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(71) **Applicant**: **CHILDREN'S MEDICAL CENTER CORPORATION** [US/US]; 55 Shattuck Street, Boston, MA 02115 (US).

(72) **Inventor**: **WATNICK, Randolph, S.**; 22 Bracebridge Road, Newton, MA 02459 (US).

(74) **Agent**: **EL-HAYEK, Roque**; Wolf, Greenfield & Sacks, P.C., 600 Atlantic Avenue, Boston, MA 02210-2206 (US).

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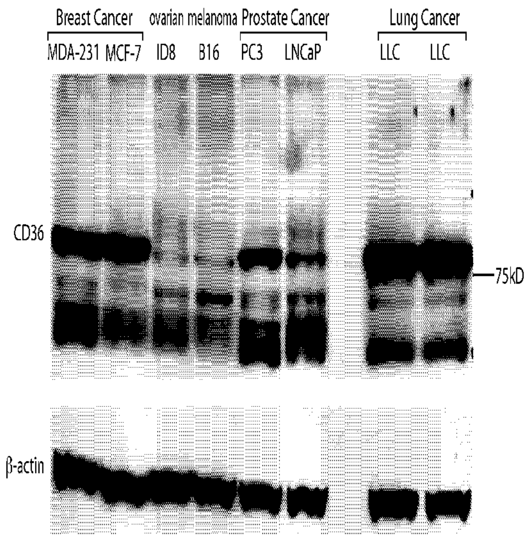
(54) **Title**: USE OF CD36 TO IDENTIFY CANCER SUBJECTS FOR TREATMENT

Fig. 2



(57) **Abstract**: Provided herein are methods for identifying a subject with cancer for treatment with a Psap peptides. The subject is identified based on a level of CD36. Also provided herein are compositions and methods for treatment of a subject with cancer based on a level of CD36.

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USE OF CD36 TO IDENTIFY CANCER SUBJECTS FOR TREATMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of the filing date of U.S. Provisional Application No. 61/782,850, filed March 14, 2013, the entire contents of which are incorporated by reference herein.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

This invention was made with U.S. Government support under R01CA135417 awarded by the National Cancer Institute. The U.S. Government has certain rights in the invention.

BACKGROUND OF INVENTION

Cancer remains a major public health priority. For example, an estimated 7.6 million deaths from cancer occurred in 2008. Treatments for cancer are constantly improving as technology and science progresses. Unfortunately, it has become apparent that many cancer therapeutics are effective only in subsets of cancer patients, even subsets of patients having the same type of cancer. As a result, it is becoming increasingly important to find ways to identify patients that are likely to respond to treatment.

SUMMARY OF INVENTION

Aspects of the disclosure are based in part on the discovery that elevated levels of CD36 in tumor cells indicate that a subject is responsive to or is likely to be responsive to treatment with a Psap peptide. Accordingly, aspects of the disclosure relate to methods for evaluating a subject's responsiveness to treatment with a Psap peptide by determining a level of CD36 in a sample, such as a tumor sample. In some embodiments, the methods described herein relate to identification or selection of a subject for treatment with a Psap peptide based on a level of CD36 in a sample. Other aspects of the disclosure relate to compositions and methods for treatment of a subject with cancer characterized by an elevated level of CD36.

In some aspects, the disclosure relates to a method for evaluating a subject's responsiveness to treatment with a Psap peptide, the method comprising determining a level of

CD36 in a sample obtained from a subject having cancer, wherein an elevated level of CD36 in the sample compared to a control level indicates that the subject is responsive to or likely to be responsive to treatment with a Psap peptide. In some embodiments, the level of CD36 in the sample is determined by performing an assay. In some embodiments, the method further comprises identifying the subject with an elevated level of CD36 in the sample compared to the control level as responsive to or likely to be responsive to treatment with a Psap peptide. In some embodiments, the method further comprises administering to the subject identified as responsive to or likely to be responsive to treatment with a Psap peptide an effective amount of a Psap peptide to treat the cancer.

Other aspects of the disclosure relate to a method for treating a subject with cancer, the method comprising administering to a subject with cancer characterized by an elevated level of CD36 in a sample compared to a control level an effective amount of a Psap peptide to treat the cancer. In some embodiments, the control level is a level of CD36 from a non-cancerous cell or tissue obtained from the subject having the cancer. In some embodiments, the control level is a level of CD36 in a cell or tissue obtained from a healthy subject or a population of healthy subjects. In some embodiments, the control level is a predetermined level. In some embodiments, the level of CD36 is a CD36 protein level.

Further aspects of the disclosure relate to a method for treating a subject with cancer, the method comprising (a) selecting a subject with cancer on the basis that the subject is known to have an elevated level of CD36 in a sample compared to a control level; and (b) administering an effective amount of a Psap peptide to the subject because the subject has an elevated level of CD36 in the sample compared to the control level. In some embodiments, the control level is a level of CD36 from a non-cancerous cell or tissue obtained from the subject having the cancer. In some embodiments, the control level is a level of CD36 in a cell or tissue obtained from a healthy subject or a population of healthy subjects. In some embodiments, the control level is a predetermined level. In some embodiments, the level of CD36 is a CD36 protein level.

In some embodiments of any of the methods provided herein, the cancer is prostate cancer, breast cancer, ovarian cancer, lung cancer, leukemia, pancreatic cancer, glioblastoma multiforme, astrocytoma, or melanoma.

In some embodiments of any of the methods provided herein, the Psap peptide comprises the amino acid sequence CDWLPK (SEQ ID NO: 1), DWLPK (SEQ ID NO: 2), or DWLP (SEQ ID NO: 3), or an amino acid substitution variant thereof, wherein the amino acid substitution is:

a) Tyrosine (Y) for Tryptophan (W);

b) an amino acid substitution for Leucine (L) selected from Valine (V), Alanine (A) or Glycine (G), or a non-canonical amino acid of similar size, or a derivative thereof;

c) Arginine (R) for Lysine (K);

d) a D-isomer of Aspartic Acid (D) for an L-isomer of Aspartic Acid (D) and/or a D-isomer of Leucine (L) for a L-isomer of Leucine (L);

e) a D-isomer of Tryptophan (W) for an L-isomer of Tryptophan (W) and/or a D-isomer of Proline (P) for an L-isomer of Proline (P); or combinations thereof. In some embodiments, the Psap peptide is 50 amino acids or fewer in length. In some embodiments, the Psap peptide is 30 amino acids or fewer in length. In some embodiments, the Psap peptide is 15 amino acids or fewer in length. In some embodiments, the Psap peptide is 6 amino acids or fewer in length. In some embodiments, the Psap peptide is a cyclic peptide. In some embodiments, the non-canonical amino acid of similar size is methylvaline, methylleucine, or sarcosine.

In yet another aspect, the disclosure relates to a composition for use in treating a subject with cancer characterized by an elevated level of CD36 in a sample compared to a control level, the composition comprising a Psap peptide.

In another aspect, the disclosure relates to use of a composition for in the manufacture of a medicament for treating a subject with cancer characterized by an elevated level of CD36 in a sample compared to a control level, the composition comprising a Psap peptide.

In some embodiments of a use or composition provided herein, the control level is a level of CD36 from a non-cancerous cell or tissue obtained from the subject having cancer. In some embodiments of a use or composition provided herein, the control level is a level of CD36 in a cell or tissue obtained from a healthy subject or a population of healthy subjects. In some embodiments of a use or composition provided herein, the control level is a predetermined level. In some embodiments of a use or composition provided herein, the level of CD36 is a CD36 protein level.

In some embodiments of a use or composition described herein, the cancer is prostate cancer, breast cancer, ovarian cancer, lung cancer, leukemia, pancreatic cancer, glioblastoma multiforme, astrocytoma, or melanoma.

In some embodiments of a use or composition described herein, the Psap peptide comprises the amino acid sequence CDWLPK (SEQ ID NO: 1), DWLPK (SEQ ID NO: 2), or DWLP (SEQ ID NO: 3), or an amino acid substitution variant thereof, wherein the amino acid substitution is:

a) Tyrosine (Y) for Tryptophan (W);

b) an amino acid substitution for Leucine (L) selected from Valine (V), Alanine (A) or Glycine (G), or a non-canonical amino acid of similar size, or a derivative thereof;

c) Arginine (R) for Lysine (K);

d) a D-isomer of Aspartic Acid (D) for an L-isomer of Aspartic Acid (D) and/or a D-isomer of Leucine (L) for a L-isomer of Leucine (L);

e) a D-isomer of Tryptophan (W) for an L-isomer of Tryptophan (W) and/or a D-isomer of Proline (P) for an L-isomer of Proline (P); or combinations thereof. In some embodiments, the Psap peptide is 50 amino acids or fewer in length. In some embodiments, the Psap peptide is 30 amino acids or fewer in length. In some embodiments, the Psap peptide is 15 amino acids or fewer in length. In some embodiments, the Psap peptide is 6 amino acids or fewer in length. In some embodiments, the Psap peptide is a cyclic peptide. In some embodiments, the non-canonical amino acid of similar size is methylvaline, methylleucine, or sarcosine.

In some embodiments of a method, composition or use provided herein, the sample is a tumor sample.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1A is a graph showing proliferation of LLC cells 48 hours after additional of serially diluted amounts of recombinant Tsp-1 or DWLPK (SEQ ID NO: 2) peptide.

Figure 1B is a photograph of a western blot showing that CD36 protein is expressed in LLC cells.

Figure 2 is a photograph of a western blot showing that CD36 protein is expressed in breast cancer (MDA-231, MCF-7), ovarian cancer (ID8), melanoma (B16), prostate cancer (PC3 and LNCaP), and lung cancer (LLC) cell lines.

Figure 3 is a photograph of a western blot showing that CD36 protein is expressed in primary ovarian cancer cell derived from patient ascites.

Figure 4 is a photograph of a western blot showing that CD36 protein is expressed in pancreatic (AsPC1), ovarian (DF-14 and ID-8), breast (MDA-MB231 and LM2), prostate (PC3, PC3-M-LN4, LN-CAP, and LN-CAP-LN3), melanoma (B16-Bl6), and lung cancer (LLC) cells. Exemplary high and low CD36 expressing cells lines are shown in boxes.

Figure 5 is a graph showing that dWIP (SEQ ID NO: 47) peptide caused regression of cancer in a cancer model that expresses high levels of CD36.

Figure 6 is a graph showing that ovarian Cancer cells expressing CD36 are sensitive to Tsp-1 mediated cell killing.

Figure 7 is a graph showing the primary tumor mass of mice injected with AsPC pancreatic cancer cells that express high levels of CD36 and then treated with dWIP (SEQ ID NO: 47) peptide or control. The primary tumor mass was inhibited by peptide treatment.

Figure 8 is a graph showing that treatment of mice with B16-Bl6 melanoma tumors (which express low levels of CD36) with dWIP (SEQ ID NO: 47) peptide inhibited tumor growth but did not regress the tumor.

DETAILED DESCRIPTION OF INVENTION

Psap peptides are therapeutic peptides containing amino acid sequences that were originally derived from fragments of Saposin A, a known anti-angiogenic protein. Psap peptides generally comprise a core sequence of CDWLPK (SEQ ID NO: 1), DWLPK (SEQ ID NO: 2), or DWLP (SEQ ID NO: 3) or an amino substitution variant thereof and can be of a length of as few as 4 amino acids (e.g., a peptide that consists of DWLP (SEQ ID NO: 3) or an amino acid substitution variant). Such Psap peptides have been shown previously to be effective for treating multiple types of cancers (see, e.g., PCT publications WO2009002931 and WO/2011/084685; PCT application PCT/US2012/71424, published as PCT publication WO/2013/096868, and US Patent Applications 12/640,788 and 13/516,511, all of which are incorporated herein by reference in their entirety). Administration of a Psap peptide was previously thought to stimulate thrombospondin (Tsp-1) *in vivo*, which in turn acted on endothelial cells causing an anti-angiogenic effect that resulted in indirect inhibition of cancer and/or metastatic growth.

As described herein, it has been discovered that tumor cells from several different types of cancers that are responsive Psap peptides express CD36. CD36 is a member of the class B scavenger receptor family of cell surface proteins and has many ligands including oxidized low density lipoprotein, oxidized phospholipids, long-chain fatty acids, collagen, and Tsp-1. Without wishing to be bound by any theory or mechanism, it is believed that administration of Psap peptide stimulates Tsp-1, which then acts directly on tumor cells by interacting with CD36 on the tumor cells. The interaction between Tsp-1 and CD36 on the tumor cells may result in inhibition of tumor cell proliferation and/or induction of tumor cell apoptosis. Thus, Psap peptides appear to treat cancer through two different independent mechanisms, indirectly through an anti-angiogenic affect and directly by interaction of Tsp-1 with CD36 on tumor cells. Thus, responsiveness of a subject with cancer to treatment with a Psap peptide may depend on the level of CD36 expressed by the cancer.

Accordingly, aspects of the disclosure relate to methods for evaluating a subject's responsiveness to treatment with a Psap peptide by determining a level of CD36 in a sample, such as a tumor sample. In some embodiments, the methods described herein relate to identification or selection of a subject for treatment with a Psap peptide based on a level of CD36 in a sample, such as a tumor sample. Other aspects of the disclosure relate to compositions and methods for treatment of a subject with cancer characterized by an elevated level of CD36 (e.g., selected or identified on the basis that the cancer has an elevated level of CD36 in a sample compared to a control level).

As used herein, "responsive to treatment with a Psap peptide" includes, but is not limited to, prevention or reduction of the development of a cancer, reduction of the symptoms of cancer, suppression or inhibition of the growth of a cancer, prevention of metastasis and/or invasion of an existing cancer, promotion or induction of regression of the cancer, inhibition or suppression of the proliferation of cancerous cells, reduction of angiogenesis and/or an increase in the amount of apoptotic cancer cells in response to treatment with a Psap peptide.

As used herein, "non-responsive to treatment with a Psap peptide" includes, but is not limited to, an absence of prevention or reduction of the development of a cancer, an absence of reduction of the symptoms of cancer, an absence of suppression or inhibition of the growth of a cancer, an absence of prevention of metastasis and/or invasion of an existing cancer, an absence of promotion or induction of regression of the cancer, an absence of inhibition or suppression of the proliferation of cancerous cells, an absence of reduction of angiogenesis and/or a decrease in the amount of apoptotic cancer cells in response to treatment with a Psap peptide.

Diagnostic and Theranostic Methods

Aspects of the disclosure relate to diagnostic and theranostic methods useful for evaluating a subject's responsiveness to treatment with a Psap peptide. In some embodiments, the method comprises determining a level of CD36 in a sample obtained from a subject having cancer, wherein an elevated level of CD36 in the sample compared to a control level indicates that the subject is responsive to or likely to be responsive to treatment with a Psap peptide (i.e., if the level of CD36 in the sample is elevated compared to a control level, the subject is identified as responsive or likely to be responsive to treatment with a Psap peptide). In some embodiments, the method further comprises identifying the subject with an elevated level of CD36 in the sample compared to the control level as responsive to or likely to be responsive to treatment with a Psap peptide. In some embodiments, the method further comprises administering to the subject identified as responsive to or likely to be responsive to treatment with a Psap peptide an effective amount of a Psap peptide described herein to treat the cancer. In some embodiments, the sample obtained from a subject having cancer is a tumor sample.

In some embodiments, an elevated level of CD36 in the sample compared to a control level indicates that the cancer will regress or is likely to regress in response to treatment with a Psap peptide. In some embodiments, the method further comprises identifying the subject with an elevated level of CD36 in the sample compared to the control level as having a cancer that will regress or is likely to regress in response to treatment with a Psap peptide. In some embodiments, the method further comprises administering to the subject identified having a cancer that will regress or is likely to regress in response to treatment with a Psap peptide an effective amount of a Psap peptide described herein to cause regression of the cancer.

As used herein, "an elevated level of CD36" means that the level of CD36 is above a control level, such as a pre-determined threshold or a level of CD36 in a control sample. Control levels are described in detail herein. An elevated level of CD36 includes a CD36 level that is, for example, 1%, 5%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%, 150%, 200%, 300%, 400%, 500% or more above a control level. An elevated level of CD36 also includes increasing a phenomenon from a zero state (e.g., no or undetectable CD36 expression in a control) to a non-zero state (e.g., some CD36 expression or detectable CD36 expression in a sample).

As used herein, "treatment with a Psap peptide" is meant to comprise administration of a Psap peptide to a subject. Psap peptides are described herein. It is to be understood that treatment with a Psap peptide may include treatment with only a Psap peptide or may include treatment with multiple agents or therapies, such as a Psap peptide and another chemotherapeutic agent and/or another form of therapy such as surgery, radiotherapy, or chemotherapy.

Treatment

Other aspects of the disclosure relate to methods for treating a subject with cancer. In some embodiments, the method comprises administering to a subject with cancer characterized by an elevated level of CD36 in a sample obtained from the subject compared to a control level an effective amount of a Psap peptide described herein to treat the cancer. In some embodiments, the method comprises:

(a) selecting a subject with cancer on the basis that the subject is known to have an elevated level of CD36 in a sample compared to a control level; and

(b) administering an effective amount of a Psap peptide to the subject because the subject has an elevated level of CD36 in the sample compared to the control level.

Other aspects of the disclosure relate to compositions and uses of compositions in the manufacture of a medicament for treating a subject with cancer characterized by an elevated level of CD36 in a sample. In some embodiments, the composition comprises a Psap peptide as described herein. In some embodiments, the sample is a tumor sample.

As used herein, "treat" or "treatment" includes, but is not limited to, preventing or reducing the development of a cancer, reducing the symptoms of cancer, suppressing or inhibiting the growth of a cancer, preventing metastasis and/or invasion of an existing cancer, promoting or inducing regression of the cancer, inhibiting or suppressing the proliferation of cancerous cells, reducing angiogenesis and/or increasing the amount of apoptotic cancer cells. In some embodiments, treatment of cancer is a direct inhibition or suppression of the proliferation of cancer cells and does not involve an inhibition or suppression of angiogenesis (which indirectly leads to inhibition or suppression of the proliferation of cancer cells).

An effective amount is a dosage of the Psap peptide sufficient to provide a medically desirable result, such as treatment of cancer. The effective amount will vary with the particular cancer being treated, the age and physical condition of the subject being treated, the severity of the condition, the duration of the treatment, the nature of any concurrent therapy, the specific route of administration and the like factors within the knowledge and expertise of the health practitioner. For administration to a subject such as a human, a dosage of from about 0.001, 0.01, 0.1, or 1 mg/kg up to 50, 100, 150, or 500 mg/kg or more can typically be employed.

Psap peptides and compositions thereof can be formulated for a variety of modes of administration, including systemic, topical or localized administration. Techniques and formulations generally can be found in Remington's Pharmaceutical Sciences, Mack Publishing Co., Easton, Pa., latest edition. When administered, a Psap peptide may be applied in pharmaceutically-acceptable amounts and in pharmaceutically-acceptable compositions. Such preparations may routinely contain salt, buffering agents, preservatives, compatible carriers, and optionally other therapeutic agents. When used in medicine, the salts should be pharmaceutically acceptable, but non-pharmaceutically acceptable salts may conveniently be used to prepare pharmaceutically-acceptable salts thereof and are not excluded from the scope of the disclosure. Such pharmacologically and pharmaceutically-acceptable salts include, but are not limited to, those prepared from the following acids: hydrochloric, hydrobromic, sulfuric, nitric, phosphoric, maleic, acetic, salicylic, citric, formic, malonic, succinic, and the like. Also, pharmaceutically-acceptable salts can be prepared as alkaline metal or alkaline earth salts, such as sodium, potassium or calcium salts.

A Psap peptide may be combined, optionally, with a pharmaceutically-acceptable carrier. The term “pharmaceutically-acceptable carrier” as used herein means one or more compatible solid or liquid filler, diluents or encapsulating substances which are suitable for administration into a human. The term “carrier” denotes an organic or inorganic ingredient, natural or synthetic, with which the active ingredient is combined to facilitate the application. The components of the pharmaceutical compositions also are capable of being co-mingled with the molecules of the present disclosure, and with each other, in a manner such that there is no interaction which would substantially impair the desired pharmaceutical efficacy. Some examples of materials which can serve as pharmaceutically-acceptable carriers include: (1) sugars, such as lactose, glucose and sucrose; (2) starches, such as corn starch and potato starch; (3) cellulose, and its derivatives, such as sodium carboxymethyl cellulose, methylcellulose, ethyl cellulose, microcrystalline cellulose and cellulose acetate; (4) powdered tragacanth; (5) malt; (6) gelatin; (7) lubricating agents, such as magnesium stearate, sodium lauryl sulfate and talc; (8) excipients, such as cocoa butter and suppository waxes; (9) oils, such as peanut oil, cottonseed oil, safflower oil, sesame oil, olive oil, corn oil and soybean oil; (10) glycols, such as propylene glycol; (11) polyols, such as glycerin, sorbitol, mannitol and polyethylene glycol (PEG); (12) esters, such as ethyl oleate and ethyl laurate; (13) agar; (14) buffering agents, such as magnesium hydroxide and aluminum hydroxide; (15) alginic acid; (16) pyrogen-free water; (17) isotonic saline; (18) Ringer's solution; (19) ethyl alcohol; (20) pH buffered solutions; (21) polyesters, polycarbonates and/or polyanhydrides; (22) bulking agents, such as polypeptides and amino acids (23) serum component, such as serum albumin, HDL and LDL; (22) C2-C12 alcohols, such as ethanol; and (23) other non-toxic compatible substances employed in pharmaceutical formulations. Wetting agents, coloring agents, release agents, coating agents, sweetening agents, flavoring agents, perfuming agents, preservative and antioxidants can also be present in the formulation.

The pharmaceutical compositions may conveniently be presented in unit dosage form and may be prepared by any of the methods well-known in the art of pharmacy. The term "unit dose" when used in reference to a pharmaceutical composition of the present disclosure refers to physically discrete units suitable as unitary dosage for the subject, each unit containing a predetermined quantity of active material calculated to produce the desired therapeutic effect in association with the required diluent; i.e., carrier, or vehicle.

A variety of administration routes are available. The particular mode selected will depend upon the type of cancer being treated and the dosage required for therapeutic efficacy. The methods of the disclosure, generally speaking, may be practiced using any mode of administration that is medically acceptable, meaning any mode that produces effective levels of the active compounds without causing clinically unacceptable adverse effects. Such modes of administration include oral, rectal, topical, nasal, interdermal, or parenteral routes. The term "parenteral" includes subcutaneous, intravenous, intramuscular, or infusion.

In some embodiments, administration is parenteral. Injectable preparations suitable for parenteral administration include, for example, sterile injectable aqueous or oleaginous suspensions and may be formulated according to the known art using suitable dispersing or wetting agents and suspending agents. The sterile injectable preparation may also be a sterile injectable solution, suspension or emulsion in a nontoxic parenterally acceptable diluent or solvent, for example, as a solution in 1,3 propanediol or 1,3 butanediol. Among the acceptable vehicles and solvents that may be employed are water, Ringer's solution, U.S.P. and isotonic sodium chloride solution. In addition, sterile, fixed oils are conventionally employed as a solvent or suspending medium. For this purpose any bland fixed oil may be employed including synthetic mono or di glycerides. In addition, fatty acids such as oleic acid find use in the preparation of injectables. The injectable formulations can be sterilized, for example, by filtration through a bacterial-retaining filter, or by incorporating sterilizing agents in the form of sterile solid compositions which can be dissolved or dispersed in sterile water or other sterile injectable medium prior to use.

For topical administration, the pharmaceutical composition can be formulated into ointments, salves, gels, or creams, as is generally known in the art. Topical administration can utilize transdermal delivery systems well known in the art. An example is a dermal patch. Alternatively the biolistic gene gun method of delivery can be used. The gene gun is a device for injecting cells with genetic information, originally designed for plant transformation. The payload is an elemental particle of a heavy metal coated with plasmid DNA. This technique is often simply referred to as biolistics. Another instrument that uses biolistics technology is the PDS-1000/He particle delivery system. The composition described herein can be coated on minute gold particles, and these coated particles are "shot" into biological tissues such as hemangiomas and melanoma under high pressure. An example of gene gun-based method is described for DNA based vaccination of cattle by Loehr B. I. et al., J. Virol. 2000, 74:6077-86.

The pharmaceutical compositions described herein are also suitably administered by intratumoral, peritumoral, intralesional or perilesional routes, to exert local as well as systemic effects. The intraperitoneal route is expected to be particularly useful, for example, in the treatment of ovarian tumors. For these uses, additional conventional pharmaceutical preparations such as tablets, granules, powders, capsules, and sprays can be preferentially required. In such formulations further conventional additives such as binding-agents, wetting agents, propellants, lubricants, and stabilizers can also be required.

Compositions suitable for oral administration may be presented as discrete units, such as capsules, tablets, lozenges, each containing a predetermined amount of the anti-inflammatory agent. Other compositions include suspensions in aqueous liquids or non-aqueous liquids such as a syrup, elixir or an emulsion.

Other delivery systems can include time-release, delayed release or sustained release delivery systems. Such systems can avoid repeated administrations of the anti-inflammatory agent, increasing convenience to the subject and the physician. Many types of release delivery systems are available and known to those of ordinary skill in the art. They include polymer base systems such as poly(lactide-glycolide), copolyoxalates, polycaprolactones, polyesteramides, polyorthoesters, polyhydroxybutyric acid, and polyanhydrides. Microcapsules of the foregoing polymers containing drugs are described in, for example, U.S. Patent 5,075,109. Delivery systems also include non-polymer systems that are: lipids including sterols such as cholesterol, cholesterol esters and fatty acids or neutral fats such as mono- di- and tri-glycerides; hydrogel release systems; sylastic systems; peptide based systems; wax coatings; compressed tablets using conventional binders and excipients; partially fused implants; and the like. Specific examples include, but are not limited to: (a) erosional systems in which the anti-inflammatory agent is contained in a form within a matrix such as those described in U.S. Patent Nos. 4,452,775, 4,667,014, 4,748,034 and 5,239,660 and (b) diffusional systems in which an active component permeates at a controlled rate from a polymer such as described in U.S. Patent Nos. 3,832,253, and 3,854,480. In addition, pump-based hardware delivery systems can be used, some of which are adapted for implantation.

Use of a long-term sustained release implant may be particularly suitable for treatment of chronic conditions. Long-term release, are used herein, means that the implant is constructed and arranged to delivery therapeutic levels of the active ingredient for at least 30 days, and preferably 60 days. Long-term sustained release implants are well-known to those of ordinary skill in the art and include some of the release systems described above.

In some embodiments, the pharmaceutical compositions used for therapeutic administration must be sterile. Sterility is readily accomplished by filtration through sterile filtration membranes (e.g., 0.2 micron membranes). Alternatively, preservatives can be used to prevent the growth or action of microorganisms. Various preservatives are well known and include, for example, phenol and ascorbic acid. The active ingredients and/or the pharmaceutical compositions ordinarily will be stored in lyophilized form or as an aqueous solution if it is highly stable to thermal and oxidative denaturation. The pH of the preparations typically will be about from 6 to 8, although higher or lower pH values can also be appropriate in certain instances.

In some embodiments, administration of a Psap peptide may be combined with another therapy, such as a chemotherapy, radiation, and/or surgery.

CD36

CD36 (Cluster of Differentiation 36) is an integral membrane protein found on the surface of many cell types in vertebrate animals and is also known as FAT, GP4, GP3B, GPIV, CHDS7, PASIV, SCARB3, and BDPLT10. The Entrez Gene ID for human CD36 is 948. Exemplary human CD36 transcripts and proteins are below:

CD36 Transcript Variant 1

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CTTTCAATTCCTCTGGCAACAAACCACACACTGGGATCTGACACTGTAGAGTGCTTTCTCTTCTCTTTT
TTTGGGGGGGGGAGGGGGTGTGGTTGCATATTTAAACTCTCACGCATTTATGTACTGAGGACTGCAGTG
TAGGACTTTCCTGCAGAATACCATTTGATCCTATTAAGAATTGTCCAAATGTTGGAGCATTTGATTGAA
AAATCCTTCTTAGCCATTTTAAAGATAGCTTTCCAATGATTAGACGAATTGATTCTTTCTGTGACTCAT
CAGTTCATTTCCTGTAAAATTCATGTCTTGCTGTTGATTTGTGAATAAGAACCAGAGCTTGTAGAAACC
ACTTTAATCATATCCAGGAGTTTGCAAGAAACAGGTGCTTAACACTAATTCACCTCCTGAACAAGAAAA
ATGGGCTGTGACCGGAACTGTGGGCTCATCGCTGGGGCTGTCATTGGTGCTGTCCTGGCTGTGTTTGGA
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GGTACAATTGCTTTTAAAAATTGGGTTAAAACAGGCACAGAAGTTTACAGACAGTTTTGGATCTTTGAT
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CD36 Transcript Variant 2

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(SEQ ID NO: 5)

CD36 Transcript Variant 3

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CD36 Transcript Variant 4

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CD36 Transcript Variant 5

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CD36 Protein

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VQNPQEVMMNSSNIQVKQRGPYTYRVRFLAKENVTQDAEDNTVSFLQPNGAIFEPSLSVGTEADNFTVL
NLAVAAASHIYQNQFVQMILNSLINKSKSSMFQVRTLRELLWGYRDPFLSLVPYPVTTTVGLFYPYNNT
ADGVYKVFNGKDNISKVAIIDTYKGKRNLSYWESHCDMINGTDAASFPPFVEKSQVLQFFSSDICRSIY
AVFESDVNLKGIPVYRFVLPSKAFASPVENPDNYCFCTEKIISKNCTSYGVLDISKCKEGRPVYISLPH
FLYASPDVSEPIDGLNPNEEEHRTYLDIEPITGFTLQFAKRLQVNLLVKPSEKIQVLKNLKRNYIVPIL
WLNETGTIGDEKANMFRSQVTGKINLLGLIEMILLSVGVVMFVAFMISYCACRSKTIK (SEQ ID NO: 9)

Psap Peptide

Prosaposin (Psap) is the Saposin precursor protein made up of approximately 524-527 amino acids which includes a 16 amino acids signal peptide. The full-length precursor polypeptide undergoes co-translational glycosylation and modification in the endoplasmic reticulum and Golgi system to yield a 70-72 kDa precursor protein. After transport to the lysosome, cathepsin D participates in its proteolytic processing to yield intermediate molecular forms of 35 to 53 kDa and then to a 13-kDa glycoprotein and finally to the mature 8-11 kDa partially glycosylated forms of individual Saposin molecules (O'Brien J. S., and Kishimoto Y, The FASEB J., 5: 301-8, 1991; Kishimoto Y. et al., J. Lipid Res. 33:1255-67, 1992). Prosaposin is processed into 4 cleavage products: Saposins A, B, C, and D. The amino acid sequences of Psap preproprotein isoforms A, B, and C and the amino acid sequence of cleavage product Saposin A are below:

Psap Preproprotein Isoform A

MYALFLLASLLGAALAGPVLGLKECTRGSAVWCQNVKTASDCGAVKHCLQTVWNK
PTVKSLPCDICKDVVTAAGDMLKDNATEEEILVYLEKTCDWLPKPNMSASCKEIVDSY
LPVILDIIKGEMSRPGEVCSALNLCESLQKHLAELNHQKQLESNKIPELDMTEVVAPFM
ANIPLLLYPQDGPRSKPQPKDNGDVCQDCIQMVTDIQTAVRTNSTFVQALVEHVKEEC
DRLGPGMADICKNYISQYSEIAIQMMMHMQPKEICALVGFCDEVKEMPMQTLVPAKV

ASKNVIPALELVEPIKKHEVPAKSDVYCEVCEFLVKEVTKLIDNNKTEKEILDAFDKM CSKLPKSLSEECQEVVDTYGSSILSILLEEVSPELVCSMLHLCSGTRLPALTVHVTQPKD GGFCEVCKKLVGYLDRNLEKNSTKQEILAALEKGCSFLPDPYQKQCDQFVAEYEPVLI EILVEVMDPSFVCLKIGACPSAHKPLLGTEKCIWGPSYWCQNTETAAQCNAVEHCKR HVWN (SEQ ID NO: 10)

Psap Preproprotein Isoform B

MYALFLLASLLGAALAGPVLGLKECTRGSAVWCQNVKTASDCGAVKHCLQTVWNK PTVKSLPCDICKDVVTAAGDMLKDNATEEEILVYLEKTCDWLPKPNMSASCKEIVDSY LPVILDIIKGEMSRPGEVCSALNLCESLQKHLAELNHQKQLESNKIPELDMTEVVAPFM ANIPLLLYPQDGPRSKPQPKDNGDVCQDCIQMVTDIQTAVRTNSTFVQALVEHVKEEC DRLGPGMADICKNYISQYSEIAIQMMMHMQDQQPKEICALVGFCDEVKEMPMQTLVP AKVASKNVIPALELVEPIKKHEVPAKSDVYCEVCEFLVKEVTKLIDNNKTEKEILDAFD KMCSKLPKSLSEECQEVVDTYGSSILSILLEEVSPELVCSMLHLCSGTRLPALTVHVTQ PKDGGFCEVCKKLVGYLDRNLEKNSTKQEILAALEKGCSFLPDPYQKQCDQFVAEYE PVLIEILVEVMDPSFVCLKIGACPSAHKPLLGTEKCIWGPSYWCQNTETAAQCNAVEH CKRHVWN (SEQ ID NO: 11)

Psap Preproprotein Isoform C

MYALFLLASLLGAALAGPVLGLKECTRGSAVWCQNVKTASDCGAVKHCLQTVWNK PTVKSLPCDICKDVVTAAGDMLKDNATEEEILVYLEKTCDWLPKPNMSASCKEIVDSY LPVILDIIKGEMSRPGEVCSALNLCESLQKHLAELNHQKQLESNKIPELDMTEVVAPFM ANIPLLLYPQDGPRSKPQPKDNGDVCQDCIQMVTDIQTAVRTNSTFVQALVEHVKEEC DRLGPGMADICKNYISQYSEIAIQMMMHMDQQPKEICALVGFCDEVKEMPMQTLVPA KVASKNVIPALELVEPIKKHEVPAKSDVYCEVCEFLVKEVTKLIDNNKTEKEILDAFDK MCSKLPKSLSEECQEVVDTYGSSILSILLEEVSPELVCSMLHLCSGTRLPALTVHVTQP KDGGFCEVCKKLVGYLDRNLEKNSTKQEILAALEKGCSFLPDPYQKQCDQFVAEYEP VLIEILVEVMDPSFVCLKIGACPSAHKPLLGTEKCIWGPSYWCQNTETAAQCNAVEHC KRHVWN (SEQ ID NO: 12)

Saposin A

SLPCDICKDVVTAAGDMLKDNATEEEILVYLEKTCDWLPKPNMSASCKEIVDSYLPVI L DIIKGEMSRPGEVCSALNLCES (SEQ ID NO: 13)

Aspects of the disclosure relate to a Psap peptide and uses thereof. Psap peptides comprise sequences that were originally derived from fragments of Saposin A. It was shown previously that fragments of Saposin A consisting of as few as 4 amino acids, and variants of these fragments, had anti-angiogenic and anti-cancer activity. Psap peptides and methods of making Psap peptides are known in the art (see, e.g., PCT publications WO2009002931 and WO/2011/084685; PCT application PCT/US2012/71424, published as PCT publication WO/2013/096868, and US Patent Applications 12/640,788 and 13/516,511, all of which are incorporated herein by reference in their entirety).

In some embodiments, a Psap peptide comprises the amino acid sequence CDWLPK (SEQ ID NO: 1), DWLPK (SEQ ID NO: 2), or DWLP (SEQ ID NO: 3), or an amino acid substitution variant thereof, wherein the amino acid substitution is:

a) Tyrosine (Y) for Tryptophan (W);

b) an amino acid substitution for Leucine (L) selected from Valine (V), Alanine (A) or Glycine (G), or a non-canonical amino acid of similar size, or a derivative thereof;

c) Arginine (R) for Lysine (K);

d) a D-isomer of Aspartic Acid (D) for an L-isomer of Aspartic Acid (D) and/or a D-isomer of Leucine (L) for a L-isomer of Leucine (L);

e) a D-isomer of Tryptophan (W) for an L-isomer of Tryptophan (W) and/or a D-isomer of Proline (P) for an L-isomer of Proline (P); or combinations thereof. In some embodiments, a Psap peptide comprises the amino acid sequence CDWLPK (SEQ ID NO: 1), DWLPK (SEQ ID NO: 2), or DWLP (SEQ ID NO: 3).

It is to be understood that a Psap peptide can be of any length. In some embodiments, the Psap peptide is 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 33, 34, 35, 36, 37, 38, 39, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95 or 100 or more amino acids in length. In some embodiments, the Psap peptide is 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 33, 34, 35, 36, 37, 38, 39, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 200, 300, 400, 500 or fewer amino acids in length. In some embodiments, the Psap peptide is 4-500, 4-400, 4-300, 4-200, 4-100, 4-90, 4-80, 4-70, 4-60, 4-50, 4-40, 4-30, 4-25, 4-20, 5-500, 5-400, 5-300, 5-200, 5-100, 5-90, 5-80, 5-70, 5-60, 5-50, 5-40, 5-30, 5-25, 5-20, 6-500, 6-400, 6-300, 6-200, 6-100, 6-90, 6-80, 6-70, 6-60, 6-50, 6-40, 6-30, 6-25, or 6-20 amino acids in length.

It is to be understood that amino acids flanking the CDWLPK (SEQ ID NO: 1), DWLPK (SEQ ID NO: 2), or DWLP (SEQ ID NO: 3) may be the naturally flanking amino acids present in Saposin A or Prosaposin (e.g., <u>LEKTC</u>DWLP<u>KPNMS</u> (SEQ ID NO: 14), the underlined amino acids are the amino acids naturally flanking the DWLP (SEQ ID NO: 3) sequence in Saposin A). Accordingly, in some embodiments, the Psap peptide comprises the amino acid sequence DWLPKPNMS (SEQ ID NO: 15), CDWLPKPNM (SEQ ID NO: 16), TCDWLPKPN (SEQ ID NO: 17), KTCDWLPKP (SEQ ID NO: 18), EKTCDWLPK (SEQ ID NO: 19), LEKTCDWLP (SEQ ID NO: 20) or an amino acid substitution variant thereof wherein the substitution occurs in CDWLPK (SEQ ID NO: 1), DWLPK (SEQ ID NO: 2), or DWLP (SEQ ID NO: 3). Other examples of Psap peptides include without limitation, DWLPKPNMS (SEQ ID NO: 21), CDWLPKPNM (SEQ ID NO: 22), TCDWLPKPN (SEQ ID NO: 23), KTCDWLPKP (SEQ ID NO: 24), EKTCDWLPK (SEQ ID NO: 25), and LEKTCDWLP (SEQ ID NO: 26). Other Psap peptide examples include, without limitation, DWLPKPNM (SEQ ID NO: 27), CDWLPKPN (SEQ ID NO: 28), TCDWLPKP (SEQ ID NO: 29), KTCDWLPK (SEQ ID NO: 30), EKTCDWLP (SEQ ID NO: 31), DWLPKPN (SEQ ID NO: 32), CDWLPKP (SEQ ID NO: 33), TCDWLPK (SEQ ID NO: 34), KTCDWLP (SEQ ID NO: 35), DWLPKP (SEQ ID NO: 36), CDWLPK (SEQ ID NO: 1), TCDWLP (SEQ ID NO: 37), DWLPK (SEQ ID NO: 2), CDWLP (SEQ ID NO: 38), and DWLP (SEQ ID NO: 3).

It is also to be understood that amino acids flanking CDWLPK (SEQ ID NO: 1), DWLPK (SEQ ID NO: 2), or DWLP (SEQ ID NO: 3) need not be the naturally flanking amino acids present in Saposin A or Prosaposin, but can instead be any amino acid. Thus, a Psap peptide can include any number and identity of flanking amino acids. In some embodiments, the flanking amino acids may comprise an antibody or antibody Fc domain, serum transferrin or portions thereof, albumin, or transthyretin (see, e.g., G. M. Subramanian, (2007), Nature Biotechnology 25, 1411 – 141).

Psap peptides can be synthesized using any method known in the art. Exemplary methods of synthesis include, but are not limited to, recombinant synthesis, liquid-phase synthesis, Solid-phase synthesis, chemical ligation (see, e.g., Molecular Cloning: A Laboratory Manual, J. Sambrook, et al., eds., Third Edition, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York, 2001; Current Protocols in Molecular Biology, F.M. Ausubel, et al., eds., John Wiley & Sons, Inc., New York; Schnolzer, M. A., P.; Jones, A.; Alewood, D.; Kent, S.B.H. (2007). "In Situ Neutralization in Boc-chemistry Solid Phase Peptide Synthesis". Int. J. Peptide Res. Therap. 13 (1–2): 31–44; Albericio, F. (2000). Solid-Phase Synthesis: A Practical Guide (1 ed.). Boca Raton: CRC Press. p. 848; and Nilsson BL, Soellner MB, Raines RT (2005). "Chemical Synthesis of Proteins". Annu. Rev. Biophys. Biomol. Struct. 34: 91–118; and US Patent Nos. 4,749,742, 4,794,150, 5,552,471, 5,637,719, 6,001,966, 7,038,103, 7,094,943, 7,176,282, and 7,645,858, the entirety of which are incorporated herein by reference).

In some embodiments, the Psap peptide may be modified, for example, through oligomerization or polymerization (e.g., dimers, trimer, multimers, etc.), modifications of amino acid residues or peptide backbone, cross-linking, cyclization, conjugation, pegylation, glycosylation, acetylation, phosphorylation, fusion to additional heterologous amino acid sequences (for example, an antibody or antibody Fc domain, serum transferrin or portions thereof, albumin, or transthyretin), or other modifications that substantially alter the stability, solubility, or other properties of the peptide while substantially retaining or enhancing therapeutic activity. Conjugation may be, e.g., to a polymer. Suitable polymers include, for example, polyethylene glycol (PEG), polyvinyl pyrrolidone, polyvinyl alcohol, polyamino acids, divinylether maleic anhydride, N-(2-Hydroxypropyl)-methacrylamide, dextran, dextran derivatives including dextran sulfate, polypropylene glycol, polyoxyethylated polyol, heparin, heparin fragments, polysaccharides, cellulose and cellulose derivatives, including methylcellulose and carboxymethyl cellulose, starch and starch derivatives, polyalkylene glycol and derivatives thereof, copolymers of polyalkylene glycols and derivatives thereof, polyvinyl ethyl ethers, and α,β-Poly[(2-hydroxyethyl)-DL-aspartamide, and the like, or mixtures thereof. Conjugation may be through a linker, e.g., a peptide or chemical linker. Methods of modifying peptides are well known in the art (see, e.g., U. S. Pat. Nos.: 5,180,816, 5,596,078, 5,990,273, 5,766,897, 5,856,456, 6,423,685, 6,884,780, 7,610,156, 7,256,258, 7,589,170 and 7,022,673, and PCT publication WO 2010/014616, the contents of which are incorporated herein by reference).

In some embodiments, the Psap peptide is a cyclic peptide. Cyclic peptides are polypeptide chains whose amino and carboxyl termini are linked together with a peptide bond or other covalent bond, forming a circular chain. In one embodiment, the peptide contains amino and carboxyl terminal cysteine amino acid residues. Cysteines facilitate S-S disulfide bond formation. In one embodiment, the peptide contains additional cysteine amino acid residues, wherein the cysteine amino acid residues are near the termini but not necessarily at the very end. In some embodiments, the cysteine amino acid residues are within the five amino acid residues of the termini of the peptide. Methods of design and synthesis of cyclic peptides are well known in the art, e.g. as described in U.S. Pat. Nos. 5,596,078; 5,990,273; 7,589,170 and U.S. Patent Application No. 20080287649.

In some embodiments, the Psap peptide is functionally modified to enhance stability. In some embodiments, the Psap peptide comprises an N-terminal acetyl group and/or a C terminal amide group. In some embodiments, the Psap peptide comprises an N-terminal acetyl group and a C terminal amide group. In some embodiments, the Psap peptide is Ac-dWlP-Amide or Ac-DWLP-Amide (Ac = acetyl group, lower case D and L indicate D-amino acids, SEQ ID NOs: 39 and 40, respectively). In some embodiments, chemical modifications to the Psap peptide include, but are not limited to the inclusion of, alkyl, alkoxy, hydroxyalkyl, alkoxyalkyl, alkoxycarbonyl, alkenyl, alkynyl, cycloalkyl, amino, alkylamino, aminoalkyl, dialkylamino, aminodialkyl, halogen, heteroatom, carbocycle, carbocyclyl, carbocyclo, carbocyclic, aryl, aralkyl, aralkoxy, aryloxyalkyl, heterocycle, heterocyclyl, heterocyclic, heteroaryl, and/or aliphatic groups.

Psap peptides also encompass peptidomimetics (e.g., D-peptides, β peptides and peptoids). The peptidomimetics utilized can encompass the entire length of the Psap peptide, or only a portion of the Psap peptide. Peptidomimetics may include, e.g., D-amino acids, reduced amide bonds for the peptide backbone, and non-peptide bonds to link the side chains, pyrrolinone and sugar mimetics. The design and synthesis of sugar scaffold peptide mimetics are described by Hirschmann et al. (J. Med. Chem., 1996, 36, 2441-2448, which is incorporated herein by reference in its entirety). Further, pyrrolinone-based peptidomimetics are also described (see, for example, Smith et al., J. Am. Chem. Soc. 2000, 122, 11037-11038, which is incorporated herein by reference in its entirety). In some embodiments the Psap peptide is in the form of a peptoid (U.S. Patent No. 5,811,387; Simon et al. Proceedings of the National Academy of Sciences USA, (1992), 89(20), 9367-9371). In some embodiments, peptoids are poly-N-substituted glycines. In peptoids the side chain is connected to the nitrogen of the peptide backbone, instead of the α-carbon as in peptides. In some embodiments the peptoid contains nitroaromatic monomer units (Fowler et al., J Org Chem. 2009 Feb 20;74(4):1440-9). In some embodiments, the peptoid is N-substituted with alpha-chiral aromatic side chains (Gorske et al., J Am Chem Soc. 2006 Nov 8;128(44):14378-87) at one or more residues. In some embodiments, the Psap peptide comprises a peptoid region (i.e., containing one or more side chains connected to the nitrogen of the peptide backbone) and a peptide region (i.e., containing one or more side chains connected to the α-carbon).

Psap Amino Acid Substitutions

In some embodiments, a Psap peptide comprises an amino acid substitution variant of CDWLPK (SEQ ID NO: 1), DWLPK (SEQ ID NO: 2), or DWLP (SEQ ID NO: 3), wherein the amino acid substitution is:

a) Tyrosine (Y) for Tryptophan (W);

b) an amino acid substitution for Leucine (L) selected from Valine (V), Alanine (A) or Glycine (G), or a non-canonical amino acid of similar size, or a derivative thereof;

c) Arginine (R) for Lysine (K);

d) a D-isomer of Aspartic Acid (D) for an L-isomer of Aspartic Acid (D) and/or a D-isomer of Leucine (L) for a L-isomer of Leucine (L);

e) a D-isomer of Tryptophan (W) for an L-isomer of Tryptophan (W) and/or a D-isomer of Proline (P) for an L-isomer of Proline (P); or combinations thereof.

Conservative amino acid substitutions can be replacement of one amino acid residue with an amino acid residue having a side chain with a similar charge, size, polarity, hydrophobicity, or combination thereof. Families of amino acid residues having side chains with similar charges have been defined in the art. These families include amino acids with basic side chains (e.g., lysine, arginine, histidine), acidic side chains (e.g., aspartic acid, glutamic acid), uncharged polar side chains (e.g., glycine, asparagine, glutamine, serine, threonine, tyrosine, cysteine), nonpolar side chains (e.g., alanine, valine, leucine, isoleucine, proline, phenylalanine, methionine, tryptophan), beta-branched side chains (e.g., threonine, valine, isoleucine) and aromatic side chains (e.g., tyrosine, phenylalanine, tryptophan, histidine).

Conservative amino acid substitutions typically do not change the overall structure of the peptide and/or the type of amino acid side chains available for forming van der Waals bonds with a binding partner. In some embodiments, a conservative substitution for Leucine is Valine. In some embodiments, a conservative substitution for Leucine is Valine or Alanine.

In some embodiments, conservative or non-conservative substitutions for Leucine are contemplated. In some embodiments, the substitution for Leucine is Valine, Glycine or Alanine. In some embodiments, a substitution for Leucine is Glycine. In some embodiments, a substitution for Leucine is Glycine or Valine. In some embodiments, the amino acid substitution is a Tyrosine (Y) for a Tryptophan (W).

Exemplary amino acid substitution variants include, but are not limited to, DWAP (SEQ ID NO: 41), DYLPK (SEQ ID NO: 42), DWVPK (SEQ ID NO: 43), DWLPR(SEQ ID NO: 44), DWAPK (SEQ ID NO: 45), and DYLP (SEQ ID NO: 46).

Substitution with a non-canonical amino acid is also contemplated herein. In some embodiments, Leucine is substituted with a non-canonical amino acid. In some embodiments, the non-canonical amino acid substitute for Leucine has a similar size to Leucine, Valine, Alanine, or Glycine. Examples of non-canonical amino acids include azidoalanine, azidohomoalanine, azidonorvaline, azidonorleucine, azidonorvaline, homoallyglycine, homoproparglycine, norvaline, norleucine, cis-crotyiglycine, trans-crotylglycine, 2-aminoheptanoic acid, 2-butynyiglycine, allyglycine, 3-(1-naphthyl)alanine, 3-(2-naphthyl)alanine, p-ethynyl-phenylalanine, p-propargly-oxy-phenylalanine, m-ethynyl-phenylalanine, 3-(6-chloroindolyl)alanine, 3-(6-bromoindolyl)alanine, 3-(5-bromoindolyl)alanine, azidohomoalanine, homopropargylglycine, p-chlorophenylalanine, α-aminocaprylic acid, methylvaline, methylleucine, or sarcosine. In some embodiments, Leucine is substituted with a non-canonical amino acid selected from methylvaline, methylleucine, or sarcosine. Non-canonical amino acids and methods of synthesis thereof are well known in the art (see, e.g., U.S. Patent Publications 2010-0247433, 2008-0214439, 2004-0053390, and 2004-0058415; PCT publication WO 03/073238; and U.S. Pat. No. 6,586,207, all of which are incorporated herein by reference).

Amino acid substitution can be achieved during chemical synthesis of the peptide by adding the desired substitute amino acid at the appropriate sequence in the synthesis process. Alternatively, molecular biology methods can be used. Non-conservative substitutions are also encompassed to the extent that they substantially retain the activities of those peptides described herein.

As previously described, Psap peptides comprising CDWLPK (SEQ ID NO: 1), DWLPK (SEQ ID NO: 2), or DWLP (SEQ ID NO: 3) having D-amino acid substitutions were also shown to have a desired therapeutic activity (see PCT application PCT/US2012/71424, published as PCT publication WO/2013/096868). As such, amino acid substitution variants resulting from substitution of one or more D-amino acids for the like L-amino acid are contemplated herein. In some embodiments, one D-amino acid substitution is present. In some embodiments, 2 or more D-amino acid substitutions are present. In some embodiments, 3, 4, or 5 D-amino acid substitutions are present. In some embodiments, the D-amino acid substitutions are evenly spaced, e.g., every other amino acid, of the 4-6 mer. In some embodiments, the D-amino acid substitution is for Tryptophan (W) and/or Proline (P). In some embodiments, the D-amino acid substitution is for Aspartic Acid (D) and/or Leucine (L)). The L and D convention for amino acid configuration refers not to the optical activity of the amino acid itself, but rather to the optical activity of the isomer of glyceraldehyde from which that amino acid can, in theory, be synthesized (D-glyceraldehyde is dextrorotary; L-glyceraldehyde is levorotary). Exemplary D amino acid substitutions include dWlP and DwLp (lower case D and L indicate D-amino acids, SEQ ID NOs: 47 and 48, respectively).

Assay

Aspects of the disclosure relate to performing an assay to determine a level of CD36 in a sample. Any assay known in the art can be used for measuring a CD36 level (see, e.g., Molecular Cloning: A Laboratory Manual, J. Sambrook, et al., eds., Third Edition, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York, 2001, Current Protocols in Molecular Biology, F.M. Ausubel, et al., eds., John Wiley & Sons, Inc., New York. Microarray technology is described in Microarray Methods and Protocols, R. Matson, CRC Press, 2009, or Current Protocols in Molecular Biology, F.M. Ausubel, et al., eds., John Wiley & Sons, Inc., New York). The level of CD36 can be an mRNA level and/or a protein level. In some embodiments, the level of CD36 is a protein level. Assays for detecting CD36 mRNA include, but are not limited to, Northern blot analysis, RT-PCR, sequencing technology, RNA in situ hybridization (using e.g., DNA or RNA probes to hybridize to RNA molecules present in the sample), in situ RT-PCR (e.g., as described in Nuovo GJ, et al. Am J Surg Pathol. 1993, 17: 683-90; Komminoth P, et al. Pathol Res Pract. 1994, 190: 1017-25), and oligonucleotide microarray (e.g., by hybridization of polynucleotide sequences derived from a sample to oligonucleotides attached to a solid surface (e.g., a glass wafer) with addressable locations, such as an Affymetrix microarray (Affymetrix®, Santa Clara, CA)). Methods for designing nucleic acid binding partners, such as probes, are well known in the art. In some embodiments, the nucleic acid binding partners bind to a part of or an entire nucleic acid sequence of CD36, the sequence being identifiable with the CD36 sequences provided herein.

Assays for detecting CD36 protein levels include, but are not limited to, immunoassays (also referred to herein as immune-based or immuno-based assays, e.g., Western blot, immunohistochemistry and ELISA assays), Mass spectrometry, and multiplex bead-based assays. Such assays for protein level detection are well-known in the art. Binding partners for protein detection can be designed using methods known in the art and as described herein. In some embodiments, the CD36 protein binding partners, e.g., anti-CD36 antibodies, bind to a part of or an entire amino acid sequence of the CD36 protein. Other examples of protein detection and quantitation methods include multiplexed immunoassays as described for example in U.S. Patent Nos. 6939720 and 8148171, and published US Patent Application No. 2008/0255766, and protein microarrays as described for example in published US Patent Application No. 2009/0088329.

In some embodiments, the sample obtained from a subject is a tumor biopsy and the assay for detecting CD36 protein levels is an immuno-based assay performed on the tumor biopsy.

Any suitable binding partner for CD36 is contemplated for detection of a CD36 level. In some embodiments, the binding partner is any molecule that binds specifically to a CD36 protein. As described herein, "binds specifically to a CD36 protein" means that the molecule is more likely to bind to a portion of or the entirety of a CD36 protein than to a portion of or the entirety of a non-CD36 protein. In some embodiments, the binding partner is an antibody or antigen-binding fragment thereof, such as Fab, F(ab)2, Fv, single chain antibodies, Fab and sFab fragments, F(ab')2, Fd fragments, scFv, or dAb fragments. Methods for producing antibodies and antigen-binding fragments thereof are well known in the art (see, e.g., Sambrook et al, "Molecular Cloning: A Laboratory Manual" (2nd Ed.), Cold Spring Harbor Laboratory Press (1989); Lewin, "Genes IV", Oxford University Press, New York, (1990), and Roitt et al., "Immunology" (2nd Ed.), Gower Medical Publishing, London, New York (1989), WO2006/040153, WO2006/122786, and WO2003/002609). Binding partners also include other peptide molecules and aptamers that bind specifically to CD36. Methods for producing peptide molecules and aptamers are well known in the art (see, e.g., published US Patent Application No. 2009/0075834, US Patent Nos. 7435542, 7807351, and 7239742).

Commercially available CD36 antibodies include, for example, N-15, SMφ, L-17, ME542, H300, 185-1G2, and V-19 from Santa Cruz Biotechnology (Catalog numbers sc-5522, sc-7309, sc-13572, sc-5523, sc-9154, sc-21772, and sc-7641, respectively), JC63.1, FA6-152, and anti-CD36 from Abcam (Catalog numbers ab23680, ab17044, and ab78054, respectively).

In some embodiments, the binding partner is any molecule that binds specifically to a CD36 mRNA. As described herein, "binds specifically to a CD36 mRNA" means that the molecule is more likely to bind to a portion of or the entirety of the CD36 mRNA (e.g., by complementary base-pairing) than to a portion of or the entirety of a non-CD36 mRNA or other non-CD36 nucleic acid. In some embodiments, the binding partner that binds specifically to a CD36 mRNA is a nucleic acid, e.g., a probe. Binding partners can be designed using the nucleotide and amino acid sequences of CD36, which are provided herein. In some embodiments, a CD36 binding partner may comprise a detectable label, such as an enzymatically active group, a fluorescent molecule, a chromophore, a luminescent molecule, a specifically bindable ligand, or a radioisotope. In some embodiments, a second binding partner specific for the CD36 binding partner is also contemplated, such as a secondary antibody.

Sample

Aspects of the disclosure relate to determining a level of CD6 in a sample obtained from a subject. In some embodiments, the sample obtained from a subject is a tumor sample.

As used herein, a tumor sample may comprise, e.g., a tumor cell, a population of tumor cells, a fragment of a tumor (e.g., a biopsy), or an entire tumor. In some embodiments, the tumor sample is a tumor biopsy. In some embodiments, the tumor sample comprises circulating tumor cells. In some embodiments, the tumor sample comprises ascites. In some embodiments, the tumor sample comprises pleural fluid. The tumor sample may contain non-tumor cells or non-tumor tissue (e.g., a biopsy that contains normal tissue surrounding a tumor fragment). In some embodiments, the sample may be a tissue or fluid sample obtained from a subject. Examples of fluid samples are blood, plasma, serum, and urine.

Subjects

Aspects of the disclosure relate to subjects, such as human subjects, with cancer. Any type of cancer is contemplated herein, including, but not limited to, leukemias, lymphomas, myelomas, carcinomas, metastatic carcinomas, sarcomas, adenomas, nervous system cancers and genitourinary cancers. Exemplary cancer types include adult and pediatric acute lymphoblastic leukemia, acute myeloid leukemia, adrenocortical carcinoma, AIDS-related cancers, anal cancer, cancer of the appendix, astrocytoma, basal cell carcinoma, bile duct cancer, bladder cancer, bone cancer, osteosarcoma, fibrous histiocytoma, brain cancer, brain stem glioma, cerebellar astrocytoma, malignant glioma, ependymoma, medulloblastoma, supratentorial primitive neuroectodermal tumors, hypothalamic glioma, breast cancer, male breast cancer, bronchial adenomas, Burkitt lymphoma, carcinoid tumor, carcinoma of unknown origin, central nervous system lymphoma, cerebellar astrocytoma, malignant glioma, cervical cancer, childhood cancers, chronic lymphocytic leukemia, chronic myelogenous leukemia, chronic myeloproliferative disorders, colorectal cancer, cutaneous T-cell lymphoma, endometrial cancer, ependymoma, esophageal cancer, Ewing family tumors, extracranial germ cell tumor, extragonadal germ cell tumor, extrahepatic bile duct cancer, intraocular melanoma, retinoblastoma, gallbladder cancer, gastric cancer, gastrointestinal stromal tumor, extracranial germ cell tumor, extragonadal germ cell tumor, ovarian germ cell tumor, gestational trophoblastic tumor, glioma, hairy cell leukemia, head and neck cancer, hepatocellular cancer, Hodgkin lymphoma, non-Hodgkin lymphoma, hypopharyngeal cancer, hypothalamic and visual pathway glioma, intraocular melanoma, islet cell tumors, Kaposi sarcoma, kidney cancer, renal cell cancer, laryngeal cancer, lip and oral cavity cancer, small cell lung cancer, non-small cell lung cancer, primary central nervous system lymphoma, Waldenstrom macroglobulinema, malignant fibrous histiocytoma, medulloblastoma, melanoma, Merkel cell carcinoma, malignant mesothelioma, squamous neck cancer, multiple endocrine neoplasia syndrome, multiple myeloma, mycosis fungoides, myelodysplastic syndromes, myeloproliferative disorders, chronic myeloproliferative disorders, nasal cavity and paranasal sinus cancer, nasopharyngeal cancer, neuroblastoma, oropharyngeal cancer, ovarian cancer, pancreatic cancer, parathyroid cancer, penile cancer, pharyngeal cancer, pheochromocytoma, pineoblastoma and supratentorial primitive neuroectodermal tumors, pituitary cancer, plasma cell neoplasms, pleuropulmonary blastoma, prostate cancer, rectal cancer, rhabdomyosarcoma, salivary gland cancer, soft tissue sarcoma, uterine sarcoma, Sezary syndrome, non-melanoma skin cancer, small intestine cancer, squamous cell carcinoma, squamous neck cancer, supratentorial primitive neuroectodermal tumors, testicular cancer, throat cancer, thymoma and thymic carcinoma, thyroid cancer, transitional cell cancer, trophoblastic tumors, urethral cancer, uterine cancer, uterine sarcoma, vaginal cancer, vulvar cancer, or Wilms tumor.

In some embodiments, the cancer is prostate cancer, breast cancer, ovarian cancer, lung cancer, leukemia, pancreatic cancer, glioblastoma multiforme, astrocytoma or melanoma. In some embodiments, the cancer is prostate cancer, breast cancer, lung cancer, leukemia, pancreatic cancer, glioblastoma multiforme, astrocytoma or melanoma. In some embodiments, the cancer is pancreatic cancer, ovarian cancer, breast cancer, prostate cancer, melanoma cancer, or lung cancer.

Control and Control Level

Aspects of the disclosure relate to comparison of a CD36 level in a sample with a control level. In some embodiments, the control level is a level of CD36 in a cell, tissue or fluid obtained from a healthy subject or population of healthy subjects. As used herein, a healthy subject is a subject that is apparently free of disease and has no history of disease, such as cancer.

In some embodiments, the control level is determined from a sample obtained from a subject having cancer. Accordingly, in some embodiments the control level is obtained from the same subject from whom the sample is obtained. In some embodiments, a control level is a level of CD36 from a non-cancerous cell or tissue obtained from the subject having the cancer.

In some embodiments, a control level is a level of CD36 that is undetectable or below a background/noise level obtained using standard methods of detection (e.g., Western blot or immunohistochemistry).

The disclosure also involves comparing the level of CD36 in a sample from the subject with a predetermined level or value, such that a control level need not be measured every time. The predetermined level or value can take a variety of forms. It can be single cut-off value, such as a median or mean. It can be established based upon comparative groups, such as where one defined group is known not to respond to treatment with a Psap peptide and another defined group is known to be responsive to treatment with a Psap peptide. It can be a range, for example, where the tested population is divided equally (or unequally) into groups, such as a unresponsive to treatment with a Psap peptide, somewhat responsive to treatment with a Psap peptide, and highly responsive to treatment with a Psap peptide, or into quadrants, the lowest quadrant being subjects with no response to treatment with a Psap peptide and the highest quadrant being subjects with the highest response to treatment with a Psap peptide response.

The predetermined value can depend upon the particular population selected. For example, an apparently healthy (no detectable cancer and no prior history of cancer) will have a different 'normal' range of CD36 than will a population the members of which have cancer but are known not to respond to treatment with a Psap peptide. Accordingly, the predetermined values selected may take into account the category in which a subject falls. Appropriate ranges and categories can be selected with no more than routine experimentation by those of ordinary skill in the art.

EXAMPLES

Example 1

Methods

Cell lines and Primary cells

The cell line PC3 was previously described (Kang et al. PNAS. 2009; 106:12115-20). PC3 cells were cultured in RPMI with 10% FBS. Human breast cancer cell lines MDA-MB-231 and MCF-7 were described previously (Ryu et al. PLoS one, 6, 2011). The murine Lewis lung carcinoma cell line LLCs (provided by Lea Eisenbach, Wiesmann Institute of Science, Rehovot, Israel) stably expressing RFP and firefly luciferase (Gupta GP, Massague J. Cancer metastasis: building a framework. Cell. 2006;127:679-95; Gao D, Nolan DJ, Mellick AS, Bambino K, McDonnell K, Mittal V. Endothelial progenitor cells control the angiogenic switch in mouse lung metastasis. Science. 2008;319:195-8; and Joyce JA, Pollard JW. Microenvironmental regulation of metastasis. Nat Rev Cancer. 2009;9:239-52), was cultured in DMEM supplemented with 10% fetal bovine serum. B16 melanoma cells, LNCaP prostate cancer cells, AsPc1 pancreatic cancer cells, and ID8 ovarian cancer cells were previously described (Overwijk WW et al. B16 as a mouse model for human melanoma. Curr Protoc Immunol. 2001, May;Chapter 20:Unit 20.1; Horoszewicz JS, Leong SS, Kawinski E et al.

LNCaP model of human prostatic carcinoma. Cancer Res. 1983, Apr;43(4):1809-18.; Chen WH, et al. Human pancreatic adenocarcinoma: in vitro and in vivo morphology of a new tumor line established from ascites. In Vitro 18: 24-34, 1982; and Roby KF, et al. Development of a syngeneic mouse model for events related to ovarian cancer. Carcinogenesis. 2000, 21:585–591). Primary ovarian cancer cells were derived from ovarian cancer patient ascites.

Western blot analysis

Cells were homogenized in lysis buffer (BioRad) containing protease inhibitors (Roche Applied Science). Samples were boiled in 1×SDS sampling buffer, and loaded onto 4-20% gradient Bis-Tris NuPAGE gels (Invitrogen). Western blotting was performed using antibodies specific for CD36 (AbCam, ab78054) or β-actin (Sigma-Aldrich).

In vitro cell proliferation assays

Cell proliferation was measured using the MTT (3-{4,5-Dimethylthiazol-2-yl}-2,5-diphenyltetrazolium bromide, Sigma-Aldrich) assay. Cells were seeded in 50 uL growth medium in 96 well culture plates and allowed to attach overnight. 50 uL of growth medium plus two-fold concentrated treatment reagents were then added. After each treatment time point, 10 uL of 5% MTT solution (buffered in PBS) was added to each well. Plates were incubated for an additional 4 h at 37°C to allow MTT to be metabolically converted into formazan crystals at cell mitochondria. The formazan crystals were finally solubilized by adding 100 ul of 10% Sodium Dodecyl Sulphate in 50% N-N-Dimethylformamide to each microplate well. Absorbances at 550 and 680 nm (corresponding to formazan salt and reference wavelengths, respectively) were measured using a colorimetry microplate reader. Wells containing only complete medium were used as controls. Each experiment was performed twice, using six replicates for each drug concentration.

Results

It was hypothesized that Tsp-1 upregulated by a Psap peptide may be acting directly on the cancer cells, rather than only through an indirect anti-angiogenic mechanism. To test this, LLC cells were treated with either recombinant Tsp-1 or DWLPK (SEQ ID NO: 2) Psap peptide and cell proliferation was measured using an MTT assay. It was found that Tsp-1 was capable of decreasing cell proliferation, while the Psap peptide did not affect cell proliferation (Figure 1A). This supports the hypothesis that Tsp-1 can act directly on cancer cells, as this assay was performed *in vitro* in the absence of any blood vessels. These results also show that the Psap peptide alone does not appear affect cancer cell proliferation, supporting the hypothesis that Psap peptides may indirectly treat cancer through upregulation of Tsp-1. LLC cells were shown to express CD36, a receptor for Tsp-1, indicating that Tsp-1 may act directly on cancer cells through CD36 (Figure 1B).

CD36 levels were measured in other cell lines to see if CD36 was also expressed by other cancer types. CD36 levels were measured in breast cancer (MDA-231, MCF-7), ovarian cancer (ID8), melanoma (B16), prostate cancer (PC3 and LNCaP), and lung cancer (LLC) cell lines by western blot analysis. It was found that CD36 protein was detectable in all cell lines tested, with particularly high levels of CD36 detectable in MDA-231, MCF-7, PC3, and LLC cell lines (Figure 2). MDA-231, ID8, B16, PC3, and LLC cells have been shown previously to respond to Treatment with a Psap peptide *in vivo*.

The pancreatic cell line AsPc1 was also examined and found to express CD36.

CD36 levels were also measured in primary ovarian cancer cells derived from patients with ascites. CD36 protein was detectable in all primary ovarian cancer cells tested (Figure 3).

<u>Example 2</u>

Methods

Mice and Cell Lines

All animal work is conducted in accordance with a protocol approved by the Institutional Animal Care and Use Committee. Wild type C57BL/6J, and GFP transgenic C57BL/6-Tg (ACTB-EGFP) 1Osb/J are obtained from The Jackson Laboratory (Bar Harbor, Maine). CB-17 SCID mice are obtained from Charles River (Wilmington, MA).

The cell lines PC3 and PC3M-LN4 are previously described (14). Human breast cancer cell lines MDA-MB-231 and MDA-MB-LM2 are described previously (Ryu et al. PLoS one, 6, 2011). The murine Lewis lung carcinoma cell line LLCs/D122 (provided by Lea Eisenbach, Wiesmann Institute of Science, Rehovot, Israel) stably expressing RFP and firefly luciferase (Gupta GP, Massague J. Cancer metastasis: building a framework. Cell. 2006;127:679-95; Gao D, Nolan DJ, Mellick AS, Bambino K, McDonnell K, Mittal V. Endothelial progenitor cells control the angiogenic switch in mouse lung metastasis. Science. 2008;319:195-8; and Joyce JA, Pollard JW. Microenvironmental regulation of metastasis. Nat Rev Cancer. 2009;9:239-52), are cultured in DMEM supplemented with 10% fetal bovine serum.

Tissue microarrays and Immunohistochemistry

Archival specimens (radical prostatectomy specimens, or biopsies of metastases) are retrieved from files of Department of Pathology, The Gade Institute, Haukeland University Hospital. Formalin fixed prostatectomy specimens were paraffin embedded and studied by whole mount step sections at 5 mm intervals. Tissue microarrays (TMAs) were constructed selecting three tissue cores (0.6 mm in diameter) from the area of highest tumor grade in each case.

Thin paraffin sections (5 um) from the TMA paraffin block are dewaxed with xylene/ethanol before heat induced microwave epitope retrieval in citrate buffer (pH 6.0) for 20 minutes, and incubated with a CD36 antibody for 60 minutes at room temperature. Immunostaining is performed on the DAKO Autostainer with the EnVision chain polymer method (Dako Cytomation, Copenhagen, Denmark) as detection system. Antigen localization is achieved using the DAB diaminobenzidine peroxidase reaction, counterstained with hematoxylin.

Immunostaining is estimated semiquantitatively, and a staining index (SI) obtained as a product of staining intensity (0-3) and proportion of immunopositive tumor cells (<10%=1, 10-50%=2, >50%=3), is calculated. The staining index (range 0-9) is a categorical scale, where some variation within each category is expected.

Knockdown of CD36 in tumor cells

CD36 levels are decreased in cancer cell lines using retroviral or lentiviral vectors encoding miRNAs or shRNAs that target CD36. Knockdown efficiency is tested using qPCR analysis. Total RNA is extracted using the PicoPure RNA extraction kit (Arcturus) following the manufacturer´s protocol. RNA is converted to cDNA using qScript™ cDNA supermix (Quanta biosciences). qPCR is performed with primers and iQTM SYBER Green master mix (Biorad, Hercule, CA). A standard protocol of initial denaturing at 95°C for 10 min, 40 cycles of 95°C for 10 sec, 60°C for 30 sec, and 72°C for 30 sec, followed by final extension at 72°C for 5 min and melt curve analysis is applied on a BioRad CFX96 Real Time System (BioRad) coupled with Bio-Rad-CFX Manager software. The relative abundance of each transcript compared with the control is calculated utilizing the delta-Ct method.

In vitro cell proliferation assays

Cell proliferation is measured using the MTT (3-{4,5-Dimethylthiazol-2-yl}-2,5-diphenyltetrazolium bromide, Sigma-Aldrich) assay. Cells are seeded in 50 uL growth medium in 96 well culture plates and allowed to attach overnight. 50 uL of growth medium plus two-fold concentrated treatment reagents were then added. After each treatment time point, 10 uL of 5% MTT solution (buffered in PBS) was added to each well. Plates were incubated for an additional 4 h at 37°C to allow MTT to be metabolically converted into formazan crystals at cell mitochondria. The formazan crystals were finally solubilized by adding 100 ul of 10% Sodium Dodecyl Sulphate in 50% N-N-Dimethylformamide to each microplate well. Absorbances at 550 and 680 nm (corresponding to formazan salt and reference wavelengths, respectively) were measured using a colorimetry microplate reader. Wells containing only complete medium were used as controls. Each experiment was performed twice, using six replicates for each drug concentration.

Metastasis assay, bioluminescence imaging and analysis

For experimental metastasis, 7-week old C57BL/6 mice are injected via tail vein with 1 X 10^5 luciferase-labeled LLC cells. For orthotopic breast cancer cell injections, 5 X 10^6 MDA-MB-231 or its metastatic variant MDA-MB-LM2 cells, are injected into CB-17 SCID mice fat pads in a volume of 0.1 ml. Tumor growth and pulmonary metastases (following resection of primary tumor) were monitored by live animal bioluminescence imaging (Xenogen) once per week. For orthotopic prostate cancer cell injections, 2 X 106 viable LN4 or cells were injected into the prostate gland of mice.

For in vivo determination of the metastatic burden, mice were anaesthetized and injected intraperitoneally with 75mg/kg of D-luciferin (100 uL of 30mg/mL in PBS). Metastatic growth was monitored over time using bioluminescence imaging performed with mice in a supine position 5 min after D-luciferin injection with a Xenogen IVIS system coupled to Living Image acquisition and analysis software (Xenogen). For BLI plots, photon flux was calculated for each mouse by using the same circular region of interest encompassing the thorax of the mouse.

Psap peptide administration

8-week old mice are treated with a Psap peptide (such as DWLPK (SEQ ID NO: 2), DWLP (SEQ ID NO: 3), or a modified version thereof), diluted in PBS, at a dose of 30mg/kg/day via intraperitoneal injection for up to two weeks.

Results

CD36 levels are measured in tissue samples from human subjects with cancer.

CD36 levels are knocked down in cancer cell lines and these cell lines with reduced CD36 are injected into mice. Mice are then administered a Psap peptide. Tumor growth and metastatic burden are monitored. It is expected that knockdown of CD36 in cancer cells will reduce the anti-cancer activity of a Psap peptide *in vivo*.

__Example 3__

Methods

Except were stated otherwise, the methods used in Example 3 are the same as the methods used in Examples 1 and 2. The cell lines tested for CD36 expression were pancreatic (AsPC1), ovarian (DF-14 and ID-8), breast (MDA-MB231 and LM2), prostate (PC3, PC3-M-LN4, LN-CAP, and LN-CAP-LN3), melanoma (B16-Bl6), and lung cancer (LLC) cell lines. All of these cell lines are known in the art and/or commercially available.

Ovarian cancer cells expressing CD36 were treated with either control or thrombospondin (Tsp-1, either 100 ng, 500 ng or 1000 ng) and the percent of viable cells was measured at 0 hours or 48 hours.

For the ovarian cancer mouse model, 1 million ovarian cancer cells expressing luciferase were injected intraperitoneally. Treatment was initiated 17 days later with cisplatin (4mg/kg QOD), the psap peptide dWlP (SEQ ID NO: 47, 40mg/kg QD), a combination of cisplatin and psap peptide, or PBS QD. Luciferase intensity was measured on several days beginning on about day 17 and measured over time.

For the pancreatic cancer mouse model, $1x10^6$ AsPc1 human pancreatic cells were injected into the pancreas of SCID mice. Mice were treated either with a control or with the psap peptide dWlP (SEQ ID NO: 47, 20mg/kg/day or 40/mg/kg/day). Treatment began on day 25 and continued daily for 21 days. The mice were then euthanized and the primary tumor mass was measured. The presence or absence of ascites was also measured.

For the melanoma mouse model, B16-Bl6 cells were injected into mice. Mice were treated with either psap peptide dWlP (SEQ ID NO: 47, 10 or 40 mg/kg) or control. The volume of the tumor was measured over time up until about 20-25 days post cell injection.

Results

Multiple cancer cell lines were tested for expression of CD36. It was found that CD36 protein was detectable in all cell lines tested, with particularly high levels of CD36 detectable in AsPC1, DF-14, MDA-MB231, and PC3 cell lines (Figure 5).

It was shown that ovarian cells expressing CD36 were sensitive to Tsp-1 mediated cell killing in a dose-dependent manner (Figure 6).

Two "high" CD36 cell lines (ovarian cancer cells and AsPC pancreatic cancer cells) and one "low" CD36 cell line (B16-B6 cancer cells) were injected into mice to study the effects of psap peptides on tumor growth and metastasis. It was found that the "high" CD36 cancer models regressed in response to psap peptide treatment (Figure 5 and 7). The ovarian cancer model also showed regression of metastatic disease (Figure 5). The pancreatic cancer model also showed inhibition of metastasis because only 1 of 19 mice treated with a psap peptide form ascites, while 4 of 10 mice treated with the control formed ascites. In the "low" CD36 melanoma model, it was found that treatment with a psap peptide inhibited primary tumor growth but did not cause tumor regression (Figure 8). These results show that "high" CD36 cancers are more likely to strongly respond to psap peptide treatment (e.g., regression of primary tumor and/or metastasis), while "low" CD36 cancers are more likely to have a weaker response (e.g., inhibition of primary tumor rather than regression).

Without further elaboration, it is believed that one skilled in the art can, based on the above description, utilize the present disclosure to its fullest extent. The specific embodiments are, therefore, to be construed as merely illustrative, and not limitative of the remainder of the disclosure in any way whatsoever. All publications cited herein are incorporated by reference for the purposes or subject matter referenced herein.

The indefinite articles "a" and "an," as used herein in the specification and in the claims, unless clearly indicated to the contrary, should be understood to mean "at least one."

From the above description, one skilled in the art can easily ascertain the essential characteristics of the present disclosure, and without departing from the spirit and scope thereof, can make various changes and modifications of the disclosure to adapt it to various usages and conditions. Thus, other embodiments are also within the claims.

What is claimed is:

CLAIMS

1. A method for evaluating a subject's responsiveness to treatment with a Psap peptide, the method comprising:

determining a level of CD36 in a sample obtained from a subject having cancer, wherein an elevated level of CD36 in the sample compared to a control level indicates that the subject is responsive to or likely to be responsive to treatment with a Psap peptide.

2. The method of claim 1, wherein the level of CD36 in the sample is determined by performing an assay.

3. The method of claim 1 or 2, wherein the method further comprises:

identifying the subject with an elevated level of CD36 in the sample compared to the control level as responsive to or likely to be responsive to treatment with a Psap peptide.

4. The method of claim 3, wherein the method further comprises:

administering to the subject identified as responsive to or likely to be responsive to treatment with a Psap peptide an effective amount of a Psap peptide to treat the cancer.

5. A method for treating a subject with cancer, the method comprising:

administering to a subject with cancer characterized by an elevated level of CD36 in a sample compared to a control level an effective amount of a Psap peptide to treat the cancer.

6. A method for treating a subject with cancer, the method comprising:

(a) selecting a subject with cancer on the basis that the subject is known to have an elevated level of CD36 in a sample compared to a control level; and

(b) administering an effective amount of a Psap peptide to the subject because the subject has an elevated level of CD36 in the sample compared to the control level.

7. The method of any one of claims 1 to 6, wherein the control level is a level of CD36 from a non-cancerous cell or tissue obtained from the subject having the cancer.

8. The method of any one of claims 1 to 6, wherein the control level is a level of CD36 in a cell or tissue obtained from a healthy subject or a population of healthy subjects.

9. The method of any one of claims 1 to 6, wherein the control level is a predetermined level.

10. The method of any one of claims 1 to 9, wherein the level of CD36 is a CD36 protein level.

11. The method of any one of claims 1 to 10, wherein the cancer is prostate cancer, breast cancer, ovarian cancer, lung cancer, leukemia, pancreatic cancer, glioblastoma multiforme, astrocytoma, or melanoma.

12. The method of any one of claims 1 to 11, wherein the Psap peptide comprises the amino acid sequence CDWLPK (SEQ ID NO: 1), DWLPK (SEQ ID NO: 2), or DWLP (SEQ ID NO: 3), or an amino acid substitution variant thereof, wherein the amino acid substitution is:

a) Tyrosine (Y) for Tryptophan (W);

b) an amino acid substitution for Leucine (L) selected from Valine (V), Alanine (A) or Glycine (G), or a non-canonical amino acid of similar size, or a derivative thereof;

c) Arginine (R) for Lysine (K);

d) a D-isomer of Aspartic Acid (D) for an L-isomer of Aspartic Acid (D) and/or a D-isomer of Leucine (L) for a L-isomer of Leucine (L);

e) a D-isomer of Tryptophan (W) for an L-isomer of Tryptophan (W) and/or a D-isomer of Proline (P) for an L-isomer of Proline (P); or combinations thereof.

13. The method of claim 12, wherein the Psap peptide is 50 amino acids or fewer in length.

14. The method of claim 13, wherein the Psap peptide is 30 amino acids or fewer in length.

15. The method of claim 14, wherein the Psap peptide is 15 amino acids or fewer in length.

16. The method of claim 15, wherein the Psap peptide is 6 amino acids or fewer in length.

17. The method of claim 12, wherein the Psap peptide is a cyclic peptide.

18. The method of any one of claims 12 to 17, wherein the non-canonical amino acid of similar size is methylvaline, methylleucine, or sarcosine.

19. A composition for use in treating a subject with cancer characterized by an elevated level of CD36 in a sample compared to a control level, the composition comprising a Psap peptide.

20. Use of a composition for in the manufacture of a medicament for treating a subject with cancer characterized by an elevated level of CD36 in a sample compared to a control level, the composition comprising a Psap peptide.

21. The composition or use of claim 19 or 20, wherein the control level is a level of CD36 from a non-cancerous cell or tissue obtained from the subject having cancer.

22. The composition or use of claim 19 or 20, wherein the control level is a level of CD36 in a cell or tissue obtained from a healthy subject or a population of healthy subjects.

23. The composition or use of claim 19 or 20, wherein the control level is a predetermined level.

24. The composition or use of any one of claims 19-23, wherein the level of CD36 is a CD36 protein level.

25. The composition or use of any one of claims 19-24, wherein the cancer is prostate cancer, breast cancer, ovarian cancer, lung cancer, leukemia, pancreatic cancer, glioblastoma multiforme, astrocytoma, or melanoma.

26. The composition or use of any one of claims 19-25, wherein the Psap peptide comprises the amino acid sequence CDWLPK (SEQ ID NO: 1), DWLPK (SEQ ID NO: 2), or DWLP (SEQ ID NO: 3), or an amino acid substitution variant thereof, wherein the amino acid substitution is:

a) Tyrosine (Y) for Tryptophan (W);

b) an amino acid substitution for Leucine (L) selected from Valine (V), Alanine (A) or Glycine (G), or a non-canonical amino acid of similar size, or a derivative thereof;

c) Arginine (R) for Lysine (K);

d) a D-isomer of Aspartic Acid (D) for an L-isomer of Aspartic Acid (D) and/or a D-isomer of Leucine (L) for a L-isomer of Leucine (L);

e) a D-isomer of Tryptophan (W) for an L-isomer of Tryptophan (W) and/or a D-isomer of Proline (P) for an L-isomer of Proline (P); or combinations thereof.

27. The composition or use of claim 26, wherein the Psap peptide is 50 amino acids or fewer in length.

28. The composition or use of claim 27, wherein the Psap peptide is 30 amino acids or fewer in length.

29. The composition or use of claim 28, wherein the Psap peptide is 15 amino acids or fewer in length.

30. The composition or use of claim 29, wherein the Psap peptide is 6 amino acids or fewer in length.

31. The composition or use of claim 26, wherein the Psap peptide is a cyclic peptide.

32. The composition or use of any one of claims 26-31, wherein the non-canonical amino acid of similar size is methylvaline, methylleucine, or sarcosine.

33. The method, use or composition of any of claims 1-32, wherein the sample is a tumor sample.

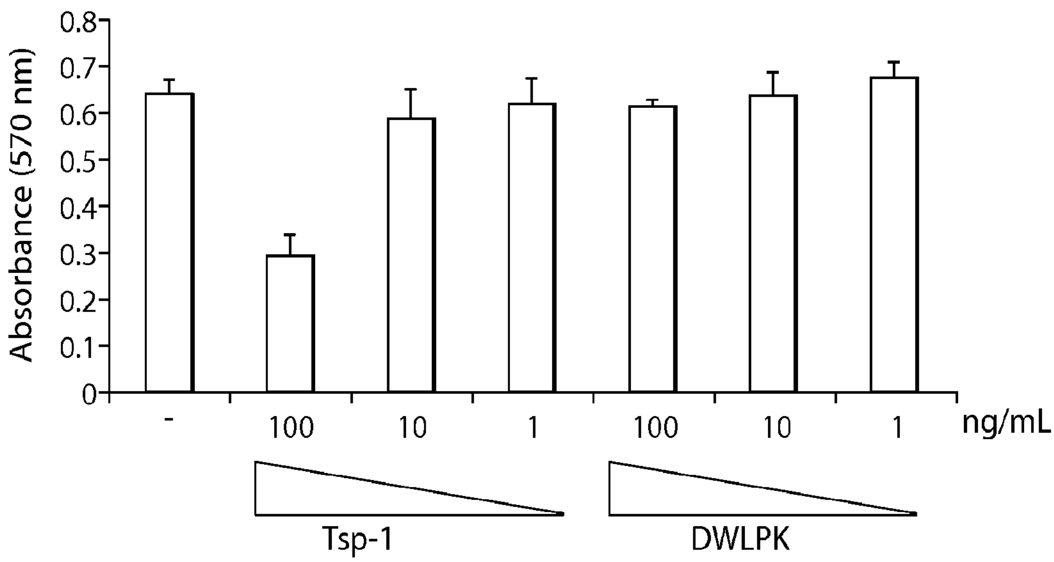
Absorbance (570 nm)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-
100
10
1
100
10
1
ng/mL
Tsp-1
DWLPK

Fig. 1A

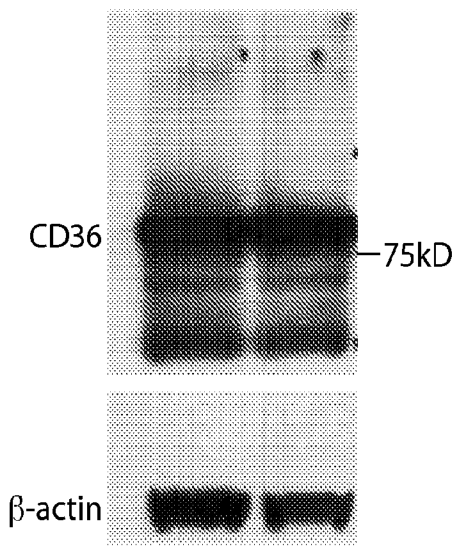
CD36
75kD
β-actin

Fig. 1B

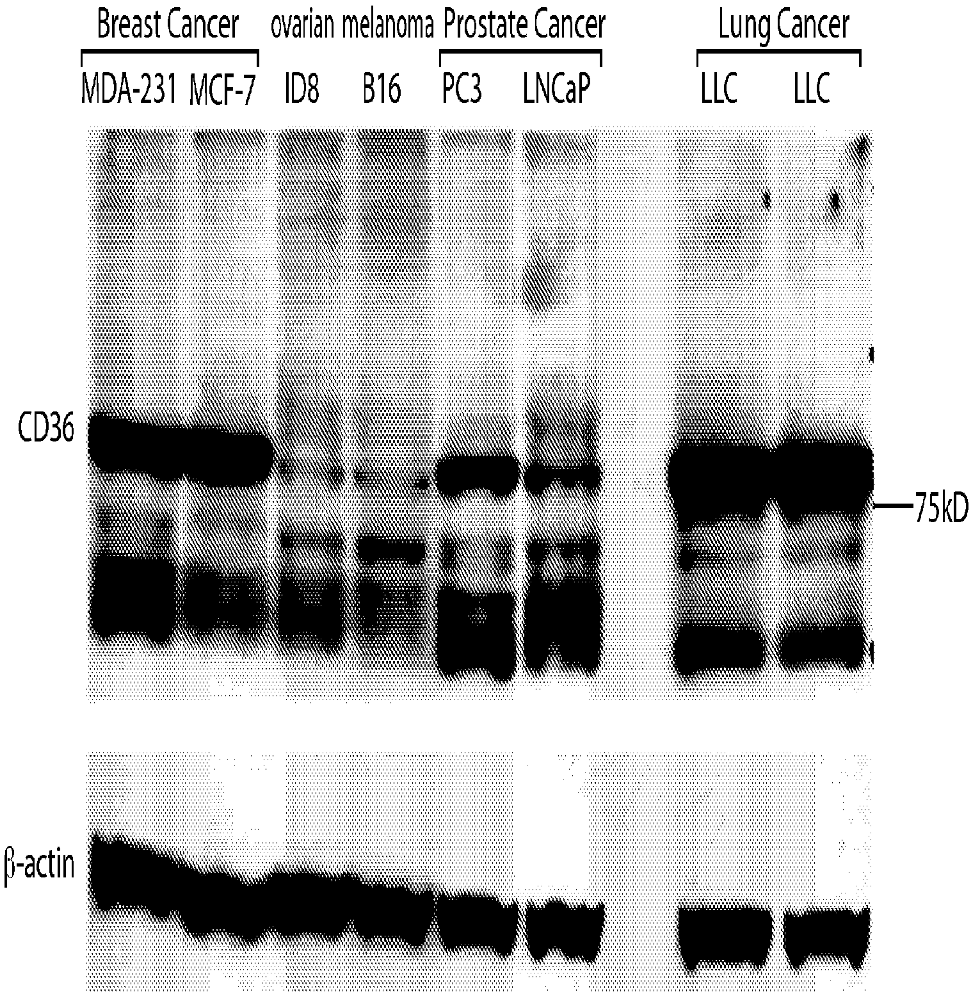
Breast Cancer
ovarian
melanoma
Prostate Cancer
Lung Cancer
MDA-231
MCF-7
ID8
B16
PC3
LNCaP
LLC
LLC
CD36
75kD
β-actin

Fig. 2

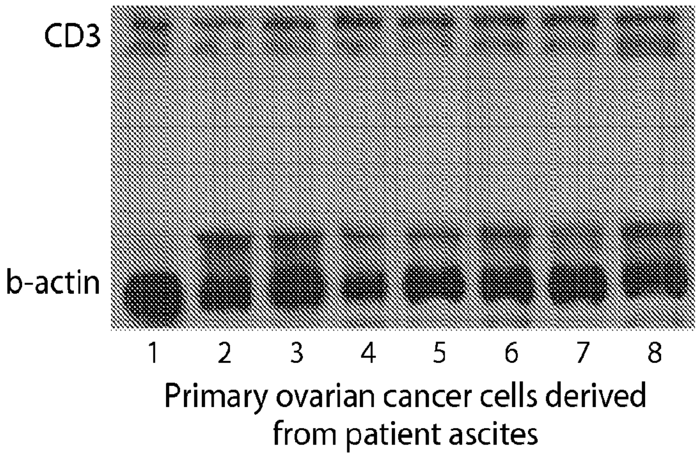
CD3
b-actin
1 2 3 4 5 6 7 8
Primary ovarian cancer cells derived
from patient ascites

Fig. 3

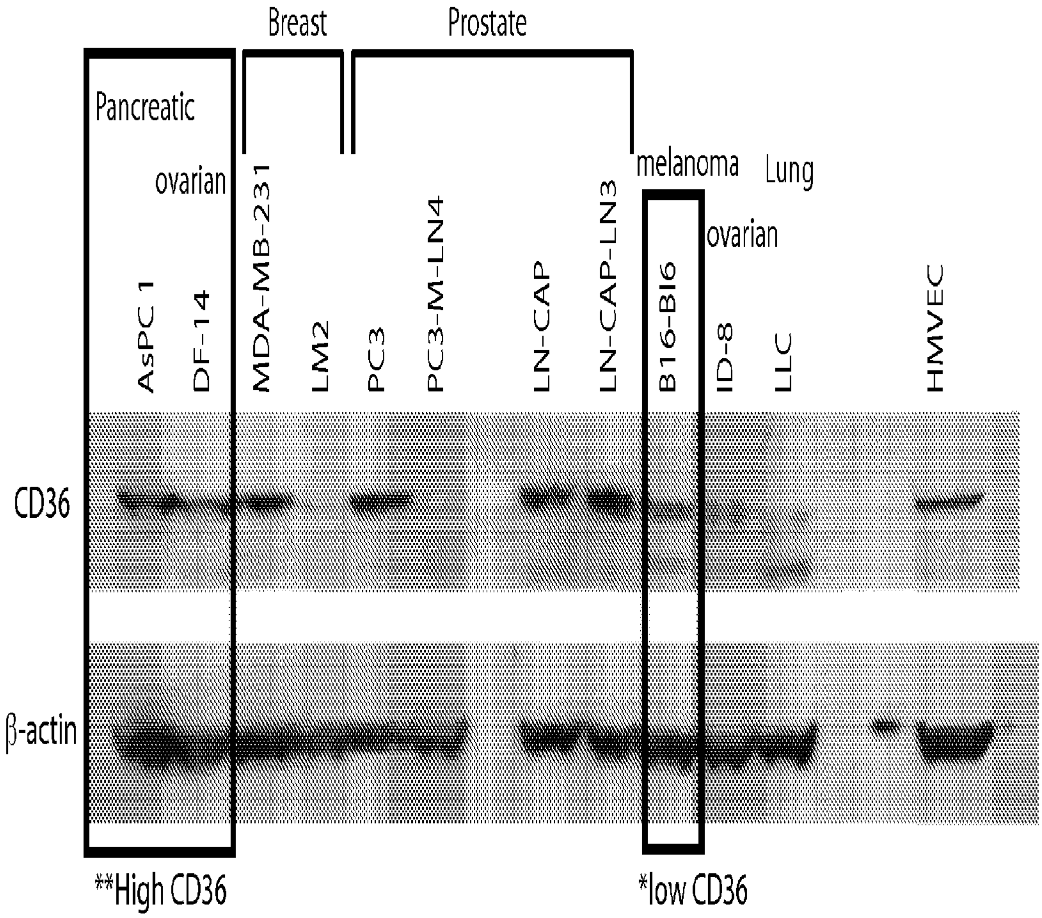
Breast
Prostate
Pancreatic
ovarian
melanoma
Lung
ovarian
AsPC 1
DF-14
MDA-MB-231
LM2
PC3
PC3-M-LN4
LN-CAP
LN-CAP-LN3
B16-BI6
ID-8
LLC
HMVEC
CD36
β-actin
**High CD36
*low CD36

Fig. 4

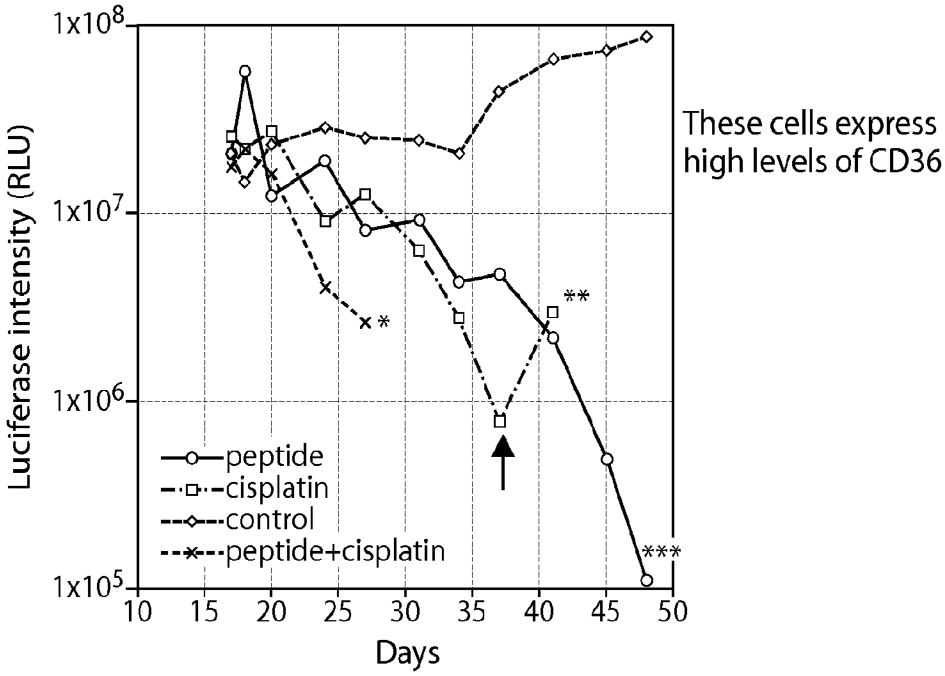
1x10^8
1x10^7
1x10^6
1x10^5
Luciferase intensity (RLU)
10 15 20 25 30 35 40 45 50
Days
peptide
cisplatin
control
peptide+cisplatin
*
**
***
These cells express high levels of CD36

Fig. 5

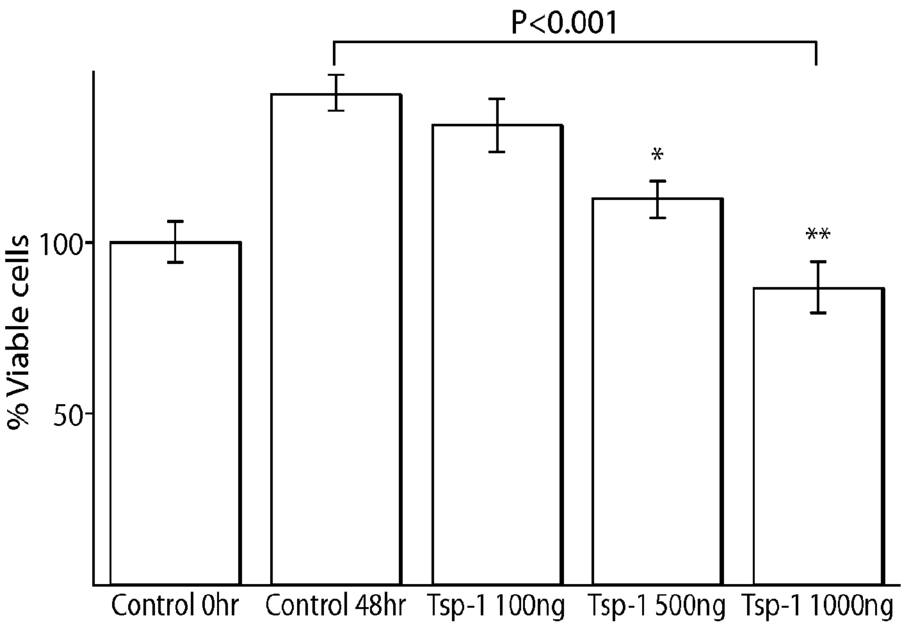
P<0.001
% Viable cells
100
50
*
**
Control 0hr
Control 48hr
Tsp-1 100ng
Tsp-1 500ng
Tsp-1 1000ng

Fig. 6

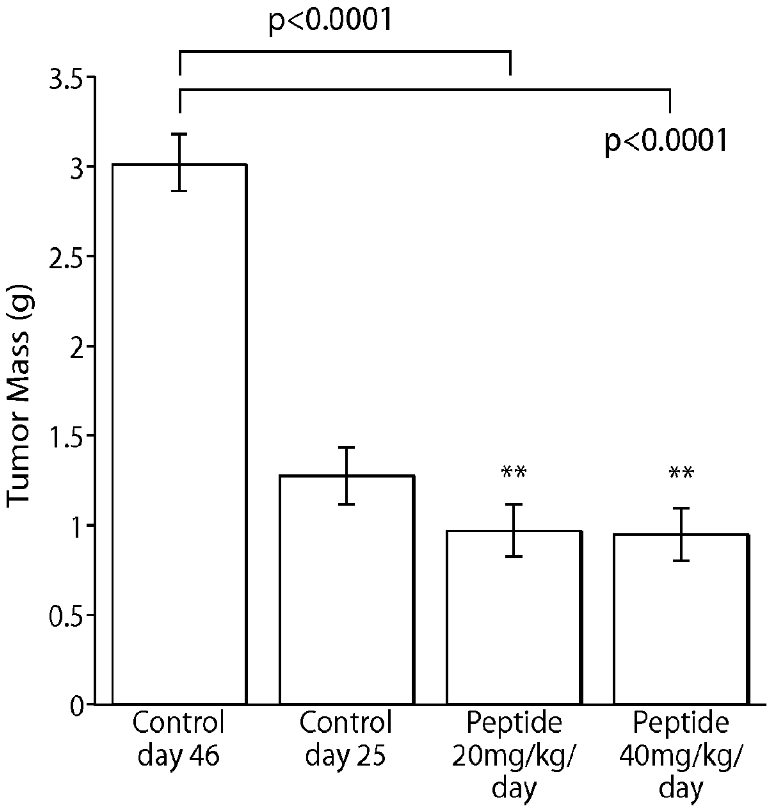
p<0.0001
p<0.0001
3.5
3
2.5
2
1.5
1
0.5
0
Tumor Mass (g)
**
**
Control day 46
Control day 25
Peptide 20mg/kg/ day
Peptide 40mg/kg/ day

Fig. 7

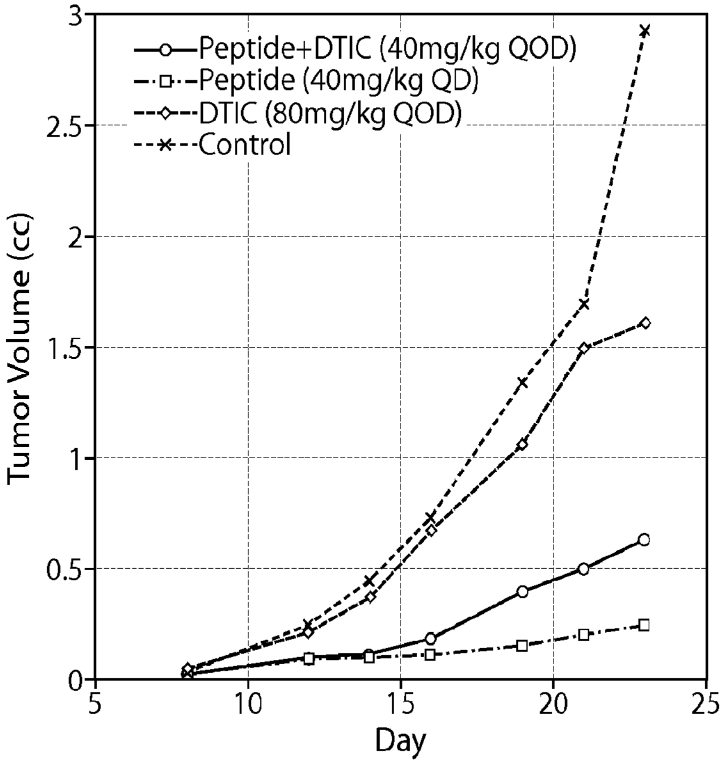
Peptide+DTIC (40mg/kg QOD)
Peptide (40mg/kg QD)
DTIC (80mg/kg QOD)
Control
Tumor Volume (cc)
Day
0
0.5
1
1.5
2
2.5
3
5
10
15
20
25

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 14/26546

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - C12Q 1/68, G01N 33/50, G01N 33/53, G01N 33/574 (2014.01)
USPC - 435/6.11, 435/6.17, 435/7.23
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - C12Q 1/68, G01N 33/50, G01N 33/53, G01N 33/574 (2014.01)
USPC - 435/6.11, 435/6.17, 435/7.23

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 435/6.12, 435/6.19, 435/7.2, 435/7.21, 435/7.9*
(keyword limited; terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, ProQuest Dialog, Google Scholar
Search terms: Psap, prosaposin, CD36, BDPLT10, CHDS7, GP3B, GP4, GPIV, PASIV, SCARB3, response, respond, susceptible, susceptibility, cancer, tumor, malignancy, neoplasm, proliferative, metastic, metastasis, high, elevated, raised, up-regulated, overexpress

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2010/0144603 A1 (WATNICK) 10 June 2010 (10.06.2010) para [0022], [0123], [0124], [0164], [0279], [0281], [0307], [0317], [0413]-[0416], Example 10	1-6 and 19-23
Y	DAWSON et al., CD36 mediates the In vitro inhibitory effects of thrombospondin-1 on endothelial cells. J Cell Biol, 11 August 1997, Vol 138, No 3, pp 707-17. Especially p 707, col 1, para 1; p 708, col 1, para 3	1-6 and 19-23

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 June 2014 (18.06.2014)	28 JUL 2014

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 7-18 and 24-33
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/26546

Box No. I Nucleotide and/or amino acid sequence(s) (Continuation of item 1.c of the first sheet)

1. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international search was carried out on the basis of a sequence listing filed or furnished:

   a. (means)

   ☐ on paper

   ☒ in electronic form

   b. (time)

   ☒ in the international application as filed

   ☐ together with the international application in electronic form

   ☐ subsequently to this Authority for the purposes of search

2. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

3. Additional comments: