of the invention, each of the wild type M4, M5, M8, M6, M7 and/or M1 sequences is placed in a tail to head (3'→5') orientation with respect to the PPE-1 promoter set forth by SEQ ID NO:13.

According to some embodiments of the invention, the wild type M4, M5, M8, M6, M7 and/or M1 sequences are placed in various orientations (head to tail or tail to head) and/or sequential order with respect the other wild type M4, M5, M8, M6, M7 and/or M1 sequences, and/or with respect to the orientation of SEQ ID NO:13.

Construction of such viral vectors may be effected using known molecular biology techniques such as those described in Sambrook et al., Molecular Cloning: A Laboratory Manual, Cold Springs Harbor Laboratory, New York (1989, 1992), in

Ausubel et al., Current Protocols in Molecular Biology, John Wiley and Sons, Baltimore, Md. (1989), Chang et al., Somatic Gene Therapy, CRC Press, Ann Arbor, Mich. (1995), Vega et al., Gene Targeting, CRC Press, Ann Arbor Mich. (1995), Vectors: A Survey of Molecular Cloning Vectors and Their Uses, Butterworths, Boston Mass. (1988) and Gilboa et at. [Biotechniques 4 (6): 504-512, 1986].

Construction of the viral vector of SEQ ID NO: 9 is described in International Application WO/2008/132729, the contents of which are incorporated herein by reference.

As used herein, the term "administration" refers to providing or giving a subject an agent, such as an anti-angiogenic viral composition, by any effective route.

The viral vector of this aspect of the present invention may be administered per se or as part of a pharmaceutical composition which also includes a physiologically acceptable carrier. The purpose of a pharmaceutical composition is to facilitate administration of the active ingredient to an organism.

As used herein a "pharmaceutical composition" refers to a preparation of one or more of the active ingredients described herein with other chemical components such as physiologically suitable carriers and excipients. The purpose of a pharmaceutical composition is to facilitate administration of a compound to an organism.

Herein the term "active ingredient" refers to the viral vector of the present invention accountable for the biological effect.

Hereinafter, the phrases "physiologically acceptable carrier" and "pharmaceutically acceptable carrier" which may be interchangeably used refer to a carrier or a diluent that does not cause significant irritation to an organism and does not abrogate the biological activity and properties of the administered compound. An adjuvant is included under these phrases.

Herein the term "excipient" refers to an inert substance added to a pharmaceutical composition to further facilitate administration of an active ingredient. Examples, without limitation, of excipients include calcium carbonate, calcium phosphate, various sugars and types of starch, cellulose derivatives, gelatin, vegetable oils and polyethylene glycols.

Techniques for formulation and administration of drugs may be found in "Remington's Pharmaceutical Sciences," Mack Publishing Co., Easton, PA, latest edition, which is incorporated herein by reference.

Suitable routes of administration may, for example, include oral, rectal, transmucosal, especially transnasal, intestinal or parenteral delivery, including intramuscular, intradermal, intraperitoneal, subcutaneous and intramedullary injections as well as intrathecal, direct intraventricular, intracardiac, e.g., into the right or left ventricular cavity, into the common coronary artery, intravenous, inrtaperitoneal, intranasal, or intraocular injections, sublingual, rectal, transdermal, intranasal, vaginal and inhalation routes. Injection of the viral vectors into a spinal fluid can also be used as a mode of administration.

The viral vectors or compositions thereof can be administered in an in-patient or out-patient setting. In one particular embodiment, the viral vectors or compositions thereof are administered in an injection or in an intravenous drip.

The present invention also contemplates engineering of the viral vectors in order to avoid, suppress or manipulate the immune response, ideally resulting in sustained expression and immune tolerance to the transgene product – such methods are described for example in Nayak et al., *Gene Therapy* (12 November 2009), incorporated herein by reference.

Alternately, one may administer the pharmaceutical composition in a local rather than systemic manner, for example, via injection of the pharmaceutical composition directly into the tissue or tumor mass of a patient and even more directly into the tumor cells themselves.

Pharmaceutical compositions of the present invention may be manufactured by processes well known in the art, e.g., by means of conventional mixing, dissolving, granulating, dragee-making, levigating, emulsifying, encapsulating, entrapping or lyophilizing processes.

Pharmaceutical compositions for use in accordance with the present invention thus may be formulated in conventional manner using one or more physiologically acceptable carriers comprising excipients and auxiliaries, which facilitate processing of the active ingredients into preparations which, can be used pharmaceutically. Proper formulation is dependent upon the route of administration chosen.

For injection, the active ingredients of the pharmaceutical composition may be formulated in aqueous solutions, preferably in physiologically compatible buffers such as Hank's solution, Ringer's solution, or physiological salt buffer. For transmucosal administration, penetrants appropriate to the barrier to be permeated are used in the formulation. Such penetrants are generally known in the art.

For buccal administration, the compositions may take the form of tablets or lozenges formulated in conventional manner.

For administration by nasal inhalation, the active ingredients for use according to the present invention are conveniently delivered in the form of an aerosol spray presentation from a pressurized pack or a nebulizer with the use of a suitable propellant, e.g., dichlorodifluoromethane, trichlorofluoromethane, dichloro-tetrafluoroethane or carbon dioxide. In the case of a pressurized aerosol, the dosage unit may be determined by providing a valve to deliver a metered amount. Capsules and cartridges of, e.g., gelatin for use in a dispenser may be formulated containing a powder mix of the compound and a suitable powder base such as lactose or starch.

The pharmaceutical composition described herein may be formulated for parenteral administration, e.g., by bolus injection or continuous infusion. Formulations for injection may be presented in unit dosage form, e.g., in ampoules or in multidose containers with optionally, an added preservative. The compositions may be suspensions, solutions or emulsions in oily or aqueous vehicles, and may contain formulatory agents such as suspending, stabilizing and/or dispersing agents.

Pharmaceutical compositions for parenteral administration include aqueous solutions of the active preparation in water-soluble form. Additionally, suspensions of the active ingredients may be prepared as appropriate oily or water based injection suspensions. Suitable lipophilic solvents or vehicles include fatty oils such as sesame oil, or synthetic fatty acids esters such as ethyl oleate, triglycerides or liposomes. Aqueous injection suspensions may contain substances, which increase the viscosity of the suspension, such as sodium carboxymethyl cellulose, sorbitol or dextran. Optionally, the suspension may also contain suitable stabilizers or agents which increase the solubility of the active ingredients to allow for the preparation of highly concentrated solutions.

Alternatively, the active ingredient may be in powder form for constitution with a suitable vehicle, e.g., sterile, pyrogen-free water based solution, before use.

The pharmaceutical composition of the present invention may also be formulated in rectal compositions such as suppositories or retention enemas, using, e.g., conventional suppository bases such as cocoa butter or other glycerides.

Pharmaceutical compositions suitable for use in context of the present invention include compositions wherein the active ingredients are contained in an amount effective to achieve the intended purpose. More specifically, a therapeutically effective amount means an amount of active ingredients (i.e. viral particles) effective to prevent, alleviate or ameliorate symptoms of a disorder (e.g., thyroid cancer, neuroendocrine cancer) or prolong the survival of the subject being treated.

Determination of a therapeutically effective amount is well within the capability of those skilled in the art, especially in light of the detailed disclosure provided herein. Therapeutic efficacy of administration of the adenoviral vector of the present invention can be assessed according to a variety of criteria, including clinical presentation, biochemical parameters, radiological evaluation and the like. In some embodiments, efficacy is evaluated according to one or more of the following exemplary parameters:

Biodistribution: for example, levels of virus DNA in blood and urine samples, expression of the fas-c transgene (mRNA) in blood;

Antibodies: for example, levels of total anti-Ad-5 Ig, IgG and neutralizing anti-Ad5 antibodies in serum;

Angiogenic biomarkers: for example, von Willebrand Factor, TNFα, VEGFR1 and VEGFR2 levels in the blood;

Cytokine levels: for example, peripheral blood cytokine levels (e.g. IL-6, IL-8- see Table 6);

Tumor response: Tumor dimensions can be measured on CT (or MRI) scans, or other radiographic means. Tumor response can then be evaluated according to accepted criteria, such as Response Evaluation Criteria in Solid Tumors (RECIST).

The criteria can be evaluated at any time following administration, and can also be compared to pre-dosing values. In one embodiment, the evaluation criteria are assessed prior to administration of the adenovirus vector, and then on days 4±1, 7±1, 14±1, 28 ± 2, day 56 ±3, day 112±4, about 3 months, about 4 months, about 5 months, about 6 months, about 1 year or more post dosing. In some embodiments, the evaluation criteria are assessed at day 7±1, 14±1, 28 ± 2, day 56 ±3, day 112±4, about 3 months, about 6 months, about 9 months, about 1 year and about every 3 months thereafter for up to 2, up to 3, up to 4 or more years post dosing.

Determination of safety of dosing or dosing regimen is well within the ability of one skilled in the art. Safety can be assessed according to a variety of criteria, including, but not limited to, clinical presentation, tissue and organ pathology, presence of abnormal vital signs (e.g. pyrexia, fatigue, chills, tachycardia, hypertension, constipation and the like), hematology values (e.g. hemoglobin, hematocrit, RCV and the like), chemistry or urinalysis abnormalities (elevated enzymes such as alkaline phosphatase ALT, AST, bilirubin and the like) and ECG, EEG, etc.

As used herein, the term "antibody" refers to a molecule including an antigen binding site which specifically binds (immunoreacts with) an antigen. The term "antibody" includes intact molecules as well as functional fragments thereof, such as Fab, F(ab')2, and Fv that are capable of binding to macrophages. These functional antibody fragments are defined as follows: (1) Fab, the fragment which contains a monovalent antigen-binding fragment of an antibody molecule, can be produced by digestion of whole antibody with the enzyme papain to yield an intact light chain and a portion of one heavy chain; (2) Fab', the fragment of an antibody molecule that can be obtained by treating whole antibody with pepsin, followed by reduction, to yield an intact light chain and a portion of the heavy chain; two Fab' fragments are obtained per antibody molecule; (3) (Fab')2, the fragment of the antibody that can be obtained by treating whole antibody with the enzyme pepsin without subsequent reduction; F(ab')2 is a dimer of two Fab' fragments held together by two disulfide bonds; (4) Fv, defined as a genetically engineered fragment containing the variable region of the light chain and the variable region of the heavy chain expressed as two chains; and (5) Single chain antibody ("SCA"), a genetically engineered molecule containing the variable region of the light chain and the variable region of the heavy chain, linked by a suitable polypeptide linker as a genetically fused single chain molecule.

Methods of producing polyclonal and monoclonal antibodies as well as fragments thereof are well known in the art (See for example, Harlow and Lane, Antibodies: A Laboratory Manual, Cold Spring Harbor Laboratory, New York, 1988, incorporated herein by reference).

As used herein, the term "antigen" refers to a substance that can stimulate the production of antibodies or a T-cell response in a mammal, including compositions that are injected or absorbed into a mammal. An antigen reacts with the products of specific humoral or cellular immunity, including those induced by heterologous immunogens. The term "antigen" includes all related antigenic epitopes. In one example, an antigen is a cancer antigen. A target antigen is an antigen against which an immune response is desired, for example to achieve a therapeutic effect, such as tumor regression.

For any preparation used in the methods of the invention, the therapeutically effective amount or dose can be estimated initially from in vitro and cell culture assays. For example, a dose can be formulated in animal models to achieve a desired concentration or titer. Such information can be used to more accurately determine useful doses in humans.

The therapeutically effective amount of the active ingredient can be formulated in a unit dose. As used herein "unit dose" refers to a physically discrete unit containing a predetermined quantity of an active material calculated to individually or collectively produce a desired effect such as an anti-cancer effect. A single unit dose or a plurality of unit doses can be used to provide the desired effect, such as an anti-cancer therapeutic effect. In some embodiments, the unit dosage is $1X10^8$ to about $1X10^{16}$ virus particles, at least about $1X10^{11}$ to about $1X10^{13}$ virus particles, and optionally about $1X10^{11}$, about $3X10^{11}$, about $5X10^{11}$, about $1X10^{12}$, about $3X10^{12}$, about $5X10^{12}$, about $1X10^{13}$, about $3X10^{13}$ or more virus particles.

Toxicity and therapeutic efficacy of the active ingredients described herein can be determined by standard pharmaceutical procedures in vitro, in cell cultures or experimental animals. The data obtained from these in vitro and cell culture assays and animal studies can be used in formulating a range of dosage for use in human. The dosage may vary depending upon the dosage form employed and the route of administration utilized. The exact formulation, route of administration and dosage can be chosen by the individual physician in view of the patient's condition. (See e.g., Fingl, et al., 1975, in "The Pharmacological Basis of Therapeutics", Ch. 1 p.1).

Dosage amount and interval may be adjusted individually to provide levels of the active ingredient sufficient to induce or suppress the biological effect (minimal effective concentration, MEC). The MEC will vary for each preparation, but can be estimated from in vitro data. Dosages necessary to achieve the MEC will depend on individual characteristics and route of administration. Detection assays can be used to determine plasma concentrations.

Depending on the severity and responsiveness of the condition to be treated, dosing can be of a single or a plurality of administrations, with course of treatment lasting from several days to several weeks or until cure is effected or diminution of the disease state is achieved.

The amount of a composition to be administered will, of course, be dependent on the subject being treated, the severity of the affliction, the manner of administration, the judgment of the prescribing physician, etc.

According to one embodiment, about 10^3 to about 10^{16} virus particles are administered to the subject.

According to another embodiment, about 10^5 to about 10^{13} virus particles are administered to the subject.

According to one embodiment, about 10^7 to about 10^{12} virus particles are administered to the subject.

According to one embodiment, about $1x10^{12}$ to about $5x10^{12}$ virus particles are administered to the subject.

According to yet another embodiment, about $1X10^9$ to about $1X10^{16}$ virus particles, at least about $1X10^{11}$ to about $1X10^{13}$ virus particles are administered to the subject.

According to yet another embodiment the subject is administered intravenously with $1x10^{12}$ - $1x10^{13}$ viral particles of SEQ ID NO: 9. or SEQ ID NO: 10.

According to yet another embodiment the subject is administered intravenously with at least two doses of $1x10^{12}$ – $1X10^{13}$ viral particles of SEQ ID NO: 9. or SEQ ID NO: 10. According to yet another embodiment the subject is administered intravenously with at least three or more doses of $1x10^{12}$ - $1x10^{13}$ viral particles of SEQ ID NO: 9. or SEQ ID NO: 10. In a particular embodiment, the at least two doses are administered at least about 1day, at least about 3 days, at least about 5 days, at least about 7 days, at least about 2 weeks, at least about 3 weeks, at least about 4 weeks, at least about 2 months, at least about 6 months, at least about 9 months, at least about 1 year, at least about 1.25 years, at least about 1.5 years, at least about 1.75 years, at least about 2 years, at least about 2.5 years, at least about 3 years or more apart.

Compositions of the present invention may, if desired, be presented in a pack or dispenser device, such as an FDA approved kit, which may contain one or more unit dosage forms containing the active ingredient. The pack may, for example, comprise metal or plastic foil, such as a blister pack. The pack or dispenser device may be accompanied by instructions for administration. The pack or dispenser may also be accommodated by a notice associated with the container in a form prescribed by a governmental agency regulating the manufacture, use or sale of pharmaceuticals, which notice is reflective of approval by the agency of the form of the compositions or human or veterinary administration. Such notice, for example, may be of labeling approved by the U.S. Food and Drug Administration for prescription drugs or of an approved product insert. Compositions comprising a preparation of the invention formulated in a compatible pharmaceutical carrier may also be prepared, placed in an appropriate container, and labeled for treatment of an indicated condition, as is further detailed above.

Thus, according to some aspects of some embodiments of the present invention there is provided a kit for treating a solid tumor in a subject in need thereof, comprising a unit dosage of virus particles of a non-replicating adenovirus vector comprising a polynucleotide having a nucleotide sequence as set forth in SEQ ID NOs: 9 or 10, wherein the non-replicating adenovirus vector is formulated for intravenous administration, and instructions for administration of the adenovirus.

The adenovirus vector can be used in combination with other treatments. For example, the uptake of adenoviral vectors into EC cells can be enhanced by treating the vectors with engineered antibodies or small peptides. Such "adenobody" treatment, was shown effective in directing adenovirus constructs to EGF receptors on cells (Watkins et al 1997, Gene Therapy 4:1004-1012). In addition, Nicklin et al have shown that a small peptide, isolated via phage display, increased specificity and efficiency of vectors in endothelial cells and decreased the expression in liver cells in culture (Nicklin et al

2000, Circulation 102:231-237). In a recent study, an FGF retargeted adenoviral vector reduced the toxicity of tk in mice (Printz et al 2000, Human Gene Therapy 11:191-204).

Low dose radiation has been shown to cause breaks in DNA strands primarily in the G2/M phase, cell membrane damage enhancing the bystander effect, and thus may potentiate other cytotoxic and anti-neoplastic therapies, when administered in combination. Vascular endothelial cells may be particularly suitable to such combination, or adjunct, therapies, since it has been demonstrated that low dose radiation specifically targets the apoptotic system of the microvascular endothelial cells (Kolesnick et al., Oncogene 2003; 22:5897-906). Angiostatin has been shown to potentiate the therapeutic effects of low dose radiation (Gorski et al. Can Res 1998;58:5686-89). However, the effects of radiation are still poorly understood, since irradiation has also been shown to increase pro-angiogenic "tissue repair factors" (Itasaka et al., Am Assoc Canc Res, 2003; abstract 115). Similarly, certain chemotherapeutic agents have been shown to activate specific cytotoxic and apoptotic pathways [doxorubicin, cisplatin and mitomycin C induce accumulation of Fas receptor, FADD, and other proapoptotic signals in the FADD/MORT-1 pathway (Micheau et al., BBRC 1999 256:603-07)].

For example International Application WO/2008/132729 teaches combined doxorubicin and AdPPE-1 (3x)-Fas-c chimera construct administration in endothelial cells (BAEC). Thus, the viral vectors and the pharmaceutical compositions comprising same of the present invention can be used to treat solid tumors alone or in combination with one or more other established or experimental therapeutic regimen for such disorders. Therapeutic regimen for treatment of solid tumors suitable for combination with the viral vectors of the present invention include, but are not limited to chemotherapy, radiotherapy, phototherapy and photodynamic therapy, surgery, nutritional therapy, ablative therapy, combined radiotherapy and chemotherapy, brachiotherapy, proton beam therapy, immunotherapy, cellular therapy and photon beam radiosurgical therapy. The vectors of the present invention may be administered with additional ingredients which may improve the uptake of the nucleic acid construct by the cells, expression of the chimeric polypeptide by the nucleic acid construct in the cells, the activity of the expressed chimeric polypeptide or the efficacy of the treatment on any aspects of the disease. Protocols for use of recombinant anti-angiogenic adenovirus vectors for cancer treatment are known in the art. Many clinical trials of adenovirus-based anti-angiogenic gene therapy are currently being conducted, mostly involving a recombinant anti-angiogenic adenovirus in combination with other cancer therapies, and administered intra-tumorally, such as an adenovirus-p53 vaccine with chemotherapy for small cell lung cancer (NCT0049218), adenovirus-suicide gene with chemotherapy for small cell lung cancer (NCT00964756), an adenovirus-endostatin construct with chemotherapy for head and neck cancer (NCT00634595), an adenovirus-suicide gene with chemotherapy for malignant melanoma (NCT00005057) and an adenovirus-tk construct with chemotherapy for hepatocellular carcinoma (NCT00844623).

Anti-cancer drugs that can be co-administered with the compounds of the invention include, but are not limited to Acivicin; Aclarubicin; Acodazole Hydrochloride; Acronine; Adriamycin; Adozelesin; Aldesleukin; Altretamine; Ambomycin; Ametantrone Acetate; Aminoglutethimide; Amsacrine; Anastrozole; Anthramycin; Asparaginase; Asperlin; Azacitidine; Azetepa; Azotomycin; Batimastat; Benzodepa; Bicalutamide; Bisantrene Hydrochloride; Bisnafide Dimesylate; Bevacizumab, Bizelesin; Bleomycin Sulfate; Brequinar Sodium; Bropirimine; Busulfan; Cactinomycin; Calusterone; Caracemide; Carbetimer; Carboplatin; Carmustine; Carubicin Hydrochloride; Carzelesin; Cedefingol; Chlorambucil; Cirolemycin; Cisplatin; Cladribine; Crisnatol Mesylate; Cyclophosphamide; Cytarabine; Dacarbazine; Dactinomycin; Daunorubicin Hydrochloride; Decitabine; Dexormaplatin; Dezaguanine; Dezaguanine Mesylate; Diaziquone; Docetaxel; Doxorubicin; Doxorubicin Hydrochloride; Droloxifene; Droloxifene Citrate; Dromostanolone Propionate; Duazomycin; Edatrexate; Eflornithine Hydrochloride; Elsamitrucin; Enloplatin; Enpromate; Epipropidine; Epirubicin Hydrochloride; Erbulozole; Esorubicin Hydrochloride; Estramustine; Estramustine Phosphate Sodium; Etanidazole; Etoposide; Etoposide Phosphate; Etoprine; Fadrozole Hydrochloride; Fazarabine; Fenretinide; Floxuridine; Fludarabine Phosphate; Fluorouracil; Flurocitabine; Fosquidone; Fostriecin Sodium; Gemcitabine; Gemcitabine Hydrochloride; Hydroxyurea; Idarubicin Hydrochloride; Ifosfamide; Ilmofosine; Interferon Alfa-2a; Interferon Alfa-2b; Interferon Alfa-nl; Interferon Alfa-n3; Interferon Beta- I a; Interferon Gamma- I b; Iproplatin; Irinotecan Hydrochloride; Lanreotide Acetate;

Letrozole; Leuprolide Acetate; Liarozole Hydrochloride; Lometrexol Sodium; Lomustine; Losoxantrone Hydrochloride; Masoprocol; Maytansine; Mechlorethamine Hydrochloride; Megestrol Acetate; Melengestrol Acetate; Melphalan; Menogaril; Mercaptopurine; Methotrexate; Methotrexate Sodium; Metoprine; Meturedepa; Mitindomide; Mitocarcin; Mitocromin; Mitogillin; Mitomalcin; Mitomycin; Mitosper; Mitotane; Mitoxantrone Hydrochloride; Mycophenolic Acid; Nocodazole; Nogalamycin; Ormaplatin; Oxisuran; pazotinib; Paclitaxel; Pegaspargase; Peliomycin; Pentamustine; Peplomycin Sulfate; Perfosfamide; Pipobroman; Piposulfan; Piroxantrone Hydrochloride; Plicamycin; Plomestane; Porfimer Sodium; Porfiromycin; Prednimustine; Procarbazine Hydrochloride; Puromycin; Puromycin Hydrochloride; Pyrazofurin; Riboprine; Rogletimide; Safingol; Safingol Hydrochloride; Semustine; Simtrazene; Sorafinib; Sparfosate Sodium; Sparsomycin; Spirogermanium Hydrochloride; Spiromustine; Spiroplatin; Streptonigrin; Streptozocin; Sulofenur; Sunitinib; Talisomycin; Taxol; Tecogalan Sodium; Tegafur; Teloxantrone Hydrochloride; Temoporfin; Teniposide; Teroxirone; Testolactone; Thiamiprine; Thioguanine; Thiotepa; Tiazofuirin; Tirapazamine; Topotecan Hydrochloride; Toremifene Citrate; Trestolone Acetate; Triciribine Phosphate; Trimetrexate; Trimetrexate Glucuronate; Triptorelin; Tubulozole Hydrochloride; Uracil Mustard; Uredepa; Vapreotide; Verteporfin; Vinblastine Sulfate; Vincristine Sulfate; Vindesine; Vindesine Sulfate; Vinepidine Sulfate; Vinglycinate Sulfate; Vinleurosine Sulfate; Vinorelbine Tartrate; Vinrosidine Sulfate; Vinzolidine Sulfate; Vorozole; Zeniplatin; Zinostatin; Zorubicin Hydrochloride. Additional antineoplastic agents include those disclosed in Chapter 52, Antineoplastic Agents (Paul Calabresi and Bruce A. Chabner), and the introduction thereto, 1202-1263, of Goodman and Gilman's "The Pharmacological Basis of Therapeutics", Eighth Edition, 1990, McGraw-Hill, Inc. (Health Professions Division).

The present inventors have shown that administering a single dose of the viral vectors of the present invention (e.g. Ad5PPE-1-3X fas-chimera) in combination with the chemotherapeutic drug sunitinib (Sutent), can improve the efficacy of the chemotherapy treatment, or of the viral vector's effect on a metastatic cancer, in the Lewis Lung Carcinoma model (see Example VI below). Thus, in some embodiments the viral vectors of the present invention are administered in combination with one or more of the chemotherapeutic drugs, such as sunitinib (Sutent).

Chemotherapeutic agents can be administered along with the viral vectors of the invention, prior to treatment with the viral vectors of the present invention, or following treatment with the viral vectors of the present invention. In a particular embodiment, the chemotherapeutic agent is administered at least about 1day, at least about 3 days, at least about 5 days, at least about 7 days, at least about 2 weeks, at least about 3 weeks, at least about 4 weeks, at least about 2 months, at least about 6 months, at least about 9 months, at least about 1 year prior to initiation of treatment with the viral vector of the present invention. In another particular embodiment, the chemotherapeutic agent is administered at least about 1day, at least about 3 days, at least about 5 days, at least about 7 days, at least about 2 weeks, at least about 3 weeks, at least about 4 weeks, at least about 2 months, at least about 6 months, at least about 9 months, at least about 1 year following initiation of treatment with the viral vector of the present invention. In another particular embodiment, the chemotherapeutic agent is administered during, or alongside with initiation of treatment with the viral vector of the present invention.

The viral vectors of the present invention may also be administered with an agent that enhances expression of transgenes in adenoviral-mediated transient expression. For example International Application WO/2008/132729 teaches administration of a corticosteroid (e.g. dexamethasone and/or N-Acetyl Cysteine (NAC) prior to AdPPE-1 (3x)-Fas-c chimera construct administration, or concomitant treatment with an endothelin inhibitor such as bosentan.

In addition, the viral vectors of the present invention may also be administered with an agent that brings about transient immunosuppression, such as for example deoxyspergualin (DSG) or cyclophosphamide (see for example Smith et al., Gene Ther. 1996 Jun;3(6):496-502) in order to allow for repetitive dosing.

Adenovirus-based gene therapy protocols have commonly been limited to single doses, for reasons pertaining to safety and efficacy of the drug, particularly concerning patient anti-adenovirus immune response, as most populations are repeatedly exposed and sensitized to various adenoviral antigens. The present inventors have surprisingly found no correlation between levels of anti-adenovirus antibodies in serum of patients following administration of the adenovirus of the invention, and the dose of adenovirus administered. Evaluation of antibody titers, including anti-Ad5 neutralizing antibodies, IgG and total anti-Ad5 antibodies in the patients (see Example II, and FIGs. 2 and 3A-3B) revealed no effect of the baseline levels of neutralizing anti-adenovirus antibody on disease progression following dosing. Evaluation of total anti-adenovirus Ad5 antibody titers, and specific anti-Ad5 IgG in serum of patients prior to, and following administration of the Ad5-PPE-1-3X-fas-c adenoviral vectors revealed increased antibody titers following adenovirus vector administration, but indicated no correlation with the doses administered (see Table 4 in Example II that follows), suggesting that repeated doses of the adenovirus as described herein may not lead to an immune response limiting the clinical utility of the adenovirus in the host. Further, it was found that administration of Ad5PPE-1-3X-fas chimera was effective in reducing disease progression even in subjects with high levels of neutralizing anti-Ad5 antibodies and total anti-Ad5 antibodies detected prior to first injection of the construct (see FIGs. 2 and 3). Yet further, assays of blood and urine Ad5-PPE-1-3X-fas-c levels (biodistribution) following administration revealed high levels of the adenovirus constructs of the invention 28 days post-administration, even in the presence of elevated total or IgG anti-Ad5 antibody levels (see Tables 4 and 7 of Example II that follows, specifically, see subjects 2, 9 and 10). In one subject [036], for example, significant levels of transgene expression were detected in an aspirate from a metastatic lesion as many as 28 days following adenovirus vector administration, despite a massive fold increase (X3125) in anti-Ad5 antibody titer (see Tables 4 and 9 in Example II that follows).

Thus, in some embodiments, administering the dose of the adenovirus vector of the present invention inhibits growth of a tumor. In other embodiments, administering the adenovirus vector inhibits angiogenesis of the tumor.

Thus, the adenovirus vectors of the present invention can be administered in one, at least two, three or more doses, with intervals therebetween sufficient for antibody formation, without causing a dose-dependent antiviral antibody response. Such intervals are typically 21-28 days, but may be as few as 1 or 2 days, or as many as 7 days, 10 days, 2 weeks, three weeks, four, six, eight ten or more weeks. Thus, according to another aspect of some embodiments of the present invention there is provided a method for administering a therapeutically effective amount of a therapeutic composition comprising an adenoviral vector to a subject in need thereof comprising administering the composition to the subject at least twice, wherein the administration does not induce a dose-dependent increase in antibodies against the adenoviral vector in the subject. According to another aspect of one embodiment of the present invention, the time between administration between a first dose and an at least second dose is sufficient for anti-Ad5 antibody formation.

In yet another embodiment, the adenovirus vectors of the present invention are effective when administered to subjects having elevated levels of serum anti Ad5 antibodies. In some particular embodiments the anti-Ad5 antibody levels are elevated compared to the subjects pre-dosing baseline anti-Ad5 levels. In yet other embodiments, the adenovirus vectors of the present invention are detected in the blood of the subjects having elevated anti-Ad5 antibody levels are compared to the subjects pre-dosing baseline anti-Ad5 levels, at day 4 post-administration, day 7 post-administration, day 15 post-administration, day 21 post-administration, day 28 post-administration, day 37 post-administration, day 56 post-administration or day 112 post-administration or more. Such anti-Ad5 antibodies can be neutralizing antibodies, total anti-Ad5 antibodies, or a specific anti-Ad5 antibody subtype, such as anti-Ad5 IgG.

Thus, in some embodiments, the adenovirus is detected in the blood of the subject at least about 4 days post administration. According to other embodiments an amount of serum anti-adenovirus antibodies is increased following the administering, and the adenovirus is detected in the blood of the subject at least about 21 days post administration.

It is expected that during the life of a patent maturing from this application many relevant chemotherapeutic agents will be developed and the scope of the term chemotherapeutic agent is intended to include all such new technologies *a priori*.

As used herein the term “about” refers to ± 10 %.

The terms "comprises", "comprising", "includes", "including", “having” and their conjugates mean "including but not limited to".

The term “consisting of means “including and limited to”.

The term "consisting essentially of" means that the composition, method or structure may include additional ingredients, steps and/or parts, but only if the additional ingredients, steps and/or parts do not materially alter the basic and novel characteristics of the claimed composition, method or structure.

As used herein, the singular form "a", "an" and "the" include plural references unless the context clearly dictates otherwise. For example, the term "a compound" or "at least one compound" may include a plurality of compounds, including mixtures thereof.

Throughout this application, various embodiments of this invention may be presented in a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the invention. Accordingly, the description of a range should be considered to have specifically disclosed all the possible subranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed subranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

Whenever a numerical range is indicated herein, it is meant to include any cited numeral (fractional or integral) within the indicated range. The phrases “ranging/ranges between” a first indicate number and a second indicate number and “ranging/ranges from” a first indicate number “to” a second indicate number are used herein interchangeably and are meant to include the first and second indicated numbers and all the fractional and integral numerals therebetween.

As used herein the term "method" refers to manners, means, techniques and procedures for accomplishing a given task including, but not limited to, those manners, means, techniques and procedures either known to, or readily developed from known manners, means, techniques and procedures by practitioners of the chemical, pharmacological, biological, biochemical and medical arts.

As used herein, the term “treating” includes abrogating, substantially inhibiting, slowing or reversing the progression of a condition, substantially ameliorating clinical or aesthetical symptoms of a condition or substantially preventing the appearance of clinical or aesthetical symptoms of a condition.

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable subcombination or as suitable in any other described embodiment of the invention. Certain features described in the context of various embodiments are not to be considered essential features of those embodiments, unless the embodiment is inoperative without those elements.

Various embodiments and aspects of the present invention as delineated hereinabove and as claimed in the claims section below find experimental support in the following examples.

EXAMPLES

Reference is now made to the following examples, which together with the above descriptions illustrate some embodiments of the invention in a non limiting fashion.

Generally, the nomenclature used herein and the laboratory procedures utilized in the present invention include molecular, biochemical, microbiological and recombinant DNA techniques. Such techniques are thoroughly explained in the literature. See, for example, "Molecular Cloning: A laboratory Manual" Sambrook et al., (1989); "Current Protocols in Molecular Biology" Volumes I-III Ausubel, R. M., ed. (1994); Ausubel et al., "Current Protocols in Molecular Biology", John Wiley and Sons, Baltimore, Maryland (1989); Perbal, "A Practical Guide to Molecular Cloning", John Wiley & Sons, New York (1988); Watson et al., "Recombinant DNA", Scientific American Books, New York; Birren et al. (eds) "Genome Analysis: A Laboratory Manual Series", Vols. 1-4, Cold Spring Harbor Laboratory Press, New York (1998); methodologies as set forth in U.S. Pat. Nos. 4,666,828; 4,683,202; 4,801,531; 5,192,659 and 5,272,057; "Cell Biology: A Laboratory Handbook", Volumes I-III Cellis, J. E., ed. (1994); "Culture of Animal Cells - A Manual of Basic Technique" by Freshney, Wiley-Liss, N. Y. (1994), Third Edition; "Current Protocols in Immunology" Volumes I-III Coligan J. E., ed. (1994); Stites et al. (eds), "Basic and Clinical Immunology" (8th Edition), Appleton & Lange, Norwalk, CT (1994); Mishell and Shiigi (eds), "Selected Methods in Cellular Immunology", W. H. Freeman and Co., New York (1980);

available immunoassays are extensively described in the patent and scientific literature, see, for example, U.S. Pat. Nos. 3,791,932; 3,839,153; 3,850,752; 3,850,578; 3,853,987; 3,867,517; 3,879,262; 3,901,654; 3,935,074; 3,984,533; 3,996,345; 4,034,074; 4,098,876; 4,879,219; 5,011,771 and 5,281,521; "Oligonucleotide Synthesis" Gait, M. J., ed. (1984); "Nucleic Acid Hybridization" Hames, B. D., and Higgins S. J., eds. (1985); "Transcription and Translation" Hames, B. D., and Higgins S. J., eds. (1984); "Animal Cell Culture" Freshney, R. I., ed. (1986); "Immobilized Cells and Enzymes" IRL Press, (1986); "A Practical Guide to Molecular Cloning" Perbal, B., (1984) and "Methods in Enzymology" Vol. 1-317, Academic Press; "PCR Protocols: A Guide To Methods And Applications", Academic Press, San Diego, CA (1990); Marshak et al., "Strategies for Protein Purification and Characterization - A Laboratory Course Manual" CSHL Press (1996); all of which are incorporated by reference as if fully set forth herein. Other general references are provided throughout this document. The procedures therein are believed to be well known in the art and are provided for the convenience of the reader. All the information contained therein is incorporated herein by reference.

Example I

Efficacy of Ad5PPE-1-3X-fas chimera in Lewis Lung Carcinoma Model

In order to evaluate effective dosage ranges Ad5PPE-1-3X-fas chimera adenovirus for treatment of solid tumors, metastatic tumors were induced in the mouse Lewis Lung Carcinoma model, and a range of doses of Ad5PPE-1-3X-fas chimera adenovirus (SEQ ID NO: 10) administered systemically.

MATERIALS AND EXPERIMENTAL METHODS

Construction and cloning of the viral vector:

The vector was constructed using a backbone containing most of the genome of adenovirus type 5, as well as partial homology to an adaptor plasmid, which enables recombination.

The E1 early transcriptional unit was deleted from the backbone plasmid, and further modified by deleting the pWE25 and the Amp resistance selection marker site.

The adaptor plasmid, containing sequences of the Ad5, CMV promoter, MCS, and SV40 polyA was modified to delete deleting the CMV promoter, and the PPE-1 promoter and Fas-c fragment were inserted by restriction digestion.

The modified PPE-1 promoter (PPE-1-3X, SEQ ID NO: 12) and the Fas-chimera transgene (Fas-c, SEQ ID NO: 4) were utilized for construction of the adenoviral vector. The PPE-1- (3X)-Fas-c element (2115bp) was constructed from the PPE-1- (3X)-luc element. This element contains the 1.4kb of the murine preproendothelin PPE-1-(3X) promoter, the Luciferase gene, the SV40 polyA site and the first intron of the murine ET-1 gene, originated from the pEL8 plasmid (8848bp) used by Harats et al (Harats D. et al., JCI, 1995). The PPE-3-Luc cassette was extracted from the pEL8 plasmid using the BamHI restriction enzyme. The Luciferase gene was substituted by the Fas-c gene [composed of the extra cellular and intra membranal domains of the human TNF-R1 (Tumor Necrosis Factor Receptor 1, SEQ ID NO: 2) and of the Fas (p55) intracellular domain (SEQ ID NO: 3) (Boldin et al, JBC, 1995)] to obtain the PPE-1-3x-Fas-c cassette.

PPE-1(3x)-Fas-c Plasmid - The cassette was further introduced into the backbone plasmid by restriction digestion, resulting with the PPE-1(3x)-Fas-c plasmid.

Adaptor-PPE-1(3x)-Fas-c Plasmid - The PPE-1-3x-Fas-c element was extracted from the first generation construct PPE-1-3x-Fas-c plasmid, and was amplified with designated PCR primers introducing SnaB1 and EcoR1 restriction sites at the 5'-and-3'-end respectively. These sites were used to clone the PPE-Fas-c fragment into the adaptor plasmid digested with SnaB1 and EcoR1, resulting in the adaptor-PPE-1-3x-Fas-c used for transfection of the host cells (for example, PER.C6 cells).

Lewis Lung Carcinoma model

Freshly harvested D122 Lewis Lung Carcinoma (LLC) cells ($5x10^5$ per mouse) were administered to C57BL/6 mice (3 months old), by subcutaneous injection into the foot pad. Primary tumors developed in the feet in about 14 days. When tumors reached a diameter of at least 7 mm, the mice were anesthetized and the distal segment of the limb was amputated. Five days after limb amputation, mice were randomized to one of the following groups:

	Treatment	**Dose- virus particles (vp/mouse)**
Group 1	Ad5PPE-1-3X-fas chimera adenovirus	10^{11}
Group 2	Ad5PPE-1-3X-fas chimera adenovirus	10^{10}
Group 3	Ad5PPE-1-3X-fas chimera adenovirus	10^{9}

Group 4	Ad5PPE-1-3X-fas chimera adenovirus	10^8
Group 5	Ad5PPE-1-3X-fas chimera adenovirus	10^7
Group 6	Ad5PPE-1-3X-fas chimera adenovirus	10^6
Group 7	Vehicle	0

Vehicle =PBS, 10% glycerol

Viruses were intravenously injected to the mouse tail. Mice were sacrificed upon death of 5 control (vehicle injected) mice (approximately 24 days after virus/control administration). Mice in which the primary tumor re-emerged after treatment, were withdrawn from the study. Upon sacrifice, animal's lungs were removed, washed and weighed, and blood was collected for liver function testing.

Liver and tumor tissues were cut and frozen in 4% formaldehyde or in OCT compound for histological analysis by hematoxylin-eosin staining or anti PECAM1 (anti- CD31) staining, respectively. Tumor weight differences were evaluated using the Mann-Whitney U-test.

The purpose of this study was to evaluate the dose dependent efficacy of Ad5PPE-1-3X-fas chimera adenovirus and to assess the minimal effective dose.

Results

Clinically significant doses (10^6 to 10^{11} vp/mouse) of Ad5PPE-1-3X-fas chimera adenovirus do not cause non-specific systemic effects

Mortality was observed in all groups prior to scheduled sacrifice with no dose response trend. Clinical signs of surviving mice did not reveal any abnormalities. No dose response trend was observed in mice weights.

No statistical significant differences were observed in the kidney function in all groups, except for an increase in uric acid observed at the lowest dose cohort on day 5 post dosing. No statistical significant differences were observed in the SGOP and SGPT levels of treated vs. non treated mice.

Macroscopic examination at necropsy (brain, liver heart, spleen, gonads, kidneys, small intestine, lungs), did not reveal any abnormalities except for metastases found in the lungs. No statistical differences were found in the weight of organs between groups (liver, spleen, small intestine, heart, kidney, lung, and brain), except for the heart and spleen where an increase (not dose dependent) in the weight was observed in mice treated with adenovirus compared to the untreated mice.

Microscopic observations (on the lung, liver and heart) showed mild to moderate inflammation and regenerative changes of the liver following treatment with 10^8-10^{11} vp/mouse.

Ad5PPE-1-3X-fas chimera adenovirus (10^8 to 10^{11} vp/mouse) suppresses metastatic tumor growth

FIGs. 1A-1C show exemplary lungs of treatment and control groups, at the completion of the study. In the lung, large metastases were found in mice treated with vehicle (FIG. 1A). These metastases were reduced in a dose dependent fashion in Ad5PPE-1-3X-fas chimera adenovirus-treated mice (FIGs. 1B-1C), with the strongest effect in the highest dose (10^{11} vp/mouse) cohort (FIG. 1C), in which most of the lungs appeared to be normal or with only small metastases. This effect decreased to non observable levels at low titers of the virus (10^7 vp/mouse and 10^6 vp/mouse). The protective, anti-tumor effect of the Ad5PPE-1-3X-fas chimera adenovirus was confirmed by the difference in weight of the lungs of the Ad5PPE-1-3X-fas chimera adenovirus-treated mice, which was significantly reduced when compared to control mice but diminished to non observable level at low virus titers (FIG. 1D).

Thus, a single, systemic injection of a clinically significant amount of Ad5PPE-1-3X-fas chimera adenovirus was highly effective in reducing the tumor burden in Lewis Lung Carcinoma model in a dose dependent fashion. 10^{11} vp/mouse resulted in a 70% decrease in tumor burden. No efficacy of treatment was observed at the lowest doses (10^6 vp/mouse-10^7 vp/mouse).

<u>Example II</u>

Administration of Ad5PPE-1-3X-fas chimera in the clinical setting

In order to determine the safety and efficacy of administration of AD5PPE-1-3X-fas-chimera in the clinical setting, outcomes such as toxicity, adverse effects, antibody titer, biodistribution, disease progression and disease recurrence and survival were monitored in subjects with solid primary and metastatic tumors receiving intravenous infusion of a range of doses of the Ad5PPE-1-3X-fas chimera adenovirus vector.

MATERIALS AND EXPERIMENTAL METHODS

Subject population:

Subjects with advanced and/or metastatic solid organ cancer 18 years of age and older, without remaining options for standard curative or palliative measures are enrolled.

Criteria for subject's inclusion in the treatment group are:

1. Subjects at least 18 years of age;
2. Histologically confirmed malignancy that is metastatic or unresectable and for which standard curative or palliative measures do not exist or are no longer effective;
3. Karnofsky performance status of ≥ 70%;
4. Adequate haematological profile: ANC >1500/μl, hemoglobin ≥10g/dl, platelets >100,000/μl, and INR within normal limits;
5. Adequate renal function (CCT >60 mL/min/1.73 m2);
6. Adequate hepatic function: (ALT and AST<2.5 x ULN) and total bilirubin within normal limits.

Criteria for subject's exclusion from the treatment group are:

1. Recent cardiac event (within 12 months) or active cardiac/vascular disease;
2. Recent surgery (within 4 weeks);
3. Proliferative retinopathy;
4. Liver disease;
5. CNS metastasis;
6. Recent anti-angiogenic therapy (within 6 weeks);
7. Current/recent (within 4 weeks) immunosuppressive therapy;
8. Recent chemo/radiotherapy or investigational agent (within 4 weeks);
9. Uncontrolled co-morbidity.

Composition: Ad5-PPE-1-3X-fas-chimera

Ad5-PPE-1-3X-fas-chimera (SEQ ID NO: 10) is a vascular disruptive gene therapeutic, consisting of a non-replicating adenovirus vector (Ad5, E1 deleted, SEQ ID NO: 1) which contains a modified murine pre-proendothelin promoter (PPE-1-3x, SEQ ID NO: 12) and a fas-chimera transgene [Fas and human tumor necrosis factor (TNF) receptor](SEQ ID NO: 4). It is formulated as a sterile vector solution and supplied frozen (below -65°C), in single use vials. Each vial contains 0.5 mL of vector solution at a specific viral titer.

Dosage

Dose escalation is done by cohort as follows:

Dose (virus particles)		Subjects per Cohort
Cohort 1	$1x10^{10}$	3
Cohort 2	$3x10^{10}$	3
Cohort 3	$1x10^{11}$	3
Cohort 4	$3x10^{11}$	3
Cohort 5	$1x10^{12}$	3
Cohort 6	$3x10^{12}$	12
Cohort 7	$1x10^{13}$	6

Since no dose limiting toxicity was observed after dosing 3 subjects in each of the first 6 cohorts, 9 additional subjects were enrolled into cohort 6 according to the protocol and after approval of the Institutional Review Boards. 27 subjects (3 in each of cohorts 1-5 [total of 15 subjects] and 12 in Cohort 6) were treated. Since no dose limiting toxicity was observed, 6 more patients were enrolled to cohort 7. A total of 33 subjects were treated. One case of NCI Grade 3 fever, shortly following administration of the highest dose (cohort 7), was observed.

The Ad5-PPE-1-3X-fas-chimera is administered as an intravenous infusion. The same drug volume and saline volume were used for each subject within each cohort, and each subject was infused with the same volume of the drug. The infusion duration was between 3 and 5 minutes in cohorts 1-5 and 15 minutes in cohort 6 and 50 minutes for cohort 7. In general, these numbers reflect the instructions specified in the pharmacy manual provided with the study.

Subject evaluation criteria

Biodistribution: Blood and urine samples were collected prior to dosing, at the end of the infusion (blood samples only), 3 hours, 6 hours, and on days 4(±1), 7(±1), 14(±1), 28(±2) and at day 56(±3) for evaluation of levels of virus DNA (in blood and urine) and the expression of the transgene (messenger RNA in blood). Only samples with detectable viral DNA are tested for transgene expression.

Antibodies: Serum samples were collected prior to dosing for analysis of total anti-Ad-5 Ig, IgG and neutralizing anti-Ad5 antibody levels, and on day 28 and day 56 for analysis of total anti-Ad-5 Ig, IgG anti-Ad5 antibody levels.

Ad-5-IgG assay: Serum samples were diluted and analyzed for adenovirus-specific immunoglobulin G (IgG) by ELISA. For the ELISA, 96 well flat bottomed, high-binding Immulon-IV plates were coated with 50 ul Ad5-antigen (Upenn Vector Core) at (5x10^8 particles/well) in pH 9.5 carbonate buffer (coating buffer) overnight at 4°C, washed two times in PBS/0.05% Tween, blocked in PBS/1% HSA for 1 hour at 24°C, and then washed two times in PBS/0.05 Tween. Appropriately diluted (3-fold) samples were added to antigen-coated plates and incubated for 4 hours at room temperature. Plates were washed three times with PBS/0.05% Tween and incubated with peroxidase conjugated goat anti-human Ig (1:5000 dilution, Jackson ImmunoResearch Laboratories, Inc.) for 1 hour at room temperature. Plates were washed three times as above and TMB substrate (Sigma Chemical Co., St Louis, MO) is added at 100 ul/well for 30 minutes. Reaction was stopped when 100 ul 2N H_2SO_4 was added, and optical densities were read at 450nm on a VersaMAX tunable microplate reader (Molecular Devices). Titer is the dilution achieving 0.5 maximum OD.

Neutralizing anti-Ad5 antibodies assay: The ability of serum to block adenovirus infection of Hela cells (ATCC) in vitro was analyzed utilizing adenovirus expressing green fluorescent protein (GFP) as a reporter (Upenn Vector Core). Various dilutions of test sera and, as a control/standard, pooled AB sera (Sigma), pre-incubated with moi of 1000 of reporter viruses for 1 hour at 37°C were added to 90% confluent cell cultures. Cells were incubated for 16 hours and expression of GFP quantified by fluoroimaging using the Victor^2 (Wallace/PerkinElmer) and visually. The neutralizing titer of the sera was calculated as the reciprocal dilution of serum with 50% of the maximum fluorescence at 1000 MOI.

Angiogenic biomarkers: Blood samples were collected prior to dosing, and at the following visits thereafter, for evaluation of von Willebrand Factor levels and TNFα levels, on days 4±1, 7±1, 14±1, 28 ± 2 and at day 56 ±3 post dosing.

Cytokine levels: Peripheral blood cytokine (see Table 6 below) levels were measured in cohort 6 patients at baseline, and at the following times after dosing with Ad5-PPE-1-3X-fas-chimera, at 6 hours, 4 days, 7 days, 14 days, 28 days, and 56 days post dosing.

Tumor response: The possible effect of the drug treatment on tumor response was evaluated by measuring the tumor dimensions on CT (or MRI) scans according to Response Evaluation Criteria in Solid Tumors (RECIST) criteria at screening and at week 4 and 8 post dosing, or according to RECIST criteria at screening, baseline day -1/0 and at day 7±1, week 4 (day 28 ± 2) and week 8 (day 56 ± 3) post dosing.

RECIST criteria:

Evaluation of target lesions

Complete Response (CR): Disappearance of all target lesions.

Partial Response (PR): At least a 30% decrease in the sum of the LD of target lesions, taking as reference the baseline sum LD.

Stable Disease (SD): Neither sufficient shrinkage to qualify for PR nor sufficient increase to qualify for PD, taking as reference the smallest sum LD since the treatment started.

Progressive Disease (PD): At least a 20% increase in the sum of the LD of target lesions, taking as reference the smallest sum LD recorded since the treatment started or the appearance of one or more new lesions

Evaluation of non-target lesions

Complete Response (CR): Disappearance of all non-target lesions and normalization of tumor marker level

Incomplete Response/ Stable Disease (SD): Persistence of one or more non-target lesion(s) or/and maintenance of tumor marker level above the normal limits

*Progressive Disease (PD):*Appearance of one or more new lesions and/or unequivocal progression of existing non-target lesions

Evaluation of best overall response

The best overall response is the best response recorded from the start of the treatment until disease progression/recurrence (taking as reference for PD the smallest measurements recorded since the treatment started). In general, the patient's best response assignment will depend on the achievement of both measurement and confirmation criteria

Patients with a global deterioration of health status requiring discontinuation of treatment without objective evidence of disease progression at that time should be classified as having "symptomatic deterioration". Every effort should be made to document the objective progression even after discontinuation of treatment.

In some circumstances it may be difficult to distinguish residual disease from normal tissue. When the evaluation of complete response depends on this determination, it is recommended that the residual lesion be investigated (fine needle aspirate/biopsy) to confirm the complete response status.

RESULTS:

Patient Disposition

Disposition of patients is summarized herein: 26 subjects in 6 cohorts were enrolled between November 2007 and August 2009, and a total of 33 subjects had enrolled by December 2010. Each of the 3 subjects in cohorts 1-4 discontinued the study prematurely: 2 subjects due to death, 8 due to voluntary subject drop out, and 2 to pursue other treatment protocols. Of the 2 deaths, patient no. 1 was reported as a serious adverse effect, whereas patient no.9 died 88 days post dosing and therefore, as defined in the protocol, was not reported as an SAE. In cohort 5, one subject completed the study (up to day 56), one withdrew prior to day 56 and one designated as "Other" withdrew due to disease progression. Five cohort 6 patients completed the study, 5 withdrew due to disease progression (2 had brain metastases), and one died approximately 2 months after receiving study treatment. Four cohort 7 patients completed the study; two withdrew due to disease progression.

Among the initial 33 patients enrolled, 31 attended the day 28 visit, and 19 attended the day 56 visit. Subjects were contacted for follow-up every 2-3 months thereafter for a period of up to 3 years or more post dosing for monitoring.

Patient Population Profile

<u>Demographics</u>

Demographics and baseline characteristics are summarized in Table 1 that follows. Overall, 54 % of the subjects were male and 46% female. All but five of the subjects (4-Hispanic and 1-Asian) enrolled were Caucasian. The mean age of the subjects enrolled was 58.5 years, with the youngest 35.1 years old and the oldest 74.1 years. The mean Karnofsky score at entry was 85.4; the lowest score at entry was 70 (the minimum permitted by the protocol inclusion criteria) and the highest 100.

Table 1: Demographics/Baseline Characteristics Summary

Demographic/Baseline Characteristic	Number	%
Gender		
Male	14	53.8
Female	12	46.2
Race		
Caucasian	21	80.8
Asian	1	3.8
Hispanic	4	15.4
Age, mean (years)	58.5	-
Karnofsky score (mean)	85.4	-

Medical History

Medical history is summarized herewith: As expected in a patient population with a mean age of 58.5 years, all subjects had other medical conditions at baseline. The most common medical conditions (defined as those present in at least three subjects) were: hypertension (13 subjects); fatigue (10 subjects); constipation (6 subjects); diarrhea and anemia (5 subjects each); nausea, GERD, hypercholesterolemia, hyperlipidemia, seasonal allergy, and cholecystectomy (4 subjects each); abdominal pain, cough, hypothyroidism, low back pain, and pneumonia (3 subjects each).

Primary Diagnosis

The frequency of tumor type at baseline is summarized in Table 2 that follows. The most frequent tumor types were colorectal adenocarcinoma, non-small cell lung cancer, melanoma, sarcoma, and carcinoid/neuroendocrine. One subject each had the following tumor types: transitional cell carcinoma of the bladder, cancer of the distal esophagus, Merkle cell carcinoma, lung small cell carcinoma, renal cell carcinoma, gastro-intestinal stromal tumor, testicular sex cord tumor, and papillary thyroid carcinoma.

Table 2: Primary Tumor Diagnoses (cohorts 1-7)

Tumor Type	**Total number**	**Number at cohort 6-7**
Colorectal Adenocarcinoma	11	5
Carcinoid/Neuroendocrine	4	4
Non-small cell lung cancer	3	1
Renal Cell Carcinoma	3	3
Melanoma	2	1
Sarcoma	2	0
Thyroid cancer	2	2
Esophageal Adenocarcinoma	1	1
Merkle cell carcinoma	1	1
Bladder/Transitional Cell	1	0
Lung small cell carcinoma	1	0
G-I stromal tumor	1	0
Testicular/ sex cord tumor	1	0

Prior Chemotherapy

Prior chemotherapy is summarized by the number and frequency of chemotherapy herewith: All subjects enrolled in the trial had previous chemotherapy with multiple agents, with 3.7 (range 1-8) mean previous chemotherapy lines. The most frequently utilized medications were: 5-FU (10.9%), Bevacizumab (10.9%), Capecitabine (8.6%), Leucovorin (8.0%), Irinotecan (8.0%), Cetuximab (5.2%), Oxaliplatin (4.6%), Temozolomide (3.4%), Cisplatin (3.4%), Folfox (3.4%), Sunitinib (2.9%), Dacarbazine (2.3%), and Docetaxel (2.3%). Most subjects (16/26, 61.5%), received at least one prior anti-angiogenic agent: Bevacizumab (12 patients), Sunitinib (4 patients), and Sorafenib (2 patients). The use of these chemotherapeutic agents reflects the types of tumors occurring in this patient population.

Other Anti-tumor Interventions

Essentially all subjects had previous surgery for their tumor. The details of the surgery and of other anti-tumor interventions, excluding chemotherapy, are summarized herewith: The average number of previous surgical procedures related to the tumor was >2/subject, with a few subjects having had 4 surgical procedures. Also, 12 of the subjects had previous radiation therapy. All of the courses of radiation therapy occurred at least 8 months prior to study treatment except for subject no. 13, whose last course of radiotherapy ended about 4.5 months previously. The protocol required no radiotherapy for at least 4 weeks prior to enrolment.

Tumor Evaluation at Baseline

All subjects had CT evaluations of tumor target lesions with measurement of tumor size at baseline for subsequent comparison post-treatment. For these measurements, the longest diameter of each target lesion was utilized.

Summary of Patient Population

Most subjects enrolled in this study were Caucasian with an almost equal gender distribution and a mean age of 58.5 years. The mean entry Karnofsky score was 85.4, and all subjects had concurrent medical conditions. The most frequent tumor types were colorectal adenocarcinoma, non-small cell lung cancer, melanoma, sarcoma and carcinoid/neuroendocrine. All subjects enrolled in the trial had previous cancer-related surgery and chemotherapy with multiple agents, the most common of which were 5-FU, Bevacizumab, Capecitabine, Leucovorin, Irinotecan, Cetuximab, Oxaliplatin, Temozolomide, Cisplatin, Folofox, Sunitinib, Dacarbazine, and Docetaxel; the majority also had previous anti-angiogenic therapy and radiation therapy.

SAFETY EVALUATIONS

Adverse Events

The incidence and frequency of adverse events are summarized in Table 3 that follows: Overall, events experienced by at least 4 (15.4%) subjects included: pyrexia (50%); fatigue (46.2%); prolonged aPTT (38.5%); chills, hyponatremia and decreased hemoglobin (26.9% each); constipation (23.1%); nausea, vomiting, anorexia, and dyspoena (19.2% each); lymphopenia, elevated aspartate aminotransferase, hyperglycemia, myalgia, and hyperhidrosis (15.4% each). Pyrexia and chills occurred at higher doses only (cohorts 4-6). In cohort 6, 9 of 11 subjects experienced pyrexia and 6 of 11 also had chills. In cohort 7, one subject experienced a grade 3 fever. In all patients, the pyrexia and chills occurred on the day of study treatment (post-infusion), were transient, and resolved within 24 hours.

Table 3: Most Frequent Adverse Events (cohort 1-6)

Adverse Event	**Number Patients**	**%**
Pyrexia	13	50.0
Fatigue	12	46.2
aPTT Prolonged	10	38.5
Chills	7	26.9
Hyponatremia	7	26.9
Hemoglobin decreased	7	26.9
Constipation	6	23.1
Nausea	5	19.2
Vomiting	5	19.2
Anorexia	5	19.2
Dyspnea	5	19.2
Lymphopenia	4	15.4
AST Increased	4	15.4
Hyperglycemia	4	15.4
Myalgia	4	15.4
Hyperhidrosis	4	15.4

Most of the events of pyrexia (11 of 14) and chills (7 of 8) that occurred in the higher dose groups were considered possibly, probably or definitely related to study drug. The only other events considered definitely related to study drug included two events of nausea and one event each of anemia, vomiting, fatigue, hyperhidrosis, anorexia, and headache. None of these events were classified as NCI Grade 3 or higher. Thus, no dose limiting toxicities had occurred. Most of the other adverse events were considered unrelated or unlikely related to study drug.

Of the most common adverse events, fatigue was considered unrelated in 9/12 subjects and unlikely in one subject; prolonged aPTT unrelated in 7/10 subjects; decreased hemoglobin was considered unrelated in all 7 subjects; and constipation unrelated in all occurrences. Note: The local investigator commented that the aPTT local lab test is highly sensitive (as used for screening for lupus anti-coagulant); indeed, all aPTT elevation adverse events occurred in patients of that clinic.

The following Grade 3 or higher adverse events were reported; all were considered unrelated or unlikely related to the investigational drug: Subject no.001 (cohort 1): Grade 3 disease progression; subject no.007 (cohort 3): Grade 3 hyponatremia and hyperkalemia; subject no.008 (cohort 3): Grade 3 hemoglobin decreased; subject no.009 (cohort 3): Grade 3 fatigue; subject no.013 (cohort 4): Grade 3 hypokalemia, hyponatremia, hypochloremia, and fatigue; subject no.025 (cohort 6): Grade 4 suicidal ideation; subject no.027 (cohort 6): Grade 3 weakness; subject no.033 (cohort 6): Grade 4 abdominal pain and Grade 3 hyperglycemia; subject no.035 (cohort 6): Grade 3 elevated total bilirubin, elevated AST, elevated ALT, and elevated alkaline phosphatase; and subject no.036 (cohort 6): Grade 3 hyponatremia. Disease progression in subject no.1 was a serious adverse event; all of the other events were not serious. All of the subjects with Grade 3 hyponatremia (no.007, no.013, and no.036) with or without other Grade 3 metabolic events had gastro-intestinal malignancies.

<u>Serious Adverse Events</u>

No serious adverse events (SAEs) related to treatment with the study drug were reported.

Laboratory Testing:

<u>Hematology and Coagulation</u>

No significant trends in mean changes occurred after treatment in any of the cohorts for the following tests: basophil count, eosinophil count, lymphocyte count, hematocrit, hemoglobin, neutrophil count, platelet count, RBC, and PT. A trend for increased aPTT after treatment was observed in each cohort, although most mean values remained within the normal range. Mean and median white blood cell counts (WBC) tended to decrease in cohorts 3-6 from the day of dosing to day 4, but individual values remained within normal limits in all subjects except for two subjects in cohort 6: (1) subject no.26 had a low WBC (3700 K/μL) on the day of dosing that decreased to 2700

K/μL on Day 4 but then increased to at least 4000 K/μL for the remainder of the study and (2) subject no.32 had a normal WBC of 6.3 K/μL on the day of dosing that decreased to 4.5 K/μL on Day 4 and then varied between 4.3 and 6.0 K/μL.

Values for hematology tests that were considered clinically significant findings include:

Subject no.8 (in cohort 3) had a hematocrit of 32.3% and hemoglobin of 10.6 g/dL on the day of dosing that gradually decreased over time to 25.5% and 7.9 g/dL, respectively, on day 28. This subject's platelet count was 443,000 K/μL on the day of dosing and increased to 516,000 K/μL on day 28.

Subject no.14 (in cohort 4) had a hematocrit of 34.2% and hemoglobin of 10.8 g/dL at screening; these values gradually decreased over time to 26.4% and 8.3 g/dL, respectively, on day 14. This subject's aPTT was 33.1 seconds at screening, 34.4 seconds at day 4, and then increased to 49.6 seconds at day 7 and 53.6 seconds at day 14.

Subject no.33 (in cohort 6) had a hematocrit of 38.3% at screening and 33.1% on the day of dosing and hemoglobin of 12.3 g/dL at screening and 10.9 g/dL on the day of dosing; both stabilized for the duration of the study. This subject's platelet count was 116,000 K/μL on the day of dosing and decreased to 89,000 K/μL on day 4 but subsequently increased to 129,000 K/μL on Day 28. The PTT was normal at 31 seconds on the day of dosing but increased to 44.5 and 48.2 seconds on Days 14 and 28, respectively.

Summarizing the shift in hematology and coagulation lab values from the day of dosing to day 28 for the combined cohorts: The shift did not suggest any trend for values to shift to below or above the normal range at 28 days post-treatment. In particular, for both hematocrit and hemoglobin, no trend was observed for values to shift to below the normal range.

Chemistry

Summary of serum chemistry testing: No significant trends in median changes occurred after treatment in any of the cohorts for the following tests: ALT, AST, albumin, alkaline phosphatase, calcium, creatinine, glucose, potassium, sodium, bilirubin, total protein, and BUN. Mean levels of the following were increased, due to a high level observed in one subject: ALT and AST in cohort 6 at Day 28 due to levels of

406 U/L and 232 U/L, respectively, in subject no.35; total bilirubin in cohort 6 at Day 28 due to a level of 7.4 in subject no.35. Very high alkaline phosphatase levels in the following subjects accounted for elevated mean levels in their respective cohorts: subjects no.4 (cohort 2), no.24 (cohort 5), and no.22, 26, 30, 35, and 36 (all in cohort 6).

Chemistry tests: Subjects no.4 and no.22 had elevated ALT and AST tests on the day of dosing that subsequently decreased/normalized. Subject no.35 in cohort 6 had elevated levels of ALT and AST at day 28: 406 U/L and 232 U/L, respectively, but these levels normalized by day 56. This subject (no.35) was hospitalized for bile duct obstruction due to tumor progression and also had markedly elevated levels of total bilirubin, 7.4 mg/dL, and alkaline phosphatase, 1176 U/L, at day 28. Otherwise, all ALT and AST elevations were <3X the upper limits of normal and tended to be sporadic. No subject other than no.35 had an abnormal total bilirubin level during participation in the study. Elevated alkaline phosphatase on the day of dosing was common, presumably due to tumor and/or metastatic disease, but a significant progressive increase in this lab test only occurred in two subjects (no.4 who had a level of 383 U/L at screening, 493 U/L on the day of dosing and 609 U/L at Day 28 and no.36 who had a level of 163 U/L on the day of dosing and 377 U/L on Day 28). No subjects developed clinically significant post-treatment levels for any of the other chemistry tests.

Summarizing the shift in serum chemistry values from the day of dosing to day 28 for the combined cohorts: 5/15 subjects who had a normal level at the day of dosing had a low level of serum sodium on day 28. However, the sodium levels were abnormal only intermittently, usually only slightly below normal, and not clinically significant. The shift tables did not suggest any other trend for values to shift to below or above the normal range at 28 days post-treatment.

<u>Urinalysis</u>

The frequency of an abnormality on urinalysis on the day of dosing (89.5%) and at screening (76.0%) was high, but no trends were observed at the post-dosing visits. A review of the data indicated that no clinically significant abnormalities occurred on urinalysis, although a few subjects had small amounts of protein in their urine, and subject no.30 in cohort 6 had 2+ proteinuria at day 28.

Antibodies to Adenovirus 5

Serum samples from subjects tested for antibodies to Adenovirus 5 (total and IgG); increase in titers between pre- and post-dose for IgG antibodies are summarized in Table 4 and Figure 11. The post-dose samples were collected at day 28 or 56 in all but 3 subjects; these 3 had post-dose samples tested earlier due to the non-availability of samples at day 28. All post-dose IgG antibody titers increased at least 7-fold; 8 of 33 subjects had at least a 100-fold increase in IgG antibodies over the pre-dose titer. All post-dose total antibody titers to adenovirus 5 increased at least 5-fold; 10 of 26 subjects had at least a 625-fold increase in total antibodies over the pre-dose titer. There was no correlation between fold increase (total and IgG antibody titers) and dose level (P> 0.05, Pearson and Spearman correlation tests). Data collected at day 56 for cohort 7 subjects indicated a trend of decreased IgG levels, compared to day 28 (see Table 4 that follows).

Table 4: Summary of Anti-Adenovirus 5 Increase in IgG Antibody Titers and Total Antibody Titers

		Anti-Ad5 Titer			Anti-Ad5 IgG Titer			
Cohort	Patient	Pre-dose	Post-dose (day 28)	Fold increase	Pre-dose	Post-dose (day 28)	Fold increase	Post-dose (day 56)
1	1	62500	1562500	25	3500	43,740	12	
	2	2500	1562500	625	400	43,740	109	
	3	12500	1562500	125	1500	43,740	29	
2	4	2500	62500	25	300	5,500	18	
	5	500	12500	25	180	1500	8	
	6	2500	7812500	3125	350	35,000	100	
3	7	2500	12500	5	600	4100	7	
	8	2500	312500	125	950	43,740	46	
	9	2500	7812500	3125	1000	29,000	29	
4	10	12500	1562500	125	420	20,000	48	
	13	2500	1562500	625	200	9,000	45	
	14	2500	1562500	625	650	11,000	17	
5	20	12500	312500	25	90	13,000	144	
	21	2500	312500	125	300	14,000	47	
	24	12500	312500	25	1,200	12,000	10	
6	22	12500	1562500	125	850	11,500	14	
	25	2500	312500	125	850	11,000	13	
	26	2500	312500	125	70	11,000	157	
	27	12500	7812500	625	540	43,740	81	
	28	ND	312500	ND	700	43,740	62	
	29	12500	312500	25	120	18,000	150	
	30	62500	7812500	125	6000	43,740	7	
	32	2500	1562500	625	200	43,740	219	
	33	2500	7812500	3125	500	43,740	87	
	35	2500	62500	25	ND	ND	ND	
	36	2500	7812500	3125	400	30,000	75	

	38	12500	7812500	625	800	43,470	54	
7	39	62,500	1,562,500	25	800	30000	38	18000
	40	12,500	312,500	25	300	35000	117	22000
	41	62,500	7,812,500	125	200	7500	38	10000
	42	12,500	1,562,500	125	450	5500	12	4500
	43	62,500	1,562,500	25	140	7000	50	5000
	44	12,500	312,500	25	200	22000	110	NA

All subjects were also assessed as to their level of neutralizing Adenovirus 5 antibodies at baseline (Table 5). Results show that 35% had highly elevated baseline levels (>210) and 41% of the subjects had low levels (≤ 18) of neutralizing antibodies.

Table 5: Summary of Anti-Adenovirus 5 Neutralizing Antibody Titers at Baseline

Subject ID	Cohort	Titer	Subject ID	Cohort	Titer
001	1	620	027	6	5
002	1	750	028	6	940
003	1	210	029	6	5
004	2	10.5	030	6	1250
005	2	10.5	032	6	195
006	2	400	033	6	220
007	3	5	035	6	10.5
008	3	380	036	6	5
009	3	210	038	6	620
010	4	1050	039	7	1000
013	4	860	040	7	5
014	4	5	041	7	15
020	5	18	042	7	5
021	5	5	043	7	160
024	5	520	044	7	85
022	6	110			
025	6	210			
026	6	5			

No correlation could be discerned between the presence of neutralizing anti-Ad5 antibodies at baseline and disease progression at days 28 (FIG. 2) or 56 (FIGs. 3A, 3B Table 5) (Pearson Product Moment Correlation; P> 0.050; Spearman Rank Order Correlation; P>0.050).

Cytokine levels in peripheral blood in cohort 6

Peripheral blood cytokine levels were measured in cohort 6 patients at baseline, and at the following times after dosing with AD5-PPE-1-3X-FAS-CHIMERA-: 6 hours, 4 days, 7 days, 14 days, 28 days, and 56 days post infusion. Results are summarized in Table 6 that follows.

Table 6: Summary of Mean Peripheral Blood Cytokine Levels in Cohort 6

Cytokine	Baseline (n=10)	6 h (n=10)	D4 (n=2)	D7 (n=9)	D14 (n=9)	D28 (n=9)	D56 (n=3)
IL-6	10.38	1018.28	2.92	7.2	47.99	12.13	0
IL-8	21.85	181.68	42.6	33.93	43.68	31.59	21.62
VEGF	73.47	54.82	0	147.09	132.77	133.53	0
FGF	11.92	9.95	5.75	20.42	19.55	12.43	7.30
TNF-a	0	1.53	0	0	0	0	0
sTNFRI	1746.44	3143.89	1725.60	2383.03	2706.33	2222.37	1456.77
sTNFRII	5819.81	7509.75	10063.71	7921.62	10155.62	7717.02	5866.12

A significant increase in mean IL-6 levels occurred 6 hours post-infusion; this level returned to baseline by day 4. A smaller increase in TNFRII levels was noted, peaking between days 4 and 14. No major elevations occurred with the other measured cytokines.

Vital Signs

No significant post-treatment trends were observed for systolic BP, diastolic BP, and respiratory rate, and no subject developed any clinically significant abnormalities.

Significant elevations in temperature (>38 degrees Centigrade) occurred in 5 subjects at 6 hours post-infusion: one subject in cohort 5: no.20 (38.3 degrees Centigrade) and 4 subjects in cohort 6: no.26 (39.1 degrees Centigrade), no.27 (39.7 degrees Centigrade), no.32 (39.8 degrees Centigrade), and no.36 (39 degrees Centigrade). In each, the temperature had normalized prior to or by day 4 (which was the first recording of temperature following that of 6 hours post-infusion). The mean heart rate was increased to 101.2 beats/minute in cohort 6 at 6 hours post-dosing. This was due to a more rapid heart rate in the subjects that had experienced pyrexia in this cohort (heart rate of 107-140 beats/minute). Weight is summarized herein: no major change in weight occurred, except for a decrease in mean weight at follow-up (75.0 kg at screening, 75.0 kg at day 56, and 63.5 kg at follow-up).

Physical Exams

No treatment-related or clinically significant changes on exams are apparent from the data of by-subject physical exams at screening and day 56.

ECGs

ECG parameters at screening are summarized herein: At screening, 15 subjects had normal ECGs, and 11 had abnormalities that were considered not clinically significant. The original protocol specified that a follow-up ECG should be performed at the day 56 follow-up visit. As most subjects withdrew from the study prior to day 56, in cohorts 1-5 only subject no.7 had a follow-up ECG and this showed ECG changes considered not clinically significant.

The protocol was later amended to obtain the follow-up ECG at the day 28 visit. In cohort 6, there were 4 follow-up ECGs obtained: two were normal and 2 had minor, non-clinically significant findings with no major changes from the screening ECG.

Biodistribution of Ad5-PPE-1-3X-fas-chimera

Due to an error, no whole blood samples were drawn for some of the patients in cohorts 5 and 6[3]). Urine samples were tested for 11 of the 12 cohort 6 patients and for the 12 additional patients from lower cohorts tested for levels in blood.

Analysis of the Urine Samples for Presence of Adenovirus:

Maximum levels of Adenovirus Vector DNA detected in urine are summarized in Table 7.

Table 7: Maximum Levels of Adenovirus Vector in Urine (cohorts 1-6)

Cohort	Subject ID	Adenovirus Vector DNA copies/µg gDNA
1	001	0
1	002	3.2×10^3 (Day 28)
1	003	5.3 (Day 56)
2	004	6.2×10^2 (3hr)
2	005	0
2	006	0

3	007	0
3	008	0
3	009	2.2×10^3 (Day 4)
4	010	5.3 (Day 14)
4	014	1.1×10^3 (6hr)
5	024	5.3 (6hr)
6	022	1.1×10^4 (3hr)
6	025	1.5×10^4 (3hr)
6	026	5.3 (3hr)
6	028	5.3 (3hr)
6	029	1.6×10^7 (3hr)
6	030	4.7×10^5 (3hr)
6	032	5.3 (3hr)
6	033	2.3×10^4 (3hr)
6	035	1.8×10^4 (3hr)
6	036	0
6	038	0

VP- Viral particles; BLQ<20 copies; BLD<1.4 copies

Analysis of the Whole Blood Samples for the Presence of Adenovirus Vector

Average levels of Adenovirus Vector DNA, as detected by RT-PCR in whole blood for cohorts 1-6 are summarized over time in Figure 12A. Table 8 that follows shows the median values for cohorts 1-6. Before infusion of the adenovirus vector, none of the patients tested showed amplification of adenoviral gene (below detectable levels). A dose-dependent increase in average maximum levels of adenovirus vector DNA found in whole blood is evident from the data. At the end of the infusion all patients had individual blood virus levels in the range of 1.9×10^3 and 5.5×10^7 copies/μg gDNA, correlating positively with dose received.

In cohort 6 patients (Figure 12A, grey dashed line), average levels of adenovirus decreased from a range of 2.1×10^5-5.5×10^7 (end of infusion) to a range of 1.1×10^4-2.6×10^5 copies/ μg gDNA (three hours post infusion, see Figure 12B). Levels of adenovirus continued to decrease 6 hours post infusion and subsequently decreased throughout the final time points. By day 56, Adenovirus DNA levels were either all reduced by at least 2 log-fold, or were undetectable.

Table 8: Presence of Adenovirus Vector in Whole Blood: Median Values

Cohort	Dose vp	**Median Adenovirus Vector DNA copies/µg gDNA at end of infusion (Maximum)**
1	**1×10^{10}**	**1.6×10^{4}**
2	**3×10^{10}**	**4.5×10^{5}**
3	**1×10^{11}**	**1.6×10^{5}**
4	**3×10^{11}**	**1.7×10^{6}**
5	**1×10^{12}**	**6.5×10^{6}**
6	**3×10^{12}**	**2.5×10^{7}**

Analysis of the expression levels of fas-chimera transgene in whole blood

None of the 21 subjects tested had detectable levels of transgene cDNA (as determined by RT- PCR, representing blood mRNA levels) in whole blood. However, in one patient 01-036 (esophageal cancer) a sample from a subcutaneous metastasis was tested and detectable levels of adenovirus transgene expression were found in the aspirate on days 4 (1.4×10^5 copies/µg RNA) and 28 (3.9×10^5 copies/µg RNA) after treatment (Table 9), providing direct evidence of the specificity of the transgene expression in the target tumor tissue.

Table 9: Aspirate from tumor of patient 01-036 (copies/µg RNA)

time	Pt no.	cohort	sample	copies
Pre	36	6	Tumor	0.00E+00
Day 4	36	6	Tumor	1.40E+05
Day 28	36	6	Tumor	3.90E+04

Summary of Safety Results

No signs of significant safety issues with Ad5-PPE-1-3X-fas-chimera were observed in this study. The maximal therapeutic dose (MTD) was determined to be 10^3 virus particles per dose, in view of a dose limiting toxicity of a NCI grade 3 fever, shortly following dosing at the highest dose tested (cohort 7). Other than abnormal lab results, the most frequent adverse events were pyrexia, fatigue, chills, and constipation. Pyrexia and chills occurred mostly in the higher dose groups and were usually considered related to study medication. Although no trend for hematology values to shift outside the normal range was observed, several subjects had declines in hemoglobin and hematocrit values after study treatment. No clinically significant post-treatment chemistry or urinalysis abnormalities occurred during the study with the exception of a markedly elevated alkaline phosphatase and elevations of ALT, AST, and total bilirubin occurring in a subject with bile duct obstruction due to progression of cancer. No clinically significant post-treatment changes in vital signs were observed, except for the occurrence of fever 6 hours post-infusion in one cohort 5 and 4 cohort 6 subjects; the cohort 6 subjects with fever also had increased heart rates, resulting in a mean increase in heart rate for cohort 6 at 6 hours post-infusion. No treatment-related changes were observed on physical exams or ECGs.

All subjects had pre-dose anti-Adenovirus 5 antibodies (total and IgG) with total antibody titers increasing at least 5-fold post-treatment. Figure 11 shows the anti-Adenovirus 5 antibodies in each of cohorts 1-6, measured at baseline, day 7, day 14 and day 28, and illustrates the tendency of the anti- Adenovirus 5 antibodies to plateau between 7 and 14 days post infusion, despite the variability observed between patients in the baseline antibody titer levels. Levels of anti-Adenovirus 5 antibodies (total and IgG) tended to increase post dosing, peaking on day 28 and tending to decrease by day 56 (FIG. 11). Overall, the fold increase was higher for the total anti-Adenovirus 5 titers than for the IgG titers, but no correlation was discerned between fold increase in anti-Adenovirus 5 antibodies and the dosage level. 34.6% of subjects had highly elevated levels of neutralizing antibodies to Adenovirus 5, measured at baseline, 23.1% had moderately elevated levels, and 42.3% had low levels. However, there was no correlation discernable between neutralizing anti-body titer at baseline and a clinical response (measured as stable disease). A significant increase in mean IL-6 blood levels occurred 6 hours post-dosing with Ad5-PPE-1-3X-fas-chimera; this level returned to baseline by day 4. No major elevations occurred with the other measured cytokines (Il-8, VEGF, FGF, and TNF-alpha).

In most subjects with detectable levels of Adenovirus 5 in the urine, the presence was transient, with levels detectable only within the initial 24 hours after the intravenous (IV) infusion of Ad5-PPE-1-3X-fas-chimera. The Ad5-PPE-1-3X-fas-chimera adenovirus vector was present in high copy numbers in whole blood directly after the IV infusion. The levels of adenovirus vector subsequently decreased with time in whole blood. Samples with vector present in the whole blood were tested for the expression of the Fas-chimera transgene (RT-PCR for the transgene mRNA). None of the 21 subjects tested had detectable levels of transgene cDNA (cDNA is the RT- PCR reaction product representing blood mRNA levels) in whole blood.

PRELIMINARY EFFICACY ASSESSMENT

Disease Progression or Recurrence

Disease progression was assessed according to clinical deterioration and radiographic growth, based on RECIST criteria. In cohorts 1-5, at day 56, 3/14 patients had stable disease. In cohort 6, on day 56 (n=12), 1 PR, 4 SD ("stable disease") and 7 had progressive disease. Thus at day 56, 5/12 (42%) had stable disease or better. In cohort 7, at day 56, 4 out of 6 subjects (67%) had stable disease. In cohorts 1-6, at day 28, 21/26 (80.8%) of the subjects were considered not to have deterioration, one had deteriorated (5.6%), and 4 had no observation for this endpoint. Only 8 subjects from cohorts 1-6 had observations at the Day 56 visit, and all of these were negative for deterioration.

Disease progression was also assessed by frequency of radiographic growth (measured according to % growth in the sum longest diameter of target lesions as defined in the RECIST scoring criteria). Where no new lesions were present and there was either no growth in the longest diameter sum of the target lesions or that growth was no more than 20%, the subject was considered to have *stable radiographic disease* at that visit.

Reduction in refractory metastatic papillary thyroid cancer following multiple infusions of $3X10^{12}$ virus particles of Ad5-PPE-1-3X-fas-chimera

Of these patients, Subject 026, a 69 year-old Hispanic female, was enrolled with metastatic papillary thyroid cancer that was resistant to radioiodine and was dosed in cohort 6 on March 16, 2009. Baseline CT scan showed a mass lesion in the neck with pressure on the airway (FIG. 4, arrows). Day 28 scan showed stable disease, and a follow-up scan 6 months (FIG. 5, arrows) and 12 months after treatment showed a greater than 30% reduction in the long diameter of the mass and no pressure on the airway, with radiographic lucency suggestive of central necrosis (FIG. 5, blue arrow). Additionally, thyroglobulin levels have decreased in this patient: the level at baseline was 426 ng/mL and 10 months later had decreased to 326 ng/mL (normal levels <55 mg/mL).

A second dose was administered one and one half years after the first dosing, and the patient was progression free at day 120 post infusion. Thyroglobulin levels at the time of second dosing were 281 ng/mL, rising to 477 ng/mL at day 28, and dropping to 382 ng/mL at day 56 post infusion. No dose limiting toxicities, severe side effects or cytokine storm were observed throughout the treatment period.(Figure 10A)

In another patient with a medullary thyroid cancer lesion, administration of $3X10^{12}$ virus particles of Ad5-PPE-1-3X-fas-chimera resulted in dramatic reduction in levels of the thyroid cancer biomarker calcitonin: levels were greatly elevated before administration (14, 331 pg/ml, normal = < 10 pg/ml), increased (16,324 pg/ml) at 56 days post infusion, but showed marked reduction (6600 pg/ml) at 120 days post infusion. At 120 days post-treatment the patient was still progression free. (Figure 10B)

Reduction in metastatic lesion of advanced neurorendocrine cancer following a single infusion of $3X10^{12}$ virus particles of Ad5-PPE-1-3X-fas-chimera.

Another patient in cohort 6, enrolled with advanced neuroendocrine cancer, was dosed in cohort 6 on March 16, 2009. Day 21 CT scan showed several hepatic metastases (FIGs. 6A and 7A, red circle). Follow-up CT scans at 50 (FIGs. 6B and 7B, red circle) and 112 (FIGs. 6C and 7C, red circle) days post dosing showed continued regression of one of these metastatic lesions. According to RECIST criteria, this patient was scored as "stable disease", and has maintained "stable disease" classification for four months afterwards.

Summary of Efficacy

Although this single infusion study with patients having advanced or metastatic solid organ cancer is small, certain trends can be discerned from the efficacy data.

On day 56 evaluation, three of the 14 patients in Cohorts 1 -5 had stable radiographic disease (SD); among the 12 Cohort-6 patients, five had stable disease on day 56, and one patient (with papillary thyroid carcinoma) had a near partial response on day 56 (out of 12 patients on cohort 6), which became a partial response (PR) later.

Among the 5 cohort 7 patients, 5 remained classified as having "stable disease" (SD). When the percent change in RECIST scores is plotted for days 0, 28 and 56, and correlated with the evaluations of stable and progressive disease, it can be seen that three out of 14 (21%) in cohorts 1-5 were stable at day 56 (Figure 8). In cohorts 6 and 7 (Figure 9), however, 9 out of 17 patients were stable at day 56.

In this open-label, dose–ranging study evaluating a single IV infusion of safety and efficacy of administration of Ad5PPE-1-3X-fas-chimera (SEQ ID NO: 9) in the clinical setting, 3 subjects with advanced or metastatic cancer have been enrolled in each of the first 5 ascending dose cohorts and 12 subjects have been enrolled in the 6th cohort. Taken together, the data indicates Ad5-PPE-1-3X-fas-chimera is safe for systemic administration, in all of the doses tested, as no safety signal or dose-limiting toxicities (DLT) have been observed at any of the utilized doses. Although two serious adverse events were reported, these were related to progression of the cancer and unrelated to study treatment. Several subjects who received Ad5-PPE-1-3X-fas-chimera at one of the 2 highest doses developed transient pyrexia and chills shortly after receiving study treatment, events commonly occurring after the administration of adenovirus vectors. Clinically significant abnormalities on laboratory testing were infrequent and considered unrelated to Ad5-PPE-1-3X-fas-chimera treatment.

Maximally tolerated dose (MTD) was determined as 10^{13} virus particles per dose, in view of the single incident of dose limiting toxicity (NCI Grade 3 fever) observed in the cohort receiving the highest dose tested (cohort 7). Although being a small single infusion study among patients with multiple types of advanced, refractory cancer, evidence for efficacy of Ad5-PPE-1-3X-fas-chimera infusion includes patients with stable radiographic disease and one prolonged partial response among patients receiving $3X10^{12}$ virus particles of Ad5-PPE-1-3X-fas-chimera (cohort 6)(Table 10).

Table 10: Disease response to a single dose of Ad5PPE-1-3X-Fas-chimera: Percent stable disease at day 56, by indication (cohorts 6 and 7).

Type of Cancer	Number of Patients	%SD at Day 56
Colorectal		
Adenocarcinoma	5	40%
Carcinoid/Neuroendocrine	4	75%

Non-small cell lung cancer	1	100%
Renal cell carcinoma	3	33%
Melanoma	1	0%
Thyroid cancer	2	100%
Merkle cell carcinoma	1	0%
Esophageal Adenocarcinoma	1	0%

In one patient suffering from esophageal cancer the subcutaneous metastasis was sampled and detectable levels of Ad5-PPE-1-3X-fas-chimera transgene expression were found in the aspirate on days 4 and 28 after treatment.

Example III

Effect of Ad5PPE-1-3X-fas chimera administration on Thyroid Cancer in the clinical setting

In order to determine the efficacy of administration of AD5PPE-1-3X-fas-chimera on Thyroid Cancer in the clinical setting, outcomes such as toxicity, adverse effects, antibody titer, biodistribution, disease progression and disease recurrence and survival were monitored in subjects with Thyroid Cancer tumors receiving intravenous infusion of the Ad5PPE-1-3X-fas chimera adenovirus vector.

MATERIALS AND EXPERIMENTAL METHODS

Indications:

Advanced progressive and radioiodine-refractory differentiated thyroid cancer (DTC) (papillary, follicular, Hurthle cell) cancer patients.

Safety objectives:

To evaluate the safety of a single systemic dose of the Ad5PPE-1-3X-fas chimera adenovirus vector in patients with advanced thyroid cancer.

Efficacy and pharmacodynamics objectives:

1. To evaluate the response to treatment for patients with advanced DTC with measurable disease using Response Evaluation Criteria in Solid Tumors (RECIST Criteria);

2. To assess the pharmacokinetic and pharmacodynamic profile of Ad5PPE-1-3X-fas chimera adenovirus vector;

3. Evaluation of changes in candidate biomarkers in response to Ad5PPE-1-3X-fas chimera adenovirus vector treatment.

4. To explore influences of pre-treatment tumor genetic alterations on response to Ad5PPE-1-3X-fas chimera adenovirus vector treatment using archival tumor materials.

Efficacy endpoints:

1. The primary efficacy endpoint is the proportion of patients who have achieved an objective response to the study agent (according to RECIST criteria).

2. Secondary endpoints will include changes in thyroglobulin levels in response to treatment (in anti-thyroglobulin antibody-negative patients only).

Study design:

Prospective, open-label, single dose study in 2 groups of patients (parallel enrolment):

Group A-Treatment of 12 evaluable patients with progressive thyroid cancer disease despite treatment with radioiodine, but naive to targeted anti-angiogenic therapies (e.g. tyrosine kinase inhibitors or anti-VEGF monoclonal antibodies). Subjects may also have had treatment with other cancer chemotherapy.

Group B -Treatment of 12 evaluable patients with progressive thyroid cancer despite prior treatment with radioiodine and with at least one anti-angiogenic therapy. Subjects may also have had treatment with other cancer chemotherapy.

Treatment plan and study duration:

Ad5PPE-1-3X-fas chimera adenovirus vectors are administered as a single intravenous infusion of $3x10^{12}$ vp (virus particles). The post-infusion efficacy follow up period will be until disease progression occurs. The post-treatment safety and efficacy evaluation visits will be every four weeks until week 12 or disease progression (whichever occurs later). Thereafter, restaging evaluations will occur every 2 months until at least one year after study enrolment or until progression (the earlier). Formal restaging of indicator lesions is performed every 8 weeks.

Population size:

Groups A and B of this study will each enroll 12 evaluable subjects, for a total of 24 evaluable subjects. Evaluable subject are subjects for whom the chosen evaluation criteria can be applied through the duration of the study. The trial is designed according to the 2-stage Simon statistical method. If at least 1 response is observed in the initial 12 patients, further 24 patients will be enrolled from that group (up to a total of 37 patients per group or 74 total).

Inclusion criteria:

1. Patients ≥18 years of age;

2. Histologically or cytologically confirmed advanced DTC (papillary, follicular, Hurthle cell);

3. Absence of sensitivity to therapeutic radioiodine;

4. No previous treatment with anti-angiogenic agents (Group A patients only);

5. Measurable disease, defined as at least one lesion that can be accurately measured in at least one dimension (longest diameter to be recorded) as ≥20 mm with conventional techniques or as ≥10 mm with spiral CT scan (Note: Disease that is measurable by physical examination only is not eligible, and CT and/or MRI are required in assessing indicator lesions);

6. Life expectancy >3 months;

7. ECOG performance status (PS) 0, 1, or 2; Karnofsky performance status of ≥60%;

8. Objective evidence of tumor progression in the 6 month period prior to the Screening Visit, as assessed by:

i. Progressively increasing suitable tumor markers, where appropriate; and

ii. Unequivocal progression of objectively measured disease on successive appropriate imaging (e.g. CT scan). In cases of uncertainty of tumor progression, the Principal Investigator of the study will be available to assist in decisions.

9. Patients with a normal/acceptable hematological profile, as demonstrated by a peripheral leukocyte count >3000 cells/ mcL, an absolute neutrophil count >1500 cells/μl, hemoglobin ≥10g/dl, platelets >100,000/μl, and International Normalized Ratio (INR) <1.2x the Upper Limit of Normal (ULN);

10. Patients with adequate renal function, i.e. serum creatinine <1.5 times upper normal limits; and adequate hepatic function, as defined by ALT and AST<2.5x the upper limit of normal and total bilirubin below the upper limit of normal;

11. Males and females of childbearing potential must utilize, throughout the course of the trial a standard contraception method;

12. Ability to understand and the willingness to sign a written informed consent document;

13. Willingness to comply with study requirements.

<u>Exclusion Criteria:</u>

1. Pregnant or breastfeeding females;

2. Disease that is measurable by physical examination only;

3. Presence of any of the following:

- Radiotherapy or chemotherapy <4 weeks prior to baseline visit;
- Radiotherapy to ≥25% of bone marrow;
- Major surgery <4 weeks prior to baseline visit;
- Concurrent and/or prior therapy with octreotide will be allowed, provided tumor progression on this therapy has been demonstrated;
- Concurrent and/or prior therapy with biphosphonates will be allowed;

4. Any other ongoing investigational agents within 4 weeks before enrolment;

5. Patients, who suffered from an acute cardiac event within the last 12 months, including myocardial infarction, cardiac arrythmia, admission for unstable angina, cardiac angioplasty, or stenting;

6. QTc prolongation (defined as QTc interval ≥500 msecs) or other significant ECG abnormalities (e.g. frequent ventricularectopy, evidence of ongoing myocardial ischemia);

7. Patients with active vascular disease, either myocardial or peripheral;

8. Patients with proliferative and/or vascular retinopathy;

9. Patients with known active liver disease (alcoholic, drug/toxin induced, genetic, or autoimmune) other than related to tumor metastases;

10. Patients with known CNS metastatic disease (Exception: patients with treated CNS metastases stable by radiographic examinations >6 moths after definitive therapy administered, are eligible);

11. Patients testing positive to one of the following viruses: HIV, HBV or HCV;

12. Any of the following conditions:

- Serious or non-healing wound, ulcer, or bone fracture;
- History of abdominal fistula, gastro-intestinal perforation, active diverticulitis, intra-abdominal abscess or gastro-intestinal tract bleeding within 28 days of enrolment;
- Any history of cerebrovascular accident (CVA) within 6 months of enrolment;
- Current use of therapeutic warfarin (Note: Low molecular weight heparin and prophylactic low-dose warfarin [International Normalized Ratio (INR) <1.2 X Upper Limit of Normal (ULN)] are permitted);
- History of bleeding disorder, including patients with hemophilia, disseminated intravascular coagulation (DIC), or any other abnormality of coagulation potentially predisposing patients to bleeding;
- Poorly controlled depression or anxiety disorder, or recent (within the previous 6 months) suicidal ideation;

13. Patients with an ongoing requirement for an immunosuppressive treatment, including the use of glucocorticoids or cyclosporin, or with a history of chronic use of any such medication within the last 4 weeks before enrolment;

14. Uncontrolled intercurrent illness including, but not limited to ongoing or active infection, or psychiatric illness/social situations that would limit compliance with study requirements.

Formulation, Dosage and Administration:

Ad5PPE-1-3X-fas chimera adenovirus vector is formulated as a sterile vector solution. The solution is supplied frozen (below-65°C), in single use vials. Each vial contains 0.5 ml of vector solution at a specific viral titer. The vector solution is thawed and maintained on ice during dilution and handling.

Ad5PPE-1-3X-fas chimera adenovirus vector is administered as a single intravenous infusion, maximal dose being $1x10^{12}$- $1x10^{13}$ virus particles (vp). Prior to infusion, the solution for injection is brought to room temperature. The vials are opened in a biological safety cabinet and diluted (by injection) 1:4 with of normal saline for infusion. A single infusion of diluted Ad5PPE-1-3X-fas chimera adenovirus vector is administered at a rate of 1 ml/minute. Multiple doses may be administered at predetermined minimal intervals.

Safety Evaluation:

1. Adverse events are recorded on an ongoing basis during. The events are followed until resolved, or until the study end, whichever comes sooner.

2. Vital signs are recorded at screening, prior to dosing, 30, 60 minutes, 4 and 6 hours after dosing and at all patient visits.

3. A physical examination is conducted in conjunction with each study visit.

4. Safety laboratory assessment (vital signs, blood haematology and chemistry, urine analysis) are conducted at screening, prior to dosing, and at all patient visits, starting from day 4±1 until disease progression or Week 12, whichever occurs later.

5. After disease progression or Week 12 (whichever occurs later), each patient is contacted for safety follow-up by telephone every 2 months until 1 year after study enrolment.

Biodistribution:

Blood and urine samples for evaluation of levels of adenovirus vector DNA and the fas transgene are collected for adenovirus vector DNA: at several time points post-infusion.

Evaluation of Efficacy: Tumor Response

The effect of Ad5PPE-1-3X-fas chimera adenovirus vector treatment on tumor response is evaluated by measuring the tumor according to RECIST criteria (see above) at screening and at subsequent visits until disease progression. Changes in tumor volume are evaluated and analyzed based on radiological studies.

Biochemical and Laboratory Assays:

Antibodies: Serum samples are collected prior to dosing and at all patient visits, starting from Week 1, for analysis of levels of antibodies to the adenovirus (both total immunoglobulin, total IgG and Ad-5 neutralizing Abs) and to the fas-chimera transgene.

Tumor markers: TSH, anti-thyroglobulin antibody, and thyroglobulin are tested in conjunction with all follow-up evaluations.

Tumor measurement: Evaluation of biological effect on indicator lesion (CT, MRI).

Statistical Evaluation:

Patients are divided into two groups of subjects based upon previous treatment of their thyroid cancer: Group A, DTC radioiodine resistant and naïve to anti-angiogenics; Group B, DTC radioiodine resistant with progression on anti-angiogenics. These two groups are evaluated independently for efficacy and toxicity end points.

Patient recruitment for each group is in 2 stages:

Stage 1: Enter 12 patients into the study. 12 subjects for each group. If no clinical responses are observed, the therapy is considered ineffective in this patient population and the study is terminated. If at least 1 response is observed, the study group proceeds to Stage 2.

Stage 2: Enter an additional 25 evaluable patients into the each group study. If three or fewer responses are observed after all 37 evaluable patients have been evaluated for response, the therapy is considered insufficiently effective in this patient population. If 4 or more responses are observed, this is considered adequate evidence of promising activity and this treatment may be recommended for further testing in subsequent studies in this patient population.

Unless toxicity is encountered or the study is stopped at the interim analysis, this study will accruing 37 eligible subjects for each group and evaluable patients. In order to account for ineligibility, cancellation, major treatment violation, or other reasons or early withdrawal or drop out, an additional 4 patients will be enrolled for each group. Thus 41 patients will be enrolled into this study for each group. Total of 82 subjects.

Assessments will be carried out according to the schedule in Table 10 that follows.

TABLE 10- SCHEDULE OF ASSESSMENTS

	Screening (≤ 2 wks from D_0)	D_0 Prior to Dosing day of dosing	Follow up after Dosing ($D_{\leq 1}$)	Day 4±1	Week 1 ±1 Day	Week 2 ±1 Day	Weeks 4 & 8 ±3 Days	Week 12, ±3 Days	Weeks[10] 20, 28, 36, 44, 52 ±3 Days	F/U [11]
Inclusion Criteria	X									
Exclusion Criteria	X									
Medical History	X									
Informed Consent	X									
Pregnancy Test[1]	X									
Physical Exam ECG	X							X		
Vital Signs[2]	X	X	X				X	X	X	
Hematology[3]	X	X		X	X	X	X	X	X	
Chemistry[4]	X	X		X	X	X	X	X	X[12]	
HIV, HBV, HCV	X									
Urinalysis[5]	X	X			X	X	X	X	X	
ECG	X							X		
Drug infusion		X								
Antibody[6]		X	X		X	X	X	X	X	
Distribution [7]		X	X	X	X	X	X			
Concomitant Medications	X	X					X	X	X	X
Adverse Events		X	X	X	X	X	X	X	X	X
Tumor Measure[8]	X						X	X	XX	
Tumor Markers [9]	X						X	X	XX	

Legend

1. Women of childbearing potential will be tested for pregnancy with the use of a serum pregnancy test at Screening and Week 12

2. Vital signs (blood pressure, body temperature and heart rate) will be recorded at screening, prior to dosing at 30 and 60 minutes after dosing and at 6 hours post-dosing, and at all patient visits thereafter.

3. Hematology will include: complete blood count with differential, PT and PTT Fibrinogen

4. Chemistry will include: electrolytes (sodium, potassium, calcium), creatinine; bilirubin, alkaline phosphatase, ALT and AST; total protein and albumin

5. Routine urine analysis

6. Blood samples will be collected for levels of serum antibodies against the adenovirus and the transgene

7. Blood and urine samples will be collected for biodistribution determination (levels of the viral DNA and transgene). See protocol for details.

8. Evaluation of indicator lesion (CT, MRI, etc.) to be done at each visit until disease progression

9. TSH, anti-thyroglobulin antibody, and thyroglobulin should be tested at each visit until disease progression

10. Visits at Weeks 20, 28, 36, 44, and 52 to be conducted only if no disease progression has occurred prior to the visit

11. Telephone contact will be performed every 2 months after Week 12 or disease progression (whichever occurs later) until one year after study enrolment.

Thyroglobulin is to be tested every 2 months until 13 months post dosing or until progression, whichever occurs first.

Example IV

Effect of Ad5PPE-1-3X-fas chimera administration Combined with Chemotherapy

In order to evaluate the combined therapeutic oncolytic effect of Ad5PPE-1-3X-fas chimera and chemotherapy on tumor size in cancer, systemic administration of Ad5PPE-1-3X-fas chimera and concomitant chemotherapy in the rapidly metastasizing Lewis Lung Carcinoma model was chosen.

The Lewis Lung Cancer model provides a method for observing the effects of treatment on established, metastatic cancer.

Sunitinib (Sutent) targets tyrosine kinase, and inhibits the action of VEGF, producing an anti-angiogenic effect, and is used, among others, in stromal tumors and advanced renal cell cancer.

Antimetastatic effects of a single systemic dose of Ad5PPE-1-3X-fas chimera and oral sunitinib in mice bearing lung metastases:

C57BL/6 male mice (13 to 19 in each group) aged 8 weeks were inoculated with $5X10^5$ LLC cells into the left footpad. The foot was amputated under general anesthesia as soon as the primary tumor developed to 7 mm. 2 days later (post foot amputation) a single intravenous injection of Ad5PPE-1-3X-fas chimera (10^9 or 10^{11} virus particles) was administered through the tail vein. After receiving the vector, a daily regimen of oral sunitinib was administered, 40 or 80 mg/kg once a day, on days 1-5, 8-13 and 16-17. Mouse sacrifice was scheduled for the 22nd day post primary tumor removal. Mouse well-being was monitored daily by observation and weighing. Results (Tumor burden) relate to the tumor mass, in grams (known as Tumor Burden).

Figures 13A and 13B detail the results of two groups of the metastatic mice receiving the combination therapy, compared to each treatment mode alone. While a dose effect of the treatments could be discerned in the tumor burden of mice receiving 80 mg/kg sunitinib compared to those receiving 40 mg/kg sunitinib, and in the tumor burden of mice receiving 10^{11} Ad5PPE-1-3X fas-c compared to those receiving 10^9 Ad5PPE-1-3X fas-c, the results of combining the two treatment modes reveals a statistically significant difference ($P<0.05$) between the control group and all the treatment groups, the mean tumor burden in the control group being significantly greater than in each of the other groups. The high viral dose (10^{11} virus particles) and the low dose-combination treatment (10^9 virus particles and 80 mg/kg sunitinib), were found to be most effective in reducing the tumor burden, resulting in a statistically lower tumor burden than that of either the 10^9 virus particles and 40 mg/kg sunitinib groups. These combination groups also showed reduced variability and generally lower scores, compared to the other experimental groups. The results show that combined treatment of systemically administered AdPPE-1-3X-fas-chimera + oral sunitinib is effective against metastatic disease.

Taken together, these results indicate that when administered in combination with currently employed clinical chemotherapy protocols, Ad5PPE-1-3X fas-c can increase their therapeutic effectiveness and potentially allow reduced dosage and frequency of treatments.

Although the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

All publications, patents and patent applications mentioned in this specification are herein incorporated in their entirety by reference into the specification, to the same extent as if each individual publication, patent or patent application was specifically and individually indicated to be incorporated herein by reference. In addition, citation or identification of any reference in this application shall not be construed as an admission that such reference is available as prior art to the present invention. To the extent that section headings are used, they should not be construed as necessarily limiting.

WHAT IS CLAIMED IS:

1. A method of treating a solid tumor in a subject in need thereof, the method comprising administering to the subject a therapeutically effective amount of a non-replicating adenovirus vector, wherein said vector comprises a polynucleotide which comprises a fas-chimera transgene transcriptionally linked to a murine pre-proendothelin promoter, wherein said therapeutically effective amount is at least $1X10^8$ virus particles.

2. The method of claim 1, wherein said therapeutically effective amount is at least about $1X10^9$ to about $1X10^{16}$ virus particles.

3. The method of claim 1, wherein said therapeutically effective amount is at least about $1X10^{11}$ to about $1X10^{13}$ virus particles.

4. The method of claim 1, wherein said therapeutically effective amount is at least about $3X10^{12}$ virus particles.

5. The method of claim 1, wherein said therapeutically effective amount is at least about $1X10^{13}$ virus particles.

6. The method of claim 1, wherein said fas-chimera transgene comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 2.

7. The method of claim 1, wherein said fas-chimera transgene comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 3.

8. The method of claim 1, wherein said fas-chimera transgene comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 4.

9. The method of claim 1, wherein said murine pre-pro endothelin promoter comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 6.

10. The method of claim 1, wherein said murine pre-pro endothelin promoter comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 8.

11. The method of claim 1, wherein said murine pre-pro endothelin promoter comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 7.

12. The method of claim 1, wherein said murine pre-pro endothelin promoter comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 13.

13. The method of claim 1, wherein said murine pre-proendothelin promoter comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 12.

14. The method of claim 1, wherein said murine pre-proendothelin promoter further comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 5.

15. The method of claim 1, wherein said non-replicating adenovirus vector is an adenovirus 5 vector.

16. The method of claim 1, wherein said adenovirus vector comprises a nucleic acid sequence as set forth in SEQ ID NO: 9 or 10.

17. The method of claim 1, wherein said solid tumor is a cancer.

18. The method of claim 1, wherein said solid tumor is a primary tumor.

19. The method of claim 1, wherein said solid tumor is a metastatic tumor.

20. The method of claim 1, wherein said adenovirus vector is administered systemically.

21. The method of claim 20, wherein said vector is administered systemically by a route selected from the group consisting of intra-articular administration, intravenous administration, intraperitoneal administration, subcutaneous administration, infusion, oral administration, rectal administration, nasal administration and inhalation.

22. The method of claim 1, comprising administering said adenovirus vector in at least two separate systemic doses.

23. The method of claim 1, wherein said adenovirus is detected in the blood of said subject at least about 4 days post administration.

24. The method of claim 1, wherein an amount of serum anti-adenovirus antibodies is increased following said administering, and said adenovirus is detected in the blood of said subject at least about 21 days post administration.

25. A method of treating a solid tumor in a subject in need thereof, the method comprising administering to the subject a therapeutically effective amount of a non-replicating adenovirus vector which comprises a polynucleotide comprising a fas-chimera transgene transcriptionally linked to a murine pre-proendothelin promoter, said adenovirus vector comprising a nucleic acid sequence as set forth in SEQ ID NO: 9 or 10.

26. The method of claim 25, wherein said therapeutically effective amount is at least about $1X10^8$ to about $1X10^{16}$ virus particles.

27. The method of claim 25, wherein said therapeutically effective amount is at least about $1X10^{11}$ to about $1X10^{13}$ virus particles.

28. The method of claim 25, wherein said therapeutically effective amount is at least about $3X10^{12}$ virus particles.

29. The method of claim 25, wherein said therapeutically effective amount is at least about $1X10^{13}$ virus particles.

30. The method of claim 25, wherein said solid tumor is a cancer.

31. The method of claim 25, wherein said solid tumor is a metastatic tumor.

32. The method of claim 25, wherein said solid tumor is a primary tumor.

33. The method of claim 25, wherein said adenovirus vector is administered systemically.

34. The method of claim 33, wherein said vector is administered systemically by a route selected from the group consisting of intra-articular administration, intravenous administration, intraperitoneal administration, subcutaneous administration, infusion, oral administration, rectal administration, nasal administration and inhalation.

35. The method of claim 25, comprising administering said adenovirus vector in a first dose and at least a second additional dose, wherein said first dose is sufficient to induce anti-Ad5 antibodies in said subject, and wherein the time between administration of said first dose and said at least a second dose is sufficient for anti-Ad5 antibody formation in said subject.

36. The method of claim 25, wherein said adenovirus is detected in the blood of said subject at least about 4 days post administration.

37. The method of claim 36, wherein an amount of serum anti-adenovirus antibodies is increased following said administering, and the adenovirus is detected in the blood of said subject at least about 21 days post administration.

38. A method of treating a solid tumor in a subject in need thereof, the method comprising administering to the subject, in at least two separate doses, a therapeutically effective amount of a non-replicating adenovirus vector which comprises a polynucleotide comprising a fas-chimera transgene transcriptionally linked to a murine pre-proendothelin promoter wherein said administration does not induce a dose-dependent increase in antibodies against said adenoviral vector in said subject.

39. The method of claim 38, wherein said therapeutically effective amount is at least about $1X10^8$ to about $1X10^{16}$ virus particles.

40. The method of claim 38, wherein said therapeutically effective amount is at least about $1X10^{11}$ to about $1X10^{13}$ virus particles.

41. The method of claim 38, wherein said therapeutically effective amount is at least about $3X10^{12}$ virus particles.

42. The method of claim 38, wherein said therapeutically effective amount is at least about $1X10^{13}$ virus particles.

43. The method of claim 38, wherein said fas-chimera transgene comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 2.

44. The method of claim 38, wherein said fas-chimera transgene comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 3.

45. The method of claim 38, wherein said fas-chimera transgene comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 4.

46. The method of claim 38, wherein said murine pre-pro endothelin promoter comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 6.

47. The method of claim 38, wherein said murine pre-pro endothelin promoter comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 8.

48. The method of claim 38, wherein said murine pre-pro endothelin promoter comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 7.

49. The method of claim 38, wherein said murine pre-pro endothelin promoter comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 13.

50. The method of claim 38, wherein said murine pre-pro endothelin promoter comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 12.

51. The method of claim 38, wherein said murine pre-proendothelin promoter further comprises a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 5.

52. The method of claim 38, wherein said non-replicating adenovirus vector is an adenovirus 5 vector.

53. The method of claim 38, wherein said adenovirus 5 vector comprises a nucleic acid sequence as set forth in SEQ ID NO: 9 or 10.

54. The method of claim 38, wherein said solid tumor is a cancer.

55. The method of claim 38, wherein said solid tumor is a primary tumor.

56. The method of claim 38, wherein said solid tumor is a metastatic tumor.

57. The method of claim 38, wherein said adenovirus vector is administered systemically.

58. The method of claim 38, wherein said vector is administered systemically by a route selected from the group consisting of intra-articular administration, intravenous administration, intraperitoneal administration, subcutaneous administration, infusion, oral administration, rectal administration, nasal administration and inhalation.

59. The method of claim 38, wherein said adenovirus is detected in the blood of said subject at least about 4 days post administration.

60. The method of claim 59, wherein an amount of serum anti-adenovirus antibodies is increased following said administering, and the adenovirus is detected in the blood of said subject at least about 21 days post administration.

61. A method of treating a solid tumor in a subject in need thereof, the method comprising administering to the subject a single intravenous dose of $3X10^{12}$ or $1X10^{12}$ virus particles of a non-replicating adenovirus vector comprising a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 9 or 10.

62. The method of claim 61, wherein said solid tumor is a cancerous tumor.

63. The method of claim 61, wherein said solid tumor is a primary tumor.

64. The method of claim 61, wherein said solid tumor is a metastatic tumor.

65. The method of claim 61, wherein administering said dose of adenovirus vector inhibits angiogenesis of said tumor.

66. The method of claim 61, wherein said administering said dose of adenovirus inhibits growth of said tumor.

67. The method of claim 61, wherein said adenovirus is detected in the blood of said subject at least about 4 days post administration.

68. The method of claim 67, wherein said subject has elevated serum anti-adenovirus antibodies compared to pre-treatment anti-adenovirus antibody levels, and said adenovirus is detected in the blood of said subject at least about 21 days post administration.

69. A method of treating a thyroid cancer in a subject in need thereof, the method comprising administering to the subject a single intravenous dose of $3X10^{12}$ or $1X10^{13}$ virus particles of a non-replicating adenovirus vector comprising a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 9 or 10.

70. The method of claim 69, wherein said therapeutically effective amount is at least about $1X10^{13}$ virus particles.

71. A method of treating a neuroendocrine cancer in a subject in need thereof, the method comprising administering to the subject a single intravenous dose of $3X10^{12}$ or $1X10^{13}$ virus particles of a non-replicating adenovirus vector comprising a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 9 or 10.

72. The method of claim 71, wherein said therapeutically effective amount is at least about $1X10^{13}$ virus particles.

73. A kit for treating a solid tumor in a subject in need thereof, comprising a unit dosage of virus particles of a non-replicating adenovirus vector comprising a polynucleotide having a nucleotide sequence as set forth in SEQ ID NO: 9 or 10 wherein said non-replicating adenovirus vector is formulated for intravenous administration, and instructions for administration of said adenovirus.

74. The kit of claim 73, wherein said unit dosage comprises about $3X10^{12}$ virus particles.

75. The kit of claim 73, wherein said unit dosage comprises at least about $1X10^{13}$ virus particles.

76. A method for administering a therapeutic composition comprising an adenoviral vector to a subject, comprising administering a therapeutically effective amount of the composition to the subject at least twice, wherein the administering does not induce a dose-dependent increase in anti-adenovirus antibodies against said adenoviral vector in the subject.

77. The method of claim 76, wherein said therapeutically effective amount is at least about $1X10^{8}$ to about $1X10^{16}$ virus particles.

78. The method of claim 76, wherein said therapeutically effective amount is at least about $1X10^{11}$ to about $1X10^{13}$ virus particles.

79. The method of claim 76, wherein said therapeutically effective amount is at least about $3X10^{12}$ virus particles.

80. The method of claim 76, wherein said therapeutically effective amount is at least about $1X10^{13}$ virus particles.

81. The method of claim 76, wherein said adenovirus is detected in the blood of said subject at least about 4 days post administration.

82. The method of claim 81, wherein an amount of serum anti-adenovirus antibodies is increased following said administering, and said adenovirus is detected in the blood of said subject at least about 21 days post administration.

83. The method of any one of claims 1 to 72, wherein said subject is further receiving a chemotherapeutic agent as well as treatment with said virus particles of said non-replicating adenovirus vector.

84. The method of claim 83, wherein said chemotherapeutic agent is administered prior to treatment with said virus particles.

85. The method of claim 83, wherein said chemotherapeutic agent is administered concomitantly with treatment with said virus particles.

86. The method of claim 83, wherein said chemotherapeutic agent is administered following treatment with said virus particles.

87. The method of claim 83, wherein said chemotherapeutic agent is sunitinib.