BIOLOGICALLY ACTIVE PEPTIDES

This application claims priority of U.S. Provisional Application No. 61/009,326, filed on April 17, 2008, and U.S. Provisional Application No. 61/113,055 filed on November 10, 2008, each of which is incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

The present invention relates to low molecular weight peptides with procoagulant activity for treatment of patients with a deficiency in FV, FVII, FVIII, FX and/or FXI.

BACKGROUND OF THE INVENTION

The blood coagulation cascade involves a series of serine protease enzymes (zymogens) and protein cofactors. When required, an inactive zymogen precursor is converted into the active form, which consequently converts the next enzyme in the cascade. It is divided into three distinct segments: the intrinsic (contact activation), extrinsic (tissue factor), and common pathways.

In the intrinsic pathway of the cascade, hemophilia is the most pronounced bleeding disorder, which results in insufficient generation of factor Xa by factor FIX (FIXa)/factor VIIIa (FVIIIa) complex (the intrinsic tenase complex) leading to an insufficient clot formation. Bleeding may then occur spontaneously or following injury.

Hemophilia is an inherited bleeding disorder and two forms of hemophilia, hemophilia A and B, are known. Hemophilia A is the consequence of a deficiency of FVIII and is characterized by hemorrhage into the joints and muscles. FVIII circulates in plasma at a very low concentration and is bound non-covalently to von Willebrand factor (vWF). During hemostasis, FVIII is activated by thrombin, separates from vWF and acts as a cofactor for activated FIXa-mediated FX activation by enhancing the rate of activation.

Patients with less than 1% normal FVIII are considered to have severe hemophilia, with 1-5% moderately severe hemophilia, and with more than 5% but less than 40% mild hemophilia.

Nowadays the treatment of choice for the management of hemophilia A is replacement therapy with various plasma derived or recombinant FVIII concentrates. Although specific viral-inactivation steps, including solvent-detergent treatment or liquid-phase heat treatment, are available to inactivate viruses, possible transmission of poorly characterized agents (e.g. prions) in plasma derived concentrates is still an issue discussed in the art.

FVIII is also synthesized as a recombinant protein for therapeutic use in bleeding disorders. Such products have lowered the risk of viral contamination. There are many recombinant products on the market for the treatment of hemophilia A. One of these concentrates is the Advate® FVIII composition, which is produced in CHO-cells and manufactured by Baxter Healthcare Corporation. No human or animal plasma proteins are added in the cell culture process, purification, or final formulation of this product.

Although progress in the production of FVIII to ensure purity, efficacy and viral safety has been made over the past decades, some limitations remain. First of all, severe hemophilia A patients are frequently affected by anti-FVIII inhibitor antibody formation, rendering the therapy ineffective.

Approximately 30 % of patients with severe HA develop alloantibody inhibitors that can neutralize FVIII (Hay, *Haemophilia* 2006;12 Suppl 6:23-9; Peerlinck and Hermans, *Haemophilia* 2006;12:579-90). These inhibitors are typically immunoglobulin G (IgG), predominantly of the IgG4 subclass, that do not fix complement and do not result in the end-organ damage observed with circulating immune complexes. The inhibitors occur at a young age (about 50% by 10 years), principally in patients with less than 1% FVIII. Furthermore, acquired hemophilia may occur, which is the development of FVIII antibody inhibitors in persons without a history of FVIII deficiency. This condition can be idiopathic (occurring in people >50 years), it can be associated with collagen vascular disease or the peripartum period, or it may represent a drug reaction (e.g., to penicillin). For clinical purposes, the magnitude of the antibody response can be

quantified through the performance of a functional inhibitor assay from which the Bethesda unit (BU) inhibitor titer can be obtained. The International Society of Thrombosis and Haemostasis (ISTH) definition of a high titer response is > 5BUs and its definition of a low titer response is between 0.5 and 5 BUs.

Attempts to overwhelm the inhibitors with large doses of human FVIII have been tried. Also porcine FVIII, which has low cross-reactivity with human FVIII antibody, has been administered. More frequently, FVIII-bypassing agents, including activated prothrombin complex concentrates (e.g. FEIBA (Factor Eight Inhibitor Bypassing Agent) and recombinant activated factor FVII (FVIIa) have also been used.

Because therapeutic polypeptide drugs such as FVIII are also rapidly degraded by proteolytic enzymes in addition to the drawback of inhibitor development, FVIII needs to be frequently administered intravenously. Taking into account the average half-lives of the various FVIII products in the circulation, this can usually be achieved by giving FVIII two to three times a week. Thus this treatment is rather complicated for an outpatient population, especially in small children.

Thus currently the aim of many manufacturers of FVIII is to develop a next generation product with enhanced pharmacodynamic and pharmacokinetic properties, while maintaining all other product characteristics. Because improved polypeptide drugs with a longer circulation half-life would decrease the number of necessary administrations, chemical or enzymatic modification of the polypeptide drugs is one of the preferred approaches to achieve this goal.

One such example is PEGylation of polypeptide drugs protecting and improving their pharmacodynamic and pharmacokinetic profiles (Harris and Chess, *Nat Rev Drug Discov.* 2003;2:214-21). US 6,037,452 describes a poly(alkylene oxide)-FVIII or FIX conjugate, where the protein is covalently bound to a poly(alkylene oxide) through carbonyl groups of said FVIII.

Even if these methods reduce inhibitor development they still would not abrogate the need for intravenous administration. The most elegant option, making most of the drawbacks of hemophilia treatment discussed above obsolete, would be the development of a low molecular weight compound such as a peptide

(peptidomimetic) with the capacity to improve coagulation and which can be administered by a non-intravenous route. Though already discussed for many years (for example Kaufman and Pipe, *Haemophilia* 1998;4.370-9; Llung, *Thromb Haemost.* 1999;82:525-30) no such agent is currently available or in clinical development.

The current state of the art for the use of small peptides in blood coagulation is documented for example by the following publications:

DK Liles, DM Monroe and HR Roberts (1997) Blood Vol 90 No 10 Supplement 1, 463a is a poster abstract disclosing a peptide 698-712 from FVIII which can promote FIXa mediated activation of FX on a phospholipid surface. However, in the presence of FVIIIa, the peptide inhibits FIXa mediated activation of FX on a phospholipid surface. To date, there has been no peer-reviewed publication by these authors confirming results disclosed in this poster abstract.

Blostein *et al* (2000) *Biochemistry* 39:12000-12006 discloses that amphipathic alpha helices can interact with FIXa Gla domains and increases activation of FX in the absence of phospholipid. The peptides appeared to work independently of amino acid sequence by mimicking phospholipids. There is no suggestion to use such peptides in therapy. Under normal conditions, activated platelets provide the lipid [0]surface supporting coagulation. Since platelets are activated by thrombin, which is formed at sites of vascular injury, coagulation processes are restricted to the sites of injuries. It is highly undesirable to provide the body with peptides that are general substitutes for procoagulant lipids as this would cause systemic coagulation and ultimately lead to disseminated intravascular coagulation (DIC). Therefore, the peptides described by Blostein would not be useful in therapy.

US Pat. Nos. 7,109,170 and 6,624,289 disclose regions of the FIXa protease domain that interact with FVIIIa. The peptides comprise the FVIIIa binding site of FIXa and inhibit binding of FIXa to FVIIIa. However, they are only useful as anticoagulants for preventing or treating thrombosis.

US20010014456A1 discloses binding molecules for human FVIII and FVIII-like proteins. These polypeptides bind FVIII and/or FVIII-like polypeptides and are

useful for the detection and purification of human FVIII and/or FVIII-like polypeptides from solutions such as blood or conditioned media.

In US Pat. No. 7,033,590 FIX/FIXa activating antibodies and antibody derivatives are used for increasing the amidolytic activity of FIXa, and for treating blood coagulation disorders such as hemophilia A and hemorrhagic diathesis.

In US Pat. No. 7,084,109 FVIIa antagonists are disclosed. These antagonists are peptides that inhibit FVIIa activity and are said to be useful for prevention of arterial thrombosis in combination with thrombolytic therapy.

The listing or discussion of a prior-published document in this specification should not necessarily be taken as an acknowledgement that the document is part of the state of the art or is common general knowledge.

There remains a great need in the art for a low molecular weight peptide with procoagulant activity for treatment of patients with hemophilia A (FVIII deficiency). The present invention provides novel low molecular weight peptides with procoagulant activity which can be used for the non-intravenous treatment of hemophilia A. The present prevention also provides these novel peptides for the treatment of a deficiency in FV, FVII, FX and/or FXI.

SUMMARY

In one example, there is provided a peptide or peptide derivative comprising: (i) an amino acid sequence comprising imfwydcye; or (ii) a variant amino acid sequence comprising one, two, three, four, five or six amino acid substitutions in imfwydcye, wherein said peptide or peptide derivative has procoagulant activity. In one aspect, the present disclosure refers to a peptide or peptide derivative comprising: (i) an amino acid sequence comprising imfwydcye; or (ii) a variant amino acid sequence comprising one, two, three, or four amino acid substitutions in imfwydcye, wherein the variant amino acid sequence comprises an amino acid sequence comprising $X_1X_2mX_4wydX_8ye$, wherein X_1, when present, is c, C or D-Pen, X_2 is i or y, X_4 is f, t, or v and X_8 is c or e; wherein said peptide or peptide derivative has procoagulant activity, and wherein the peptide or peptide derivative has a molecular weight of between 0.5 and 3.5kD.

In one aspect, the present disclosure refers to a dual peptide comprising a peptide or peptide derivative as disclosed herein conjugated to a further peptide or peptide derivative as disclosed herein, wherein the peptide or peptide derivative may be the same as or different from the further peptide or peptide derivative, and wherein the dual peptide has procoagulant activity.

In one aspect, the present disclosure refers to a pharmaceutical composition comprising the peptide or peptide derivative disclosed herein and one or more pharmaceutically acceptable excipients, carriers and/or diluents.

In one aspect, the present disclosure refers to the peptide or peptide derivative disclosed herein for use in medicine.

In one aspect, the present disclosure refers to the peptide or peptide derivative disclosed herein for treating a patient having a deficiency in FV, FVII, FVIII, FX and/or FXI.

In one aspect, the present disclosure refers to use of a peptide or peptide derivative disclosed herein in the manufacture of a medicament for the treatment of a deficiency in FV, FVII, FVIII, FX and/or FXI.

In one aspect, the present disclosure refers to use of a therapeutically effective amount of the pharmaceutical composition disclosed herein in the manufacture of a medicament for treating a patient having a deficiency in FV, FVII, FVIII, FX and/or FXI.

In one aspect, the present disclosure refers to a method of making the peptide or peptide derivative disclosed herein by solid phase synthesis.

In a first example, disclosed is a peptide or peptide derivative comprising:
(i) WDLYFEIVW (SEQ ID NO: 1); or
(ii) a variant amino acid sequence comprising one, two, three or four L-amino acid substitutions in WDLYFEIVW (SEQ ID NO: 1); or
(Hi) the retro-inverso variant of the peptide or peptide derivative of either one of parts (i) and (ii),
wherein said peptide or peptide derivative has procoagulant activity.

For the avoidance of doubt, the sequence WDLYFEIVW (SEQ ID NO: 1) may be represented as the L-amino acids Trp-Asp-Leu-Tyr-Phe-Glu-Ile-Val-Trp using the three letter code for amino acids. The retro-inverso variant of WDLYFEIVW (SEQ ID NO: 1) is wviefyldw and comprises D-amino acids.

In a second example, disclosed is a peptide or peptide derivative comprising:
(i) an amino acid sequence comprising imfwydcye; or
(ii) a variant amino acid sequence comprising one, two, three, four, five or six amino acid substitutions in imfwydcye,
wherein said peptide or peptide derivative has procoagulant activity.

For the avoidance of doubt, the sequence cimfwydcye may be represented as D-amino acids ile-met-phe-trp-tyr-asp-cys-tyr-glu using the three letter code for amino acids.

In a third example, disclosed is a dual peptide comprising a peptide or peptide derivative of the first or second examples of the disclosure conjugated to a further peptide or peptide derivative of the first or second examples of the disclosure, wherein the two peptides/derivatives may be the same as or different from each other and wherein the dual peptide has procoagul ant activity.

In a fourth example, disclosed is a pharmaceutical composition comprising the peptide or peptide derivative of the first or second examples of the disclosure or the dual peptide of the third example of the disclosure.

In a fifth example, disclosed is a peptide or peptide derivative of the first or second examples or a dual peptide of the third example of the disclosure for treating a patient having a deficiency in FV, FVII, FVIII, FX and/or FXI.

In a sixth example, disclosed is a use of a peptide or peptide derivative of the first or second examples or a dual peptide of the third example of the disclosure in the manufacture of a medicament for the treatment of a deficiency in FV, FVII, FVIII, FX and/or FXI in a patient.

In a seventh example, disclosed is a method of treating a patient having a deficiency in FV, FVII, FVIII, FX and/or FXI comprising administering a therapeutically effective amount of the pharmaceutical composition of the fourth example of the disclosure.

In an eighth example, disclosed is a peptide or peptide derivative which has procoagulant activity, wherein the peptide or peptide derivative is not FVIII or a fragment thereof and, wherein the procoagulant activity is a thrombin generation time of 25, 50 or 100 μM of peptide, peptide derivative or dual peptide equivalent to that of at least 100 mU/mL Factor Eight Inhibitor Bypassing Activity (FEIBA), preferably at least 300 mU/mL FEIBA, more preferably at least 900 mU/mL FEIBA, most preferably at least 1200 mU/mL FEIBA in the Defined Intrinsic Thrombin Generation Assay.

In a ninth example, disclosed is a peptide or peptide derivative which has procoagulant activity, wherein the peptide or peptide derivative is not FVIII or a fragment thereof and, wherein the procoagulant activity is a thrombin generation time of 25, 50 or 100 μM of peptide, peptide derivative or dual peptide in a Defined Intrinsic Thrombin Generation Assay peaking within 30 minutes, preferably within 15 minutes and most preferably within 10 minutes.

In a tenth example, disclosed is a peptide or peptide derivative which has procoagulant activity, wherein the peptide or peptide derivative is not FVIII or a fragment thereof and, wherein the peptide or peptide derivative can at least partially compensate for the absence of biologically active FVIII when administered in an animal model of severe human hemophilia A.

DESCRIPTION OF FIGURES

Figure 1: Effect of therapeutics approved for treatment of hemophilia on peak thrombin generation and thrombin peak time in a defined Dual-pathway thrombin generation assay

Figure 2: Effect of A01 on FVIII -/- mouse bleeding model - blood loss

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

The term "amino acid" within the scope of the present invention is intended to include all naturally occurring L α-amino acids. The one and three letter abbreviations for naturally occurring amino acids are used herein (Lehninger, Biochemistry, 2d ed., Worth Publishers, New York, 1995: 71-92). The term

"amino acid" also includes stereoisomers (for example D-amino acids) and modifications of naturally occurring amino acids, non-proteinogenic amino acids, and structures designed to mimic amino acids.

Modified and non-proteinogenic amino acids are described generally in Grant, Synthetic Peptides: A User's Guide, Oxford University Press, 1992.

It is possible to provide, for example, improved stability and solubility, resistance to protease degradation, and activity of the peptide by the introduction of various amino acids that do not naturally occur, or by modification of the amino acid as discussed herein.

Non-proteinogenic amino acids may include but are not limited to β-alanine (β-Ala), norvaline (Nva), norleucine (Nle), 4-aminobutyric acid (γ-Abu), 2-aminoisobutyric acid (Aib), 6-aminohexanoic acid (ε-Ahx), ornithine (orn), hydroxyproline (Hyp), sarcosine, citrulline, cysteic acid (Coh), and cyclohexylalanine, methioninesulfoxide (Meo), methioninesulfone (Moo), homoserinemethylester (Hsm), propargylglycine (Eag), 5-fluorotryptophan (5Fw), 6-fluorotryptophan (6Fw), 3′,4′-dimethoxyphenyl-alanine (Ear), 3′,4′-difluorophenylalanine (Dff), 4′-fluorophenyl-alanine (Pff), 1-naphthyl-alanine (1Ni), 1-methyltryptophan (1Mw), penicillamine (Pen), homoserine (HSe). Further, such amino acids may include but are not limited to, α-amino isobutyric acid, t-butylglycine, t-butylalanine, phenylglycine (Phg), benzothienylalanine (Bta), L-homo-cysteine (L-Hcys), N-methyl-phenylalanine (NMF), 2-thienylalanine (Thi), 3,3-diphenylalanine (Ebw), homophenylalanine (Hfe), s-benzyl-L-cysteine (Ece) or cyclohexylalanine (Cha). These and other non-proteinogenic amino acids may exist as D- or L- isomers. Where no indication of the isomer is given, the L-isomer is intended.

Structures which are designed to mimic amino acids are compounds in which the amino and/or carboxyl group of an amino acid is replaced by another group. Non-limiting examples are the incorporation of thioamides, ureas, thioureas, acylhydrazides, esters, olefines, sulfonamides, phosphoric acid amides, ketones, alcohols, boronic acid amides, benzodiazepines and other aromatic or non-aromatic heterocycles (for a review see M. A. Estiarte, D. H. Rich in Burgers Medicinal Chemistry, 6th edition, volume 1, part 4, John Wiley & Sons, New York,

2002). If these structures are included in a peptide derivative they are usually connected to the rest of the peptide derivative with at least one of the above mentioned functional groups instead of an amide bond.

By "peptide" we include not only molecules in which amino acid residues are joined by peptide (-CO-NH-) linkages but also molecules in which the peptide bond is reversed. A "retro modified" peptide is a peptide that is made up of amino acids in which the amino acid residues are assembled in opposite direction to the native peptide with respect to which it is retro modified. Where the native peptide comprises L-amino acids, the "retro modified" peptide will also comprise L-amino acids. However, where the native peptide comprises D-amino acids, the "retro modified" peptide will comprise D-amino acids. Retro peptides contain NH-CO bonds instead of CO-NH peptide bonds. An "inverso modified" peptide is a peptide in which the amino acid residues are assembled in the same direction as the native peptide with respect to which it is inverso modified, but the chirality of the amino acids is inverted. Thus, where the native peptide comprises L-amino acids, the "inverso modified" peptide will comprise D-amino acids. Where the native peptide comprises D-amino acids, the "inverso modified" peptide will comprise L-amino acids. Inverso peptides still have CO-NH peptide bonds. A "retro-inverso modified" peptide refers to a peptide that is made up of amino acid residues which are assembled in the opposite direction and which have inverted chirality with respect to the native peptide to which it is retro-inverso modified. A retro-inverso analogue has reversed termini and reversed direction of peptide bonds (i.e. NH-CO) while approximately maintaining the topology of the side chains as in the native peptide sequence. Guichard *et al* (1994) *Proc. Natl. Acad. Sci USA* 91:9765-9769 described that a retro-inverso peptide mimicked the structure and antigenic activity of the natural L-peptide IRGERA, but not of the D- and retro peptides. Such retro-inverso peptidomimetics may be made using methods known in the art, for example such as those described in Meziere *et al* (1997) *J. Immunol.* **159**, 3230-3237, incorporated herein by reference. Partial retro-inverso peptide analogues are polypeptides in which only part of the sequence is reversed and replaced with enantiomeric amino acid residues. Processes for making such analogues are described in Pessi, A., Pinori, M., Verdini, A. S. & Viscomi, G. C. (1987) "Totally solid phase synthesis of peptide(s)-containing retro-inverted peptide bond, using crosslinked sarcosinyl copolymer as support", European Patent 97994-B.

Conventionally, L-amino acids are designated using upper case, and D-amino acids are designated in lower case. The peptides and peptide derivatives of the invention are designated in their preferred form, but without limiting them to the preferred form. The peptide of the first aspect of the invention is designated as comprising WDLYFEIVW (SEQ ID NO: 1) or a variant thereof. The peptide of the first aspect of the invention may also be the retro-inverso variant of WDLYFEIVW (SEQ ID NO: 1) or a variant thereof, namely wviefyldw or a variant thereof. The peptide of the second aspect of the invention is designated as comprising cimfwydcye or a variant thereof.

Conventionally, where the amino acids are joined by peptide bonds, a peptide is represented such that the amino group at the N-terminus appears to the left and the carboxyl group at the C-terminus to the right. Peptides and peptide derivatives according to the present invention are represented in this manner.

A "peptide derivative" contains a modification of one or more amino acid residues or a linker group or other covalently linked group.

Examples of derivatives include N-acyl derivatives of the amino terminal or of another free amino group, esters of the carboxyl terminal or of another free carboxyl or hydroxy group, amides of the carboxyl terminal or of another free carboxyl group produced by reaction with ammonia or with a suitable amine, glycosylated derivatives, hydroxylated derivatives, nucleotidylated derivatives, ADP-ribosylated derivatives, pegylated derivatives, phosphorylated derivatives, derivatives conjugated to lipophilic moieties, and derivatives conjugated to an antibody or other biological ligand. Also included among the chemical derivatives are those obtained by modification of the peptide bond --CO--NH--, for example by reduction to --CH_2--NH-- or alkylation to --CO--N(alkyl)--.

A preferred derivatisation is C-terminal amidation. C-terminal amidation of a peptide removes the negative charge of the C terminus. Peptide derivatives having a C-terminal amide are represented with "NH_2" at the C-terminus, for example Ac-WDLYFEIVW-NH_2 (SEQ ID NO: 1). Another preferred derivatisation is N-terminal acetylation. This removes the positive charge at the N-terminus. Blocking of the C- or N- terminus, such as by C-terminal amidation or N-terminal

acetylation, may improve proteolytic stability due to reduced susceptibility to exoproteolytic digestion.

Suitable linkers include the flexible linker 4,7,10-trioxa-1,13-tridecanediamine (Ttds), glycine, 6-aminohexanoic acid, beta-alanine, or combinations of Ttds, glycine, 6-aminohexanoic acid and beta-alanine.

The peptides of this invention can be produced by chemical synthesis, recombinant DNA technology, biochemical or enzymatic fragmentation of larger molecules, combinations of the foregoing or by any other method.

Peptides (at least those containing peptide linkages between amino acid residues) may be synthesised by the Fmoc strategy of solid-phase peptide synthesis as described in "Fmoc Solid Phase Peptide Synthesis – A Practical Approach", edited by W.C.Chan, P.D. White, Oxford University Press, New York 2000 and references therein. Temporary N-amino group protection is afforded by the 9-fluorenylmethyloxycarbonyl (Fmoc) group. Repetitive cleavage of this highly base-labile protecting group is effected using 20% piperidine in N,N-dimethylformamide. Side-chain functionalities may be protected as their butyl ethers (in the case of serine, threonine and tyrosine), butyl esters (in the case of glutamic acid and aspartic acid), butyloxycarbonyl derivative (in the case of lysine and histidine), trityl derivative (in the case of cysteine, asparagine and glutamine) and 4-methoxy-2,3,6-trimethylbenzenesulphonyl derivative (in the case of arginine). The solid-phase support is based on a polydimethyl-acrylamide polymer constituted from the three monomers dimethylacrylamide (backbone-monomer), bisacryloylethylene diamine (cross linker) and acryloylsarcosine methyl ester (functionalising agent). The peptide-to-resin cleavable linked agent used is the acid-labile 4-hydroxymethyl-phenoxyacetic acid derivative, or in case of C-terminal amides, the Rink-amide linker. All amino acid derivatives are added as their preformed symmetrical anhydride derivatives with the exception of asparagine and glutamine, which are added using a reversed N,N-dicyclohexyl-carbodiimide/1-hydroxybenzotriazole mediated coupling procedure. All coupling and deprotection reactions are monitored using ninhydrin, trinitrobenzene sulphonic acid or isotin test procedures. Upon completion of synthesis, peptides are cleaved from the resin support with concomitant removal of side-chain protecting groups by treatment with 95% trifluoroacetic acid containing a 50%

scavenger mix. Scavengers commonly used are ethanedithiol, phenol, anisole and water, the exact choice depending on the constituent amino acids of the peptide being synthesised. Trifluoroacetic acid is removed by evaporation *in vacuo*, with subsequent trituration with diethyl ether affording the crude peptide. Any scavengers present are removed by a simple extraction procedure which on lyophilisation of the aqueous phase affords the crude peptide free of scavengers. Reagents for peptide synthesis are generally available from Calbiochem-Novabiochem (UK) Ltd, Nottingham NG7 2QJ, UK. Purification may be effected by any one, or a combination of, techniques such as size exclusion chromatography, ion-exchange chromatography, affinity chromatography, differential solubility and (principally) reverse-phase high performance liquid chromatography. Analysis of peptides may be carried out using thin layer chromatography, reverse-phase high performance liquid chromatography, amino-acid analysis after acid hydrolysis and by fast atom bombardment (FAB) mass spectrometric analysis.

SPOT-synthesis, which allows the positional addressable, chemical synthesis of peptides on continuous cellulose membranes may be also used (R Frank *Tetrahedron* (1992) 48, 9217).

As an alternative to solid phase peptide synthesis techniques, peptides may also be produced by recombinant protein expression or *in vitro* translation systems (Sambrook *et al*, "Molecular cloning: A laboratory manual", 2001, 3rd edition, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY). Of course, it is only peptides which contain naturally occurring amino acid residues joined by naturally-occurring peptide bonds which are encodable by a polynucleotide. Such methods are preferred over solid phase peptide synthesis techniques where the peptide is particularly large, such as larger than 50 amino acids, or larger than 100 amino acids.

A "variant" amino acid sequence as defined in relation to the first aspect of the invention may comprise one, two, three or four L-amino acid substitutions in WDLYFEIVW (SEQ ID NO: 1).

Preferably, the variant amino acid sequence comprises an amino acid sequence comprising $X_1X_2X_3YX_4EX_5X_6X_7$ wherein X_1 is W, L or P, X_2 is D or S, X_3 is L or F,

X_4 is F, Phg, L, Ebw, Pff, Thi, 1Ni, Hfe, Ece or Cha, X_5 is I or F, X_6 is S, V or G and X_7 is W or L (SEQ ID NO: 1).

More preferably, the variant amino acid sequence comprises an amino acid sequence comprising $X_1X_2X_3YX_4EX_5X_6X_7$ wherein X_1 is W or L, X_2 is D or S, X_3 is L or F, X_4 is F, Phg or L, X_5 is I or F, X_6 is S, V or G and X_7 is W or L (SEQ ID NO: 1).

A "variant" amino acid sequence as defined in relation to the second aspect of the invention may comprise one, two, three, four, five or six amino acid substitutions in imfwydcye.

Preferably, at least one, two, three, four, five or six of said substitutions in imfwydcye are D-amino acids.

Any substitution within the variant may be non-conservative or conservative.

By "conservative substitutions" we mean substitutions within the following groups: Val, Ile, Leu, Ala, Met; Asp, Glu; Asn, Gln; Ser, Thr, Gly, Ala; Lys, Arg, His; and Phe, Tyr, Trp.

Preferably, the peptide or peptide derivative of the first aspect of the invention comprises RMEFDVWDLYFEIVW (SEQ ID NO: 2) or RMKFDVWDLYFEIVW (SEQ ID NO: 2); or a variant amino acid sequence comprising one, two, three, four, five or six amino acid substitutions in RMEFDVWDLYFEIVW (SEQ ID NO: 2) or RMKFDVWDLYFEIVW (SEQ ID NO: 2).

For the avoidance of doubt, the sequence RMEFDVWDLYFEIVW (SEQ ID NO: 2) may be represented as Arg-Met-Glu-Phe-Asp-Val-Trp-Asp-Leu-Tyr-Phe-Glu-Ile-Val-Trp using the three letter code for amino acids. RMKFDVWDLYFEIVW (SEQ ID NO: 2) may be represented as Arg-Met-Lys-Phe-Asp-Val-Trp-Asp-Leu-Tyr-Phe-Glu-Ile-Val-Trp using the three letter code for amino acids.

More preferably, the variant amino acid sequence comprises an amino acid sequence comprising $X_8X_9X_{10}FDVX_1X_2X_3YX_4EX_5X_6X_7$ wherein X_8 is R or P, X_9 is M, Nva, Moo, N, Nle, Meo, Q, Eag, X_{10} is E, K or D, X_1 is W, L or P, X_2 is D or S,

X_3 is L or F, X_4 is F, Phg, L, Ebw, Pff, Thi, 1Ni, Hfe, Ece, Cha, X_5 is I or F, X_6 is S, V or G and X_7 is W or L (SEQ ID NO: 2).

More preferably, the variant amino acid sequence comprises an amino acid sequence comprising $X_8X_9X_{10}FDVX_1X_2X_3YX_4EX_5X_6X_7$ wherein X_8 is R or P, X_9 is M or Nva, X_{10} is E, K or D, X_1 is W or L, X_2 is D or S, X_3 is L or F, X_4 is F, Phg or L, X_5 is I or F, X_6 is S, V or G and X_7 is W or L (SEQ ID NO: 2).

Suitably, the peptide or peptide derivative of the first aspect of the invention is a peptide or peptide derivative as represented in the table below, or comprises or consists of the amino acid sequence of a peptide or peptide derivative as represented in tables 1 to 3 below:

Table 1: Most preferred peptides

	Peptide	Sequence
SEQ ID NO: 2	A01	Ac-RMKFDVWDLYFEIVW-NH_2
SEQ ID NO: 2	A02	Ac-PMKFDVWDLYFEIVW-NH_2
SEQ ID NO: 2	A03	Ac-RMDFDVWDLYFEIVW-NH_2
SEQ ID NO: 2	A04	Ac-RMEFDVWDLYFEIVW-NH_2
SEQ ID NO: 1	A05	Ac-WDLYFEIVW-NH_2
SEQ ID NO: 3	A06	Ac-WDLYFEIVWE
SEQ ID NO: 1	A07	Ac-WDLYFEIVW-ttds-E
SEQ ID NO: 2	A08	ttds-RMEFDVWDLYFEIVW-ttds-NH_2
SEQ ID NO: 4	A09	ERMEFDVWDLYFEIVW-NH_2
SEQ ID NO: 5	A12	ERXEFDVWDLYFEIVW-NH_2 X is Nva
	A13	ttds-RMEFDVWDLYXEIVW-ttds-NH_2 X is Phg
SEQ ID NO: 6	A14	Ac-WSLYFEIVWE
SEQ ID NO: 1	A15	Ac-WDLYFEISW-ttds-E
SEQ ID NO: 2	A16	PEG5000-RMKFDVWDLYFEIVW-NH_2
SEQ ID NO: 6	A17	PEG5000-WSLYFEIVWE
SEQ ID NO: 4	A18	PEG5000-ERMEFDVWDLYFEIVW-NH_2
SEQ ID NO: 7	A19	Ac-VWDLYFEIVW-NH_2
SEQ ID NO: 8	A21	Ac-FDVWDLYFEIVW-NH_2
SEQ ID NO: 9	A24	EWDLYFEIVW-NH_2
SEQ ID NO: 1	A25	E-ttds-WDLYFEIVW-NH_2

	Peptide	Sequence
SEQ ID NO: 1	A26	Ac-WDLYFEIVW-ttds-E-NH_2
SEQ ID NO: 2	A27	Ac-RMEFDVWDLYFEIVW
SEQ ID NO: 2	A28	RMEFDVWDLYFEIVW
SEQ ID NO: 2	A29	Ac-K-ttds-RMEFDVWDLYFEIVW-NH_2
SEQ ID NO: 10	A30	Ac-RMEFDVWDLYFEIVWK
SEQ ID NO: 10	A31	Ac-RMEFDVWDLYFEIVWK-NH_2
SEQ ID NO: 2	A32	Ac-RMEFDVWDLYFEIVW-ttds-K-NH_2
SEQ ID NO: 11	A33	Ac-WDLYFEISWE
SEQ ID NO: 12	A34	Ac-WDLYLEIVWE
SEQ ID NO: 13	A35	Ac-WDLYFEIVLE
SEQ ID NO: 1	A38	WDLYFEIVW
SEQ ID NO: 2	A49	RMEFDVWDLYFEIVW-NH_2
SEQ ID NO: 2	A50	Ac-RMEFDVWDLYFEIVW-ttds-NH_2
SEQ ID NO: 14	A52	Ac-KRMEFDVWDLYFEIVW-NH_2
SEQ ID NO: 2	A53	K-ttds-RMEFDVWDLYFEIVW-NH_2
SEQ ID NO: 2	A54	Ac-RMEFDVWDLYFEIVW-ttds-K
SEQ ID NO: 1	A55	Ac-LDLYFEIVW-ttds-E
SEQ ID NO: 1	A56	Ac-WDLYFEIVL-ttds-E
SEQ ID NO: 15	A57	E-RMEFDVLDLYFEIVW-NH_2
SEQ ID NO: 16	A58	E-RMEFDVWDLYFEIVL-NH_2
SEQ ID NO: 17	A84	Ac-WDFYFEIVWE
SEQ ID NO: 18	A85	Ac-WDLYFEFVWE
SEQ ID NO: 19	A86	Ac-LDLYFEIVWE
SEQ ID NO: 20	A87	Ac-WDLYFEIGWE
SEQ ID NO: 21	A89	Ac-WDLYLEISLE
	A90	Ac-WDLYXEIVLE X is Phg
	A91	Ac-WSLYXEIVWE X is Phg
SEQ ID NO: 22	A92	Ac-LDLYFEIVLE
SEQ ID NO: 23	A93	Ac-LDLYFEISLE
	A94	Ac-LDLYXEISWE X is Phg
SEQ ID NO: 24	A95	Ac-LSLYFEIVWE
SEQ ID NO: 25	A96	Ac-LSLYFEIVLE
SEQ ID NO: 26	A97	Ac-LSLYFEISLE

Table 2: Preferred peptides

	Peptide	Sequence
SEQ ID NO: 1	A20	Ac-WDLYFEIVW-ttds-K
SEQ ID NO: 27	A22	Ac-DVWDLYFEIVW-NH_2
	A23	Ac-wviefyldwvdfkmr-NH_2
SEQ ID NO: 1	A37	Ac-WDLYFEIVW
SEQ ID NO: 1	A39	Ac-ttds-WDLYFEIVW-NH_2
SEQ ID NO: 1	A40	ttds-WDLYFEIVW-NH_2
SEQ ID NO: 1	A41	Ac-WDLYFEIVW-ttds-NH_2
SEQ ID NO: 1	A42	Ac-ttds-WDLYFEIVW-ttds-NH_2
SEQ ID NO: 1	A43	ttds-WDLYFEIVW-ttds
SEQ ID NO: 1	A44	ttds-WDLYFEIVW-ttds-NH_2
SEQ ID NO: 28	A45	Ac-KWDLYFEIVW-NH_2
SEQ ID NO: 1	A46	Ac-K-ttds-WDLYFEIVW-NH_2
SEQ ID NO: 29	A47	Ac-WDLYFEIVWK
SEQ ID NO: 29	A48	Ac-WDLYFEIVWK-NH_2
	A71	E-R(Moo)EFDVWDLYFEIVW-NH_2
SEQ ID NO: 30	A73	E-RNEFDVWDLYFEIVW-NH_2
	A78	ttds-RMEFDVWDLY(Ebw)EIVW-ttds-NH_2
	A83	ttds-RMEFDVWDLY(Pff)EIVW-ttds-NH_2
SEQ ID NO: 31	A88	Ac-PDLYFEIVWE
SEQ ID NO: 32	A98	Ac-LSLYLEIVLE
SEQ ID NO: 33	A99	Ac-LSLYLEISLE
	A100	Ac-LSLYXEIVLE X is Phg
SEQ ID NO: 1	A101	Ac-WDLYFEIVW-ttds-K-NH_2

Table 3: Active peptides

	Peptide	Sequence
SEQ ID NO: 34	A10	E-PMKFDVWDLYFEIVW-NH_2
SEQ ID NO: 2	A11	ttds-RMDFDVWDLYFEIVW-ttds-NH_2
SEQ ID NO: 2	A16	PEG5000-RMKFDVWDLYFEIVW-NH_2
SEQ ID NO: 1	A36	WDLYFEIVW-NH_2
SEQ ID NO: 14	A51	KRMEFDVWDLYFEIVW-NH_2
SEQ ID NO: 2	A59	ttds-PMKFDVWDLYFEIVW-ttds-NH_2

	Peptide	Sequence
SEQ ID NO: 35	A60	E-RMDFDVWDLYFEIVW-NH_2
SEQ ID NO: 2	A61	(Coh)-ttds-RMEFDVWDLYFEIVW-ttds-NH_2
SEQ ID NO: 2	A62	Glucosyl-aminooxyacetyl-ttds-RMEFDVWDLYFEIVW-ttds-NH_2
	A63	Ac-P(Moo)KFDVWDLYFEIVW-NH_2
SEQ ID NO: 2	A64	Ac-P(Nle)KFDVWDLYFEIVW-NH_2
SEQ ID NO: 2	A65	Ac-PNKFDVWDLYFEIVW-NH_2
	A66	Ac-R(Moo)DFDVWDLYFEIVW-NH_2
SEQ ID NO: 2	A67	Ac-R(Nle)DFDVWDLYFEIVW-NH_2
SEQ ID NO: 2	A68	Ac-RNDFDVWDLYFEIVW-NH_2
SEQ ID NO: 2	A69	ttds-R(Nle)EFDVWDLYFEIVW-ttds-NH_2
SEQ ID NO: 2	A70	ttds-RNEFDVWDLYFEIVW-ttds-NH_2
SEQ ID NO: 321	A72	E-R(Nle)EFDVWDLYFEIVW-NH_2
	A74	E-R(Meo)EFDVWDLYFEIVW-NH_2
SEQ ID NO: 36	A75	E-R(Gln)EFDVWDLYFEIVW-NH_2
	A76	E-R(Eag)EFDVWDLYFEIVW-NH_2
	A77	ttds-RMEFDVWDLY(Thi)EIVW-ttds-NH_2
	A79	ttds-RMEFDVWDLY(1Ni)EIVW-ttds-NH_2
	A80	ttds-RMEFDVWDLY(Hfe)EIVW-ttds-NH_2
	A81	ttds-RMEFDVWDLY(Ece)EIVW-ttds-NH_2
	A82	ttds-RMEFDVWDLY(Cha)EIVW-ttds-NH_2
SEQ ID NO: 28	A102	KWDLYFEIVW-NH_2
SEQ ID NO: 1	A103	K-ttds-WDLYFEIVW-NH_2

In the above tables, -ttds- is 4,7,10-trioxa-1,13-tridecanediamine. "N" is asparagine. "NH_2" is a C-terminal amide group.

Preferably, the peptide or peptide derivative of the first aspect of the invention does not comprise or consist of a peptide represented in the list below:

AMKFDVWDLYFEIVW (SEQ ID NO: 37), CMKFDVWDLYFEIVW (SEQ ID NO: 38), DMKFDVWDLYFEIVW (SEQ ID NO: 39), EMKFDVWDLYFEIVW (SEQ ID NO: 40), FMKFDVWDLYFEIVW (SEQ ID NO: 41), GMKFDVWDLYFEIVW (SEQ ID NO: 42), HMKFDVWDLYFEIVW (SEQ ID NO: 43), IMKFDVWDLYFEIVW (SEQ ID NO: 44), KMKFDVWDLYFEIVW (SEQ ID NO: 45), LMKFDVWDLYFEIVW (SEQ ID NO: 46), MMKFDVWDLYFEIVW (SEQ ID NO: 47), NMKFDVWDLYFEIVW (SEQ ID NO: 48), QMKFDVWDLYFEIVW (SEQ ID NO: 49), SMKFDVWDLYFEIVW (SEQ ID NO: 50), TMKFDVWDLYFEIVW (SEQ ID NO: 51), VMKFDVWDLYFEIVW (SEQ ID NO: 52), WMKFDVWDLYFEIVW (SEQ ID NO: 53), YMKFDVWDLYFEIVW (SEQ ID NO: 54), RAKFDVWDLYFEIVW (SEQ ID NO: 55), RCKFDVWDLYFEIVW (SEQ ID NO: 56), RDKFDVWDLYFEIVW (SEQ ID NO: 57), REKFDVWDLYFEIVW (SEQ ID NO:

58), RFKFDVWDLYFEIVW (SEQ ID NO: 59), RGKFDVWDLYFEIVW (SEQ ID NO: 60), RHKFDVWDLYFEIVW (SEQ ID NO: 61), RIKFDVWDLYFEIVW (SEQ ID NO: 62), RKKFDVWDLYFEIVW (SEQ ID NO: 63), RLKFDVWDLYFEIVW (SEQ ID NO: 64), RNKFDVWDLYFEIVW (SEQ ID NO: 65), RPKFDVWDLYFEIVW (SEQ ID NO: 66), RQKFDVWDLYFEIVW (SEQ ID NO: 67), RRKFDVWDLYFEIVW (SEQ ID NO: 68), RSKFDVWDLYFEIVW (SEQ ID NO: 69), RTKFDVWDLYFEIVW (SEQ ID NO: 70), RVKFDVWDLYFEIVW (SEQ ID NO: 71), RWKFDVWDLYFEIVW (SEQ ID NO: 72), RYKFDVWDLYFEIVW (SEQ ID NO: 73), RMAFDVWDLYFEIVW (SEQ ID NO: 74), RMCFDVWDLYFEIVW (SEQ ID NO: 75), RMFFDVWDLYFEIVW (SEQ ID NO: 76), RMGFDVWDLYFEIVW (SEQ ID NO: 77), RMHFDVWDLYFEIVW (SEQ ID NO: 78), RMIFDVWDLYFEIVW (SEQ ID NO: 79), RMLFDVWDLYFEIVW (SEQ ID NO: 80), RMMFDVWDLYFEIVW (SEQ ID NO: 81), RMNFDVWDLYFEIVW (SEQ ID NO: 82), RMPFDVWDLYFEIVW (SEQ ID NO: 83), RMQFDVWDLYFEIVW (SEQ ID NO: 84), RMRFDVWDLYFEIVW (SEQ ID NO: 85), RMSFDVWDLYFEIVW (SEQ ID NO: 86), RMTFDVWDLYFEIVW (SEQ ID NO: 87), RMVFDVWDLYFEIVW (SEQ ID NO: 88), RMWFDVWDLYFEIVW (SEQ ID NO: 89), RMYFDVWDLYFEIVW (SEQ ID NO: 90), RMKADVWDLYFEIVW (SEQ ID NO: 91), RMKCDVWDLYFEIVW (SEQ ID NO: 92), RMKDDVWDLYFEIVW (SEQ ID NO: 93), RMKEDVWDLYFEIVW (SEQ ID NO: 94), RMKGDVWDLYFEIVW (SEQ ID NO: 95), RMKHDVWDLYFEIVW (SEQ ID NO: 96), RMKIDVWDLYFEIVW (SEQ ID NO: 97), RMKKDVWDLYFEIVW (SEQ ID NO: 98), RMKLDVWDLYFEIVW (SEQ ID NO: 99), RMKMDVWDLYFEIVW (SEQ ID NO: 100), RMKNDVWDLYFEIVW (SEQ ID NO: 101), RMKPDVWDLYFEIVW (SEQ ID NO: 102), RMKQDVWDLYFEIVW (SEQ ID NO: 103), RMKRDVWDLYFEIVW (SEQ ID NO: 104), RMKSDVWDLYFEIVW (SEQ ID NO: 105), RMKTDVWDLYFEIVW (SEQ ID NO: 106), RMKVDVWDLYFEIVW (SEQ ID NO: 107), RMKWDVWDLYFEIVW (SEQ ID NO: 108), RMKYDVWDLYFEIVW (SEQ ID NO: 109), RMKFAVWDLYFEIVW (SEQ ID NO: 110), RMKFCVWDLYFEIVW (SEQ ID NO: 111), RMKFEVWDLYFEIVW (SEQ ID NO: 112), RMKFFVWDLYFEIVW (SEQ ID NO: 113), RMKFGVWDLYFEIVW (SEQ ID NO: 114), RMKFHVWDLYFEIVW (SEQ ID NO: 115), RMKFIVWDLYFEIVW (SEQ ID NO: 116), RMKFKVWDLYFEIVW (SEQ ID NO: 117), RMKFLVWDLYFEIVW (SEQ ID NO: 118), RMKFMVWDLYFEIVW (SEQ ID NO: 119), RMKFNVWDLYFEIVW (SEQ ID NO: 120), RMKFPVWDLYFEIVW (SEQ ID NO: 121), RMKFQVWDLYFEIVW (SEQ ID NO: 122), RMKFRVWDLYFEIVW (SEQ ID NO: 123), RMKFSVWDLYFEIVW (SEQ ID NO: 124), RMKFTVWDLYFEIVW (SEQ ID NO: 125), RMKFVVWDLYFEIVW (SEQ ID NO: 126), RMKFWVWDLYFEIVW (SEQ ID NO: 127), RMKFYVWDLYFEIVW (SEQ ID NO: 128), RMKFDAWDLYFEIVW (SEQ ID NO: 129), RMKFDCWDLYFEIVW (SEQ ID NO: 130), RMKFDDWDLYFEIVW (SEQ ID NO: 131), RMKFDEWDLYFEIVW (SEQ ID NO: 132), RMKFDFWDLYFEIVW (SEQ ID NO: 133), RMKFDGWDLYFEIVW (SEQ ID NO: 134), RMKFDHWDLYFEIVW (SEQ ID NO: 135), RMKFDIWDLYFEIVW (SEQ ID NO: 136), RMKFDKWDLYFEIVW (SEQ ID NO: 137), RMKFDLWDLYFEIVW (SEQ ID NO: 138), RMKFDMWDLYFEIVW (SEQ ID NO: 139), RMKFDNWDLYFEIVW (SEQ ID NO: 140), RMKFDPWDLYFEIVW (SEQ ID NO: 141), RMKFDQWDLYFEIVW (SEQ ID NO: 142), RMKFDRWDLYFEIVW (SEQ ID NO: 143), RMKFDSWDLYFEIVW (SEQ ID NO: 144), RMKFDTWDLYFEIVW (SEQ ID NO: 145), RMKFDWWDLYFEIVW (SEQ ID NO: 146), RMKFDYWDLYFEIVW (SEQ ID NO: 147), RMKFDVADLYFEIVW (SEQ ID NO: 148), RMKFDVCDLYFEIVW (SEQ ID NO: 149), RMKFDVDDLYFEIVW (SEQ ID NO: 150), RMKFDVEDLYFEIVW (SEQ ID NO: 151), RMKFDVFDLYFEIVW (SEQ ID NO: 152), RMKFDVGDLYFEIVW (SEQ ID NO: 153), RMKFDVHDLYFEIVW (SEQ ID NO: 154), RMKFDVIDLYFEIVW (SEQ ID NO: 155), RMKFDVKDLYFEIVW (SEQ ID NO: 156), RMKFDVLDLYFEIVW (SEQ ID NO: 157), RMKFDVMDLYFEIVW (SEQ ID NO: 158),

RMKFDVNDLYFEIVW (SEQ ID NO: 159), RMKFDVPDLYFEIVW (SEQ ID NO: 160), RMKFDVQDLYFEIVW (SEQ ID NO: 161), RMKFDVRDLYFEIVW (SEQ ID NO: 162), RMKFDVSDLYFEIVW (SEQ ID NO: 163), RMKFDVTDLYFEIVW (SEQ ID NO: 164), RMKFDVVDLYFEIVW (SEQ ID NO: 165), RMKFDVYDLYFEIVW (SEQ ID NO: 166), RMKFDVWALYFEIVW (SEQ ID NO: 167), RMKFDVWCLYFEIVW (SEQ ID NO: 168), RMKFDVWELYFEIVW (SEQ ID NO: 169), RMKFDVWFLYFEIVW (SEQ ID NO: 170), RMKFDVWGLYFEIVW (SEQ ID NO: 171), RMKFDVWHLYFEIVW (SEQ ID NO: 172), RMKFDVWILYFEIVW (SEQ ID NO: 173), RMKFDVWKLYFEIVW (SEQ ID NO: 174), RMKFDVWLLYFEIVW (SEQ ID NO: 175), RMKFDVWMLYFEIVW (SEQ ID NO: 176), RMKFDVWNLYFEIVW (SEQ ID NO: 177), RMKFDVWPLYFEIVW (SEQ ID NO: 178), RMKFDVWQLYFEIVW (SEQ ID NO: 179), RMKFDVWRLYFEIVW (SEQ ID NO: 180), RMKFDVWSLYFEIVW (SEQ ID NO: 181), RMKFDVWTLYFEIVW (SEQ ID NO: 182), RMKFDVWVLYFEIVW (SEQ ID NO: 183), RMKFDVWWLYFEIVW (SEQ ID NO: 184), RMKFDVWYLYFEIVW (SEQ ID NO: 185), RMKFDVWDAYFEIVW (SEQ ID NO: 186), RMKFDVWDCYFEIVW (SEQ ID NO: 187), RMKFDVWDDYFEIVW (SEQ ID NO: 188), RMKFDVWDEYFEIVW (SEQ ID NO: 189), RMKFDVWDFYFEIVW (SEQ ID NO: 190), RMKFDVWDGYFEIVW (SEQ ID NO: 191), RMKFDVWDHYFEIVW (SEQ ID NO: 192), RMKFDVWDIYFEIVW (SEQ ID NO: 193), RMKFDVWDKYFEIVW (SEQ ID NO: 194), RMKFDVWDMYFEIVW (SEQ ID NO: 195), RMKFDVWDNYFEIVW (SEQ ID NO: 196), RMKFDVWDPYFEIVW (SEQ ID NO: 197), RMKFDVWDQYFEIVW (SEQ ID NO: 198), RMKFDVWDRYFEIVW (SEQ ID NO: 199), RMKFDVWDSYFEIVW (SEQ ID NO: 200), RMKFDVWDTYFEIVW (SEQ ID NO: 201), RMKFDVWDVYFEIVW (SEQ ID NO: 202), RMKFDVWDWYFEIVW (SEQ ID NO: 203), RMKFDVWDYYFEIVW (SEQ ID NO: 204), RMKFDVWDLAFEIVW (SEQ ID NO: 205), RMKFDVWDLCFEIVW (SEQ ID NO: 206), RMKFDVWDLDFEIVW (SEQ ID NO: 207), RMKFDVWDLEFEIVW (SEQ ID NO: 208), RMKFDVWDLFFEIVW (SEQ ID NO: 209), RMKFDVWDLGFEIVW (SEQ ID NO: 210), RMKFDVWDLHFEIVW (SEQ ID NO: 211), RMKFDVWDLIFEIVW (SEQ ID NO: 212), RMKFDVWDLKFEIVW (SEQ ID NO: 213), RMKFDVWDLLFEIVW (SEQ ID NO: 214), RMKFDVWDLMFEIVW (SEQ ID NO: 215), RMKFDVWDLNFEIVW (SEQ ID NO: 216), RMKFDVWDLPFEIVW (SEQ ID NO: 217), RMKFDVWDLQFEIVW (SEQ ID NO: 218), RMKFDVWDLRFEIVW (SEQ ID NO: 219), RMKFDVWDLSFEIVW (SEQ ID NO: 220), RMKFDVWDLTFEIVW (SEQ ID NO: 221), RMKFDVWDLVFEIVW (SEQ ID NO: 222), RMKFDVWDLWFEIVW (SEQ ID NO: 223), RMKFDVWDLYAEIVW (SEQ ID NO: 224), RMKFDVWDLYCEIVW (SEQ ID NO: 225), RMKFDVWDLYDEIVW (SEQ ID NO: 226), RMKFDVWDLYEEIVW (SEQ ID NO: 227), RMKFDVWDLYGEIVW (SEQ ID NO: 228), RMKFDVWDLYHEIVW (SEQ ID NO: 229), RMKFDVWDLYIEIVW (SEQ ID NO: 230), RMKFDVWDLYKEIVW (SEQ ID NO: 231), RMKFDVWDLYLEIVW (SEQ ID NO: 232), RMKFDVWDLYMEIVW (SEQ ID NO: 233), RMKFDVWDLYNEIVW (SEQ ID NO: 234), RMKFDVWDLYPEIVW (SEQ ID NO: 235), RMKFDVWDLYQEIVW (SEQ ID NO: 236), RMKFDVWDLYREIVW (SEQ ID NO: 237), RMKFDVWDLYSEIVW (SEQ ID NO: 238), RMKFDVWDLYTEIVW (SEQ ID NO: 239), RMKFDVWDLYVEIVW (SEQ ID NO: 240), RMKFDVWDLYWEIVW (SEQ ID NO: 241), RMKFDVWDLYYEIVW (SEQ ID NO: 242), RMKFDVWDLYFAIVW (SEQ ID NO: 243), RMKFDVWDLYFCIVW (SEQ ID NO: 244), RMKFDVWDLYFDIVW (SEQ ID NO: 245), RMKFDVWDLYFFIVW (SEQ ID NO: 246), RMKFDVWDLYFGIVW (SEQ ID NO: 247), RMKFDVWDLYFHIVW (SEQ ID NO: 248), RMKFDVWDLYFIIVW (SEQ ID NO: 249), RMKFDVWDLYFKIVW (SEQ ID NO: 250), RMKFDVWDLYFLIVW (SEQ ID NO: 251), RMKFDVWDLYFMIVW (SEQ ID NO: 252), RMKFDVWDLYFNIVW (SEQ ID NO: 253), RMKFDVWDLYFPIVW (SEQ ID NO: 254), RMKFDVWDLYFQIVW (SEQ ID NO: 255), RMKFDVWDLYFRIVW

(SEQ ID NO: 256), RMKFDVWDLYFSIVW (SEQ ID NO: 257), RMKFDVWDLYFTIVW (SEQ ID NO: 258), RMKFDVWDLYFVIVW (SEQ ID NO: 259), RMKFDVWDLYFWIVW (SEQ ID NO: 260), RMKFDVWDLYFYIVW (SEQ ID NO: 261), RMKFDVWDLYFEAVW (SEQ ID NO: 262), RMKFDVWDLYFECVW (SEQ ID NO: 263), RMKFDVWDLYFEDVW (SEQ ID NO: 264), RMKFDVWDLYFEEVW (SEQ ID NO: 265), RMKFDVWDLYFEFVW (SEQ ID NO: 266), RMKFDVWDLYFEGVW (SEQ ID NO: 267), RMKFDVWDLYFEHVW (SEQ ID NO: 268), RMKFDVWDLYFEKVW (SEQ ID NO: 269), RMKFDVWDLYFELVW (SEQ ID NO: 270), RMKFDVWDLYFEMVW (SEQ ID NO: 271), RMKFDVWDLYFENVW (SEQ ID NO: 272), RMKFDVWDLYFEPVW (SEQ ID NO: 273), RMKFDVWDLYFEQVW (SEQ ID NO: 274), RMKFDVWDLYFERVW (SEQ ID NO: 275), RMKFDVWDLYFESVW (SEQ ID NO: 276), RMKFDVWDLYFETVW (SEQ ID NO: 277), RMKFDVWDLYFEVVW (SEQ ID NO: 278), RMKFDVWDLYFEWVW (SEQ ID NO: 279), RMKFDVWDLYFEYVW (SEQ ID NO: 280), RMKFDVWDLYFEIAW (SEQ ID NO: 281), RMKFDVWDLYFEICW (SEQ ID NO: 282), RMKFDVWDLYFEIDW (SEQ ID NO: 283), RMKFDVWDLYFEIEW (SEQ ID NO: 284), RMKFDVWDLYFEIFW (SEQ ID NO: 285), RMKFDVWDLYFEIGW (SEQ ID NO: 286), RMKFDVWDLYFEIHW (SEQ ID NO: 287), RMKFDVWDLYFEIIW (SEQ ID NO: 288), RMKFDVWDLYFEIKW (SEQ ID NO: 289), RMKFDVWDLYFEILW (SEQ ID NO: 290), RMKFDVWDLYFEIMW (SEQ ID NO: 291), RMKFDVWDLYFEINW (SEQ ID NO: 292), RMKFDVWDLYFEIPW (SEQ ID NO: 293), RMKFDVWDLYFEIQW (SEQ ID NO: 294), RMKFDVWDLYFEIRW (SEQ ID NO: 295), RMKFDVWDLYFEISW (SEQ ID NO: 296), RMKFDVWDLYFEITW (SEQ ID NO: 297), RMKFDVWDLYFEIWW (SEQ ID NO: 298), RMKFDVWDLYFEIYW (SEQ ID NO: 299), RMKFDVWDLYFEIVA (SEQ ID NO: 300), RMKFDVWDLYFEIVC (SEQ ID NO: 301), RMKFDVWDLYFEIVD (SEQ ID NO: 302), RMKFDVWDLYFEIVE (SEQ ID NO: 303), RMKFDVWDLYFEIVF (SEQ ID NO: 304), RMKFDVWDLYFEIVG (SEQ ID NO: 305), RMKFDVWDLYFEIVH (SEQ ID NO: 306), RMKFDVWDLYFEIVI (SEQ ID NO: 307), RMKFDVWDLYFEIVK (SEQ ID NO: 308), RMKFDVWDLYFEIVL (SEQ ID NO: 309), RMKFDVWDLYFEIVM (SEQ ID NO: 310), RMKFDVWDLYFEIVN (SEQ ID NO: 311), RMKFDVWDLYFEIVP (SEQ ID NO: 312), RMKFDVWDLYFEIVQ (SEQ ID NO: 313), RMKFDVWDLYFEIVR (SEQ ID NO: 314), RMKFDVWDLYFEIVS (SEQ ID NO: 315), RMKFDVWDLYFEIVT (SEQ ID NO: 316), RMKFDVWDLYFEIVV (SEQ ID NO: 317), RMKFDVWDLYFEIVY (SEQ ID NO: 318), MKFDVWDLYFEIVW (SEQ ID NO: 319), KFDVWDLYFEIVW (SEQ ID NO: 320).

Preferably, the peptide or peptide derivative of the second aspect of the invention comprises:

(i) an amino acid sequence comprising cimfwydcye; or

(ii) a variant amino acid sequence comprising one, two, three, four, five, six or seven amino acid substitutions in cimfwydcye.

Preferably, at least one, two, three, four, five, six or seven of said substitutions in cimfwydcye are D-amino acids.

Preferably, the peptide or peptide derivative of the second aspect of the invention comprises: an amino acid sequence comprising $X_1X_2X_3X_4X_5X_6X_7X_8X_9X_{10}$, wherein X_1, where present, is c, s, y, i, D-Pen, C, t, D-Nva, D-Nle or k, X_2 is i, y, w or d, X_3

is c or m, X_4 is f, t, v or c, X_5 is w or c, X_6 is y or c, X_7 is d, e or f, X_8 is c, e, f, y or d, X_9 is y or w and X_{10} is e or i, with no more than seven amino acids substitutions compared to cimfwydcye.

Preferably, the peptide or peptide derivative comprises an amino acid sequence comprising $X_1X_2X_3X_4$wydX_8ye, wherein X_1 is c, C, D-Pen or s, X_2 is l, y or w, X_3 is c or m, X_4 is f, t, or v and X_8 is c or e.

Preferably, the peptide or peptide derivative comprises an amino acid sequence comprising X_1X_2mX_4wydX_8ye, wherein X_1 is c, C or D-Pen, X_2 is i or y, X_4 is f, t, or v and X_8 is c or e.

Suitably, the peptide or peptide derivative of the second aspect of the invention is a peptide or peptide derivative as represented in the table below, or comprises or consists of the amino acid sequence of a peptide or peptide derivative as represented in tables 4 to 6 below:

Table 4: Most preferred peptides

Peptide	Sequence
B03	Ac-cimfwydeye-NH_2
B04	Disulphide-Dimer(Ac-cimfwydeye-NH_2)$_2$
B05	Ac-TTDS-(cymfwydc)-ye-NH_2
B06	K-TTDS-(cymfwydc)-ye-NH_2
B14	Ac-(cimtwydc)-ye-NH_2
B15	Ac-(cimvwydc)-ye-NH_2
B17	(cymfwydc)-ye
B18	Ac-(cymfwydc)-yeG-NH_2
B19	Ac-(D-Pen)imfwydeye-NH_2
B23	O(CH_2-CH_2-O-CH_2-CO-imfwydeye-NH_2)$_2$
B24	Pyridine-3 (SEQ ID NO: 1),5-(CO-imfwydeye-NH_2)$_2$
B34	H_2N-E-TTDS-(cymfwydc)-ye-NH_2
B35	Ac-(cymfwydc)-yeK
B37	Ac-(cymfwydc)-ye-TTDS-K

In a preferred embodiment, peptides B05, B06, B14, B15, B17, B18, B34, B35 and B37 are cyclic.

Table 5: Preferred peptides

Peptide	Sequence
B07	Ac-simfwydeye-NH_2
B07	Ac-simfwydeye-NH_2
B09	Ac-ydmcwcefyi-NH_2
B10	Ac-idmccyfywe-NH_2
B16	Ac-cimfwyddye-NH_2
B26	Ac-(cymfwydc)-ye
B27	Ac-(cymfwydc)-ye-TTDS-NH_2
B28	Ac-TTDS-(cymfwydc)-ye-TTDS-NH_2
B30	K-(cymfwydc)-ye-NH_2
B31	Ac-K-(cymfwydc)-ye-NH_2
B32	E-(cymfwydc)-ye-NH_2
B33	Ac-K-TTDS-(cymfwydc)-ye-NH_2
B36	Ac-(cymfwydc)-yeK-NH_2
B38	Ac-(cymfwydc)-ye-TTDS-K-NH_2
B39	Ac-(cymfwydc)-ye-TTDS-E-NH_2
B41	Ac-timfwydeye-NH_2

In a preferred embodiment, peptides B26, B27, B28, B30, B31, B32, B33, B36, B38 and B39 are cyclic.

Table 6: Active peptides

Peptide	Sequence
B01	Ac-(cimfwydc)-ye-NH_2
B02	Ac-(cymfwydc)-ye-NH_2
B11	Ac-(cwmfwydc)-ye-NH_2
B13	Ac-cicfwydcye-NH_2
B20	Ac-(D-Nva)imfwydeye-NH_2
B21	Ac-(D-Nle)imfwydeye-NH_2
B22	Ac-(Cys)imfwydeye-NH_2
B25	(cymfwydc)-ye-NH_2
B29	TTDS-(cymfwydc)-ye-TTDS-NH_2
B40	Ac-kimfwydeye-NH_2

In a preferred embodiment, peptides B01, B02, B11, B25 and B29 are cyclic.

In the above tables, -TTDS- is 4,7,10-trioxa-1,13-tridecanediamine. "NH_2" is a C-terminal amide group.

B08 is deleted in the above tables, as being identical to B01. B12 is deleted in the above tables, as being identical to B02.

Preferably, the peptide or peptide derivative of the first aspect of the invention does not comprise or consist of a peptide represented in the list below:

feiycwdcym, ywcfiymced, dmwceyfcyi, ceicwyfdym, ccwfiemdyy, cemdwycyfi, aimfwydcye, dimfwydcye, eimfwydcye, fimfwydcye, himfwydcye, iimfwydcye, kimfwydcye, limfwydcye, mimfwydcye, nimfwydcye, pimfwydcye, qimfwydcye, rimfwydcye, simfwydcye, timfwydcye, vimfwydcye, wimfwydcye, yimfwydcye, camfwydcye, ccmfwydsye, cdmfwydcye, cemfwydcye, cfmfwydcye, chmfwydcye, ckmfwydcye, clmfwydcye, cmmfwydcye, cnmfwydcye, cpmfwydcye, cqmfwydcye, crmfwydcye, csmfwydcye, ctmfwydcye, cvmfwydcye, ciafwydcye, cidfwydcye, ciefwydcye, ciffwydcye, cihfwydcye, ciifwydcye, cikfwydcye, cilfwydcye, cinfwydcye, cipfwydcye, ciqfwydcye, cirfwydcye, cisfwydcye, citfwydcye, civfwydcye, ciwfwydcye, ciyfwydcye, cimawydcye, cimcwydsye, cimdwydcye, cimewydcye, cimhwydcye, cimiwydcye, cimkwydcye, cimlwydcye, cimmwydcye, cimnwydcye, cimpwydcye, cimqwydcye, cimrwydcye, cimswydcye, cimwwydcye, cimywydcye, cimfaydcye, cimfcydsye, cimfdydcye, cimfeydcye, cimffydcye, cimfhydcye, cimfiydcye, cimfkydcye, cimflydcye, cimfmydcye, cimfnydcye, cimfpydcye, cimfqydcye, cimfrydcye, cimfsydcye, cimftydcye, cimfvydcye, cimfyydcye, cimfwadcye, cimfwcdsye, cimfwddcye, cimfwedcye, cimfwfdcye, cimfwhdcye, cimfwidcye, cimfwkdcye, cimfwldcye, cimfwmdcye, cimfwndcye, cimfwpdcye, cimfwqdcye, cimfwrdcye, cimfwsdcye, cimfwtdcye, cimfwvdcye, cimfwwdcye, cimfwyacye, cimfwycsye, cimfwyecye, cimfwyfcye, cimfwyhcye, cimfwyicye, cimfwykcye, cimfwylcye, cimfwymcye, cimfwyncye, cimfwypcye, cimfwyqcye, cimfwyrcye, cimfwyscye, cimfwytcye, cimfwyvcye, cimfwywcye, cimfwyycye, cimfwydaye, cimfwydfye, cimfwydhye, cimfwydiye, cimfwydkye, cimfwydlye, cimfwydmye, cimfwydnye, cimfwydpye, cimfwydqye, cimfwydrye, cimfwydsye, cimfwydtye, cimfwydvye, cimfwydwye, cimfwydyye, cimfwydcae, cimfwydsce, cimfwydcde, cimfwydcee, cimfwydcfe, cimfwydche, cimfwydcie, cimfwydcke, cimfwydcle, cimfwydcme, cimfwydcne, cimfwydcpe, cimfwydcqe, cimfwydcre, cimfwydcse, cimfwydcte, cimfwydcve, cimfwydcwe, cimfwydcya, cimfwydsyc, cimfwydcyd, cimfwydcyf, cimfwydcyh, cimfwydcyi, cimfwydcyk, cimfwydcyl, cimfwydcym, cimfwydcyn, cimfwydcyp, cimfwydcyq, cimfwydcyr, cimfwydcys, cimfwydcyt, cimfwydcyv, cimfwydcyw, cimfwydcyy.

Preferably, the peptide or peptide derivative of the second aspect of the invention is a cyclic peptide. The peptide or peptide derivatives of the first aspect may also be cyclic.

The term "cyclic peptide" as used herein refers to a cyclic derivative of a peptide to which, for example, two or more additional groups suitable for cyclization have been added, often at the carboxyl terminus and at the amino terminus. Suitable groups include amino acid residues. A cyclic peptide may contain either an intramolecular disulfide bond, i.e. --S--S--, an intramolecular amide bond between the two added residues, i.e. --CONH-- or --NHCO--, or intramolecular S-alkyl bonds, i.e. --S--(CH_2)n --CONH-- or --NH--$CO(CH_2)$n --S--, wherein n is 1, 2 or more and preferably no more than 6. Cyclization may be also carried out by triazine chemistry as exemplified in Scharn, D. et al. (2001) *J. Org. Chem* **66**; 507. Cyclic peptide sequences are denoted with the prefix "cyclo" in front of the peptide sequence and the cyclic part of the sequence is incorporated in parenthesis and additionally separated from the rest of the sequence by hyphens.

A peptide or peptide derivative of the first or second aspect of the invention may be modified by conjugation to polyethylene glycol (PEG). Suitable methods of PEGylation are disclosed in U.S. Patent Nos. 5,122,614 (Zalipsky; Enzon, Inc.) and 5,539,063 (Hakimi et al; Hoffmann-La Roche Inc.), all of which PEGylation methods are incorporated herein by reference. Various molecular weights of PEG may be used, suitably from 5000 to 40000 kD. A preferred molecular weight is 5000 kD. Preferably, the PEG is monodisperse, meaning that there is little variation in molecular weight between PEG molecules. PEGylation may improve the solubility and plasma half-life of a peptide.

A third aspect of the invention provides a dual peptide comprising a peptide or peptide derivative of the first or second aspects of the invention conjugated to a further peptide or peptide derivative of the first or second aspects of the invention, wherein the peptide or peptide derivative may be the same as or different from the further peptide or peptide derivative, and wherein the dual peptide has procoagulant activity.

The dual peptide may comprise two of the same, or two different, peptides or peptide derivatives of the first or second aspects of the invention covalently linked to one another, either by a flexible linker which can be peptidic, peptidomimetic or non-peptidic, or by a conformationally constrained linker that can comprise conformationally constrained peptidic, peptidomimetic or non-peptidic building blocks e.g. triazine moieties, or by any other possible method known in the art.

Preferably, the peptide or peptide derivative of the first and second aspects of the invention and the dual peptide of the third aspect of the invention has a molecular weight of between 0.5 and 3.5kD. By "molecular weight" we mean the theoretical mass of a monomer of the peptide or peptide derivative exclusive of any counter ions or adducts. For PEGylated peptides the molecular weight is defined as the mass of the monomeric molecule exclusive of any counter ions or adducts and exclusive of the PEG moiety or moieties. Peptides, peptide derivatives and dual peptides of between 0.5 kD and 3.5 kD are more readily synthesised than larger peptides, have a reduced risk being immunogenic, and are generally easily administered to a patient. Peptides of less than 0.5 kD may be readily synthesised and administered and are less likely to be immunogenic, but may not possess the required procoagulant activity. Nevertheless, peptides, peptide derivatives and dual peptides of less than 0.5 kD and greater than 3.5 kD are encompassed by the invention if they possess the appropriate activity.

The peptides and peptide derivatives of the first and second aspects of the invention and the dual peptide of the third aspect of the invention possess procoagulant activity.

By "procoagulant activity" we mean the ability to promote thrombin generation and/or fibrin deposition in a suitable test system.

It will be appreciated that different assays are available to determine procoagulant activity. Indeed, there are different types of procoagulant activity. Peptides and peptide derivatives may promote coagulation in plasma depleted of FV, FVII, FVIII, FX or FXI. In a preferred embodiment, a peptide or peptide derivative of the invention promotes thrombin generation and/or fibrin deposition in plasma in which FVIII is depleted or absent. This type of activity is referred to as coagulation FVIII activity. Where the plasma is from an individual lacking FVIII, the activity is typically referred to as FVIII equivalent activity. Where the plasma contains inhibitors against FVIII, the activity is typically referred to as FVIII inhibitor bypassing equivalent activity. Other procoagulant activities include FV activity, FVII activity, FX activity and FXI activity.

Individual peptides and peptide derivatives may vary in their relative efficacy between different types of assay. Therefore, even if a peptide or peptide derivative appears to have a low efficacy in a particular assay, it may nevertheless possess a suitably high level of procoagulant activity in another assay.

A suitable assay to determine procoagulant activity is the Defined Intrinsic Thrombin Generation Assay described below. In this assay, a compound is considered to have procoagulant activity if, at a concentration of 25, 50 or 100 μM it can stimulate the generation of 5 nM thrombin in 60 minutes, and preferably in 50, 40, 30, 20 or 10 minutes. Preferably, it can stimulate generation of 10 nM thrombin in 60 minutes, and more preferably in 50, 40, 30, 20 or 10 minutes. An alternative assay is the Defined Dual-Pathway Thrombin Generation Assay described below. In this assay, a compound is considered to have procoagulant activity if, at a concentration of 25, 50 or 100 μM it can stimulate the generation of 5 nM thrombin in 70 minutes, and preferably 60, 50, 40, 30 or 20 minutes. Preferably, it can stimulate generation of 10 nM thrombin in 70 minutes, and more preferably 60, 50, 40, 30 or 20 minutes. The above assays are particularly useful for determining coagulation FVIII activity because they are conducted in the presence of FVIII-depleted or inhibited plasma. However, they can be readily adapted to test for other types of procoagulant activity by substituting a suitable depleted or inhibited plasma for FVIII-depleted or inhibited plasma.

Suitably, the procoagulant activity is a thrombin generation time of 25, 50 or 100 μM of compound in a Defined Intrinsic Thrombin Generation Assay equivalent to that of at least 100 mU/mL Factor Eight Inhibitor Bypassing Activity (FEIBA), preferably at least 300 mU/mL FEIBA, more preferably at least 600 mU/mL FEIBA and most preferably at least 1200 mU/mL FEIBA. Thrombin generation time or peak time is the time interval from the addition of the pre-warmed plasma to the other components in the assay described below, to the time of the thrombin peak maximum.

Alternatively, the procoagulant activity is a thrombin peak maximum of 25, 50 or 100 μM of compound in a Defined Dual-Pathway Thrombin Generation Assay (DDPTGA) equivalent to at least 1 mU/mL Factor Eight Inhibitor Bypassing Activity (FEIBA), preferably at least 5 mU/mL FEIBA, most preferably at least 10

mU/mL FEIBA. Thrombin peak maximum, also referred to as Peak IIa is the maximal thrombin concentration generated during the assay. The Defined Dual-Pathway Thrombin Generation Assay can be used to determine coagulation activities other than FVIII activity if suitable factor depleted plasma is substituted for FVIII deficient or inhibited plasma. A peptide, peptide derivative or dual peptide of the invention is considered to have FV, FVII, FX or FXI activity if, at a concentration of 25, 50 or 100 μM, it can stimulate the generation of more thrombin in a DDPTGA using FV, FVII, FX or FXI deficient plasma respectively over 120 minutes than is stimulated in the absence of peptide.

Suitably, the procoagulant activity is a thrombin generation time of 25, 50 or 100 μM of compound in a Defined Intrinsic Thrombin Generation Assay peaking within 30 minutes, preferably within 15 minutes and most preferably within 10 minutes. [0]Alternatively, the procoagulant activity is a thrombin generation time of 25, 50 or 100 μM of compound in a Defined Dual-Pathway Thrombin Generation Assay peaking within 50 minutes, preferably within 45 minutes and most preferably within 30 minutes.

The effect of a peptide or peptide derivative or dual peptide on thrombin generation may be determined in FVIII immuno inhibited, FVIII immuno depleted, FVIII inhibitor patient or hemophilia A patient plasma or other types of coagulation factor deficient plasmas, for example by continuously monitoring the slow cleavage of the thrombin-specific fluorogenic substrate I-1140 (Bachem) in a black 96-well micro plate (Cliniplate, Thermo Labsystems) as described below. Parameters that can usefully be measured in thrombin generation assays to determine the effect of the peptide or peptide derivative are thrombin concentration at peak time; thrombin generation time at peak thrombin; slope of propagation phase of thrombin generation curve and lag time of thrombin generation (initiation phase).

The intrinsic pathway of thrombin generation may be assayed in a thrombin generation assay by including FXIa and phospholipids. In such an assay, which is similar to an activated partial thromboplastin time (aPTT) test, thrombin generation is solely directed through the intrinsic pathway, and is FVIII dependent. A suitable assay is the Defined Intrinsic Thrombin Generation Assay described below. Alternatively, by employing low concentrations of TF and

phospholipids instead of FXIa and phospholipids, thrombin is generated by both the extrinsic (tissue factor) and the intrinsic pathways. This form of the thrombin generation assay is the more physiologic one, as both thrombin generation pathways are involved; it is partially FVIII dependent. A suitable assay is the Defined Dual-Pathway Thrombin Generation Assay.

The Defined Intrinsic Thrombin Generation Assay is performed as follows. FVIII activity of human plasma is inhibited by incubating (2 hours, 37°C) 40µl of human normal plasma with 10µl heat inactivated anti-human FVIII plasma raised in goat (600 BU/ml, 6 hours incubated at 56°C). A 15µl mix of FXIa (16.67nM) (Enzyme Research Laboratories) and phospholipids (Phosphatidylcholine / Phosphatidyl-serine 60% / 40%, 120µM) (Avanti Polar Lipids), 15µl mix of 3.33mM I-1140 and 50mM $CaCl_2$ and 10µl peptide solution (different concentrations) are added to 10µl 2x HNa/HSA5 (50mM Hepes, 350mM NaCl, pH7.35, 10mg/ml HSA). After six minutes incubation at 37°C, thrombin generation is started by the addition of 50µl pre-warmed (37°C) FVIII-inhibited plasma. Instead of FVIII-inhibited plasma, FVIII inhibitor patient plasma or several depleted plasmas can be used. The micro-plate is immediately put into a GENios Plus (Tecan) or Safire 2 (Tecan) fluorescence reader and the fluorescence signal (ex 340nm / em 440nM) is followed kinetically by reading the plate every 21 seconds. By deviating the original fluorescence data the amount of generated thrombin is calculated from a standard curve constructed using a concentration range of thrombin.

For calculation of activity equivalent units experiments are performed with dilutions of Factor Eight Inhibitor Bypassing Agent (FEIBA, Baxter AG), Immunate (human FVIII, purified plasma derived) reference standard (Baxter AG) or Recombinate standard (human FVIII, purified recombinant, Baxter AG). A linear fit of the logarithm of FEIBA (FVIII) concentration plotted against thrombin generation time at peak thrombin results in a standard curve. With this curve FEIBA (FVIII) equivalent activity is calculated for a defined peptide concentration.

Where a peptide concentration is given herein, it is to be understood that it is not the concentration of peptide in the final assay volume, but a concentration as corrected for plasma volume. The concentration in the final assay volume is the corrected concentration divided by 2.5. Thus, where a concentration of 100 µM is given, the actual concentration in the final assay volume in 40 µM. Similarly, the

FEIBA equivalent activity is also corrected for plasma volume. Thus, if it is stated that at 100 µM a peptide has an activity equivalent to 100 mU/ml FEIBA in the DITGA, the concentration of peptide in the final assay volume is 40 µM and the equivalent concentration of FEIBA in the control assay is 40 mU/ml FEIBA.

The Defined Dual-Pathway Thrombin Generation Assay is performed as described below, using a commercial test kit (Technothrombin TGA, Technoclone GmbH, Vienna, Austria). Briefly, a mix of 40µl 1.25mM fluorogenic substrate (Z-GGR-AMC) 18.75mM $CaCl_2$, 10µl TGA reagent B (phospholipid vesicles Phosphatidylcholine / Phosphatidylserine 80% / 20% (3.2µM) containing 17.9pM recombinant human tissue factor; Technoclone GmbH) or 10 µl TGA reagent C high (phospholipid vesicles Phosphatidylcholine / Phosphatidylserine 80% / 20% (32µM) containing 71.6 pM recombinant human tissue factor; Technoclone GmbH) and 10µl peptide dilution, FEIBA reference standard or FVIIa standard dilutions (Enzyme Research Laboratories, South Bend, Indiana USA) are incubated four minutes at 37°C. Preferably, Reagent C high is used. Thrombin generation is started by the addition of 40µl of one of several types of human plasma (37°C). Conversion of the fluorogenic substrate by thrombin is followed by immediately putting the plate into a preheated (37°C) microplate fluorescence reader (Tecan Safire 2, ex 360nm / em 460nm) and kinetically reading the plate every 30 seconds. By deviating the original fluorescence data the amount of generated thrombin is calculated from a standard curve constructed using a concentration range of thrombin. Non linear regression analysis of factor VIIa or FEIBA concentrations plotted against the thrombin at peak of the thrombin generation curve or time to peak thrombin results in standard curves. With these curves, factor VIIa or FEIBA equivalent activity can be calculated for a defined peptide concentration. As described in relation to DITGA, where a peptide concentration is given herein in relation to the DDPTGA, it is to be understood that it is not the concentration of peptide in the final assay volume, but a concentration as corrected for plasma volume. The concentration in the final assay volume is the corrected concentration divided by 2.5. FEIBA equivalent activity is also corrected for plasma volume by applying the same correction factor.

Another suitable assay to determine procoagulant activity, and particularly FVIII equivalent activity or FVIII inhibitor bypassing activity, is the Defined Fibrin

Deposition Assay as described below. Suitably, the procoagulant activity of a sample of 25 μM test compound in the Defined Fibrin Deposition Assay is equivalent to at least 30 mU/mL Factor Eight Inhibitor Bypassing Activity (FEIBA), preferably at least 80 mU/mL FEIBA, most preferably at least 200 mU/mL FEIBA. This assay is particularly useful for determining coagulation FVIII activity because it is conducted in the presence of FVIII-depleted or inhibited plasma.

The Defined Fibrin Deposition Assay is performed as follows. FVIII activity of human citrated plasma (Baxter AG) is first inhibited by incubating (2 hours, 37°C) 100μl of human normal plasma with 25μl heat inactivated anti-human FVIII plasma (300 BU/ml, 6 hours incubated at 56°C) raised in goat. For each sample to be tested, 125μl of this FVIII-inhibited human normal plasma is transferred to a pre-warmed cuvette and a 75μl dilution of a test compound or FEIBA reference standard (Baxter AG) is added. The dilutions of test compound or FEIBA reference standard contain 50mM imidazole, 100mM NaCl and 10mg/ml human serum albumin (Sigma) pH 7.4. As a trigger and for providing procoagulant surfaces 100μl of a mix of human factor XIa (3.13nM, Enzyme Research Laboratories) and phospholipid (PL) vesicles (Phosphatidylcholine / Phosphatidylserine 60% / 40%, 30μM; Avanti Polar Lipids) in 50mM Imidazole, 100mM NaCl, 10mg/ml human serum albumin (Sigma) pH 7.4 is included. After incubating for three minutes at 37°C the coagulation reaction is started by adding 100μl of 25mM $CaCl_2$. Clot formation is monitored by a coagulometer (KC10A, Amelung, Germany). In brief, each cuvette rotates slowly above the magnetic detection device and contains a small magnetic metallic ball. Whilst the plasma components remain in solution, the ball sits at the bottom of the cuvette. Over time, a clot begins to form, such that the ball starts to rotate with the developing clot in the rotating cuvette. The "clotting time" is recorded and is defined as the time from addition of the $CaCl_2$ to the time that the developing clot begins to rotate the metallic ball. A standard curve for FEIBA reference standard dilutions is calculated by linear regression of logarithmic FEIBA concentrations (x-axis) against the clotting time (y-axis). Based on the clotting time of each compound concentration FEIBA equivalent activities are calculated according to this standard curve.

Where a peptide concentration is given herein in relation to the Defined Fibrin Deposition Assay, it is to be understood that it is not the concentration of peptide

in the final assay volume, but a concentration as corrected for plasma volume. The concentration in the final assay volume is the corrected concentration divided by 4. Thus, where a concentration of 100 µM is given, the actual concentration in the final assay volume in 25 µM. Similarly, the FEIBA equivalent activity is also corrected for plasma volume. Thus, if it is stated that at 100 µM a peptide has an activity equivalent to 100 mU/ml FEIBA in the Defined Fibrin Deposition Assay, the concentration of peptide in the final assay volume is 25 µM and the equivalent concentration of FEIBA in the control assay is 25 mU/ml FEIBA.

Preferably, the peptides and peptide derivatives of the first and second aspects of the invention and the dual peptide of the third aspect of the invention can at least partially compensate for the absence of biologically active FVIII when administered in an animal model of severe human hemophilia A. For example, they may be active in controlling bleeding in FVIII deficient mice, such as the strains described in detail by Bi *et al* (Nat Genet. 1995;10:119-21), in which exon 17 or exon 16 of FVIII is disrupted. The exon 16 FVIII-/- mice are available from Jackson Laboratory, 600 Main Street, Bar Harbor, Maine 04609 USA (strain name: B6;129S4-*F8*^{tm1Kaz}/J).

A suitable assay to test the ability of a compound to control bleeding is the tail clip assay. Peptides, peptide derivatives or dual peptides are administered to mice in a suitable vehicle, typically i.v., i.p. or s.c. Different doses of each peptide or peptide derivative may be administered to different groups of mice to determine dose-dependency. Groups of mice, typically 8 - 16 male and female exon 17 FVIII knockout mice with severe hemorrhagic diathesis, receive a single i.v. (tail vein), i.p. or s.c. bolus injection (10 ml/kg body weight). Two minutes before tail clip, animals are anesthetized by an i.p. application of 100 mg/kg ketamine and 5 mg/kg xylazine. Five minutes after i.v. and 60 minutes after i.p. or s.c. peptide or peptide derivative administration 0.5 cm of the tail tip is ablated. Blood dropping from the wound is collected in tubes containing 5.0 ml 0.04 % NH_3 for defined time periods, such as 0-2 minutes, 2-4 minutes, 4-6 minutes, 6-8, 8-10, 10-12, 12-14, 14-16, 16-20, 20-24, 24-28, 28-32, 32-42, 42-52 and 52-62 minutes. Blood cells in each tube are disrupted and hemoglobin is extracted by a three hour incubation period at room temperature followed by ultrasound treatment. The absorbance at 414 nm and 620 nm of the extracts is determined in micro titre plates. 620 nm is a reference wavelength and the A_{620} reading is subtracted from

the A_{414} reading. The amount of blood in the extract corresponding to the subtracted reading is calculated from a standard curve created by known amounts of blood from wild type control mice, such as C57/Bl6 mice. Parameters of the bleeding characteristics of the mice to be recorded are total blood loss, bleeding rate, bleeding time, 1h, 2h, 3h, 4h, 24h and 48h survival. Cumulative blood loss is calculated by summing up the amounts of blood for each time period. Data for the animals of a group are averaged and plotted against bleeding time. At each time point data sets for treatment and vehicle control groups are analysed by Student's t-test for statistical significance.

Preferably, mice administered the peptide, peptide derivative or dual peptide have a blood loss in the tail clip assay at 62 minutes from tail clip of no more than 70% of the blood loss of mice administered the vehicle alone, more preferably no more than 60% and most preferably no more than 50% of the blood loss of mice administered the vehicle alone.

Preferably, survival of mice administered the peptide, peptide derivative or dual peptide in the above assay is at least 40%, more preferably at least 60% and most preferably at least 80% at 2 hours after tail clip. Preferably, survival of mice administered the peptide or peptide derivative in the tail clip assay is at least 20%, more preferably at least 30% and most preferably at least 40% at 24 hours after tail clip.

Preferably, the peptide or peptide derivative of the first and second aspects of the invention or the dual peptide of the third aspect of the invention has a stability in human plasma at 30 minutes of at least 50%, preferably at least 70%, more preferably at least 80% and most preferably at least 90%. A suitable assay to determine stability in human plasma is described in the Examples.

Preferably, the peptide or peptide derivative of the first and second aspects of the invention or the dual peptide of the third aspect of the invention has an aqueous solubility in phosphate buffered saline pH 7.4 at 25 °C of at least 25 μM, preferably at least 60 μM and most preferably at least 100 μM. A suitable assay to determine aqueous solubility in phosphate buffered saline pH 7.4 at 25 °C is described in the Examples.

Herein, the term "Factor VIII" or "FVIII" refers to any FVIII moiety which exhibits biological activity that is associated with native FVIII. The sequence of FVIII can be found as NCBI Accession Number NP_000123 or UniProtKB/Swiss-Prot entry P00451.

As used herein, "plasma-derived FVIII" includes all forms of the protein found in blood obtained from a mammal having the property of activating the coagulation pathway.

As used herein, "rFVIII" denotes FVIII obtained via recombinant DNA technology.

A fourth aspect of the invention provides a pharmaceutical composition comprising the peptide or peptide derivative of the first or second aspects of the invention or the dual peptide of the third aspect of the invention. Peptides, peptide derivatives and dual peptides may be in the form of pharmaceutically acceptable salts, solvates or hydrates. Suitably, the pharmaceutical composition comprises a pharmaceutically acceptable carrier. The carrier may be preferably a liquid formulation, and is preferably a buffered, isotonic, aqueous solution. Suitably, the pharmaceutical composition has a pH that is physiologic, or close to physiologic. Suitably it is of physiologic or close to physiologic osmolarity and salinity. It may contain sodium chloride and/or sodium acetate. The peptides, peptide derivatives and dual peptides of the invention can be made without significant pyrogenicity that might occur in production of biological treatments. This can be important, especially for intravenous formulations where only low levels of endotoxin can be tolerated. It is preferred that subcutaneous, intraperitoneal, buccal, intravenous and other parenteral formulations are sterile and endotoxin free.

Pharmaceutically acceptable carriers may also include excipients, such as diluents, and the like, and additives, such as stabilizing agents, preservatives, solubilizing agents, and the like. The peptides of this invention may be also in the form of any pharmaceutically acceptable salt.

As used herein, the term "pharmaceutically acceptable" means approved by a regulatory agency of US or EU or other government or listed in the U.S. Pharmacopeia or other generally recognized pharmacopeia for use in humans.

The composition can be also for example a suspension, emulsion, sustained release formulation, cream, gel or powder. The composition can be formulated as a suppository, with traditional binders and carriers such as triglycerides.

Though intravenous delivery of the peptides, peptide derivatives and dual peptides of the present invention may be possible a non-intravenous route is preferred, particularly subcutaneous, nasal, buccal, oral or pulmonary delivery. Intraperitoneal (i.p.) delivery may also be used.

Pharmaceutical compositions may additionally comprise, for example, one or more of water, buffers (*e.g.*, neutral buffered saline or phosphate buffered saline), ethanol, mineral oil, vegetable oil, dimethylsulfoxide, carbohydrates (*e.g.*, glucose, mannose, sucrose or dextrans), mannitol, proteins, adjuvants, polypeptides or amino acids such as glycine, antioxidants, chelating agents such as EDTA or glutathione and/or preservatives. Furthermore, one or more other active ingredients may (but need not) be included in the pharmaceutical compositions provided herein.

Pharmaceutical compositions may be formulated for any appropriate manner of administration, including, for example, topical (*e.g.*, transdermal or ocular), oral, buccal, nasal, vaginal, rectal or parenteral administration. The term parenteral as used herein includes subcutaneous, intradermal, intravascular (*e.g.*, intravenous), intramuscular, spinal, intracranial, intrathecal, intraocular, periocular, intraorbital, intrasynovial and intraperitoneal injection, as well as any similar injection or infusion technique. Forms suitable for oral use include, for example, tablets, troches, lozenges, aqueous or oily suspensions, dispersible powders or granules, emulsion, hard or soft capsules, or syrups or elixirs. Compositions provided herein may be formulated as a lyophilizate.

Aqueous suspensions contain the active ingredient(s) in admixture with excipients suitable for the manufacture of aqueous suspensions. Such excipients include suspending agents (*e.g.*, sodium carboxymethylcellulose, methylcellulose, hydropropylmethylcellulose, sodium alginate, polyvinyl-pyrrolidone, gum tragacanth and gum acacia); and dispersing or wetting agents (*e.g.*, naturally-occurring phosphatides such as lecithin, condensation products of

an alkylene oxide with fatty acids such as polyoxyethylene stearate, condensation products of ethylene oxide with long chain aliphatic alcohols such as heptadecaethyleneoxycetanol, condensation products of ethylene oxide with partial esters derived from fatty acids and a hexitol such as polyoxyethylene sorbitol monooleate, or condensation products of ethylene oxide with partial esters derived from fatty acids and hexitol anhydrides such as polyethylene sorbitan monooleate). Aqueous suspensions may also comprise one or more preservatives, for example ethyl, or n-propyl p-hydroxybenzoate, one or more coloring agents, one or more flavoring agents, and one or more sweetening agents, such as sucrose or saccharin.

Peptides or peptide derivatives may be formulated for local or topical administration, such as for topical application to the skin, wounds or mucous membranes, such as in the eye. Formulations for topical administration typically comprise a topical vehicle combined with active agent(s), with or without additional optional components. Suitable topical vehicles and additional components are well known in the art, and it will be apparent that the choice of a vehicle will depend on the particular physical form and mode of delivery. Topical vehicles include water; organic solvents such as alcohols (*e.g.*, ethanol or isopropyl alcohol) or glycerin; glycols (*e.g.*, butylene, isoprene or propylene glycol); aliphatic alcohols (*e.g.*, lanolin); mixtures of water and organic solvents and mixtures of organic solvents such as alcohol and glycerin; lipid-based materials such as fatty acids, acylglycerols (including oils, such as mineral oil, and fats of natural or synthetic origin), phosphoglycerides, sphingolipids and waxes; protein-based materials such as collagen and gelatin; silicone-based materials (both non-volatile and volatile); and hydrocarbon-based materials such as microsponges and polymer matrices. A composition may further include one or more components adapted to improve the stability or effectiveness of the applied formulation, such as stabilizing agents, suspending agents, emulsifying agents, viscosity adjusters, gelling agents, preservatives, antioxidants, skin penetration enhancers, moisturizers and sustained release materials. Examples of such components are described in Martindale - The Extra Pharmacopoeia (Pharmaceutical Press, London 1993) and Martin (ed.), Remington's Pharmaceutical Sciences. Formulations may comprise microcapsules, such as hydroxymethylcellulose or gelatin-microcapsules, liposomes, albumin microspheres, microemulsions, nanoparticles or nanocapsules.

A pharmaceutical composition may be formulated as inhaled formulations, including sprays, mists, or aerosols. For inhalation formulations, the compounds provided herein may be delivered via any inhalation methods known to those skilled in the art. Such inhalation methods and devices include, but are not limited to, metered dose inhalers with propellants such as CFC or HFA or propellants that are physiologically and environmentally acceptable. Other suitable devices are breath operated inhalers, multidose dry powder inhalers and aerosol nebulizers. Aerosol formulations for use in the subject method typically include propellants, surfactants and co-solvents and may be filled into conventional aerosol containers that are closed by a suitable metering valve.

Inhalant compositions may comprise liquid or powdered compositions containing the active ingredient that are suitable for nebulization and intrabronchial use, or aerosol compositions administered via an aerosol unit dispensing metered doses. Suitable liquid compositions comprise the active ingredient in an aqueous, pharmaceutically acceptable inhalant solvent, *e.g.*, isotonic saline or bacteriostatic water. The solutions are administered by means of a pump or squeeze-actuated nebulized spray dispenser, or by any other conventional means for causing or enabling the requisite dosage amount of the liquid composition to be inhaled into the patient's lungs. Suitable formulations, wherein the carrier is a liquid, for administration, as for example, a nasal spray or as nasal drops, include aqueous or oily solutions of the active ingredient.

Formulations or compositions suitable for nasal administration, wherein the carrier is a solid, include a coarse powder having a particle size, for example, in the range of 20 to 500 microns which is administered in the manner in which snuff is administered (*i.e.,* by rapid inhalation through the nasal passage from a container of the powder held close up to the nose). Suitable powder compositions include, by way of illustration, powdered preparations of the active ingredient thoroughly intermixed with lactose or other inert powders acceptable for intrabronchial administration. The powder compositions can be administered via an aerosol dispenser or encased in a breakable capsule which may be inserted by the patient into a device that punctures the capsule and blows the powder out in a steady stream suitable for inhalation.

Pharmaceutical compositions may be formulated as sustained release formulations (*i.e.*, a formulation such as a capsule that effects a slow release of modulator following administration). Such formulations may generally be prepared using well known technology and administered by, for example, oral, rectal or subcutaneous implantation, or by implantation at the desired target site. Carriers for use within such formulations are biocompatible, and may also be biodegradable; preferably the formulation provides a relatively constant level of modulator release. The amount of modulator contained within a sustained release formulation depends upon, for example, the site of implantation, the rate and expected duration of release and the nature of the condition to be treated or prevented.

Pharmaceutical compositions may be formulated with an agent to improve bioavailability, such an as organic solvent. For example, Cremophor EL® (Product No. 00647/1/63; BASF Aktiengesellschaft, Germany) is a polyethoxylated castor oil which is prepared by reacting 35 moles of ethylene oxide with each mole of castor oil. It may be used to stabilise emulsions of non-polar materials in aqueous systems. Alternatively, peptide, peptide derivative or dual peptide may be incorporated within or bound to a proteinaceous micro or nano-particle for improved bioavailability. Suitable micro- and nano-particles are described in US 5,439,686 (Desai et al; Vivorx Pharmaceuticals, Inc., CA) and US 5,498,421 (Grinstaff et al; Vivorx Pharmaceuticals, Inc., CA). Suitably, the proteinaceous nano-particle comprises human serum albumin, particularly human serum albumin or a recombinant form thereof. WO 2007/077561 (Gabbai; Do-Coop Technologies Ltd., Israel) describe another suitable carrier comprising nanostructures and a liquid, referred to therein as Neowater™.

For oral and parenteral administration to patients, including human patients, the daily dosage level of the peptide, peptide derivative or dual peptide of the invention will usually be from 2 to 2000 mg per adult (*i.e.* from about 0.03 to 30 mg/kg), administered in single or divided doses.

Thus, for example, the tablets or capsules of the peptide, peptide derivative or dual peptide of the invention may contain from 2 mg to 2000 mg of active compound for administration singly or two or more at a time, as appropriate. The physician in any event will determine the actual dosage which will be most

suitable for any individual patient and it will vary with the age, weight and response of the particular patient. The above dosages are exemplary of the average case. There can, of course, be individual instances where higher or lower dosage ranges are merited and such are within the scope of this invention.

For veterinary use, a peptide, peptide derivative or dual peptide of the invention is administered as a suitably acceptable formulation in accordance with normal veterinary practice and the veterinary surgeon will determine the dosing regimen and route of administration which will be most appropriate for a particular animal.

The peptides, peptide derivatives and dual peptides disclosed herein can be used for medical applications and animal husbandry or veterinary applications. Typically, the product is used in humans. The term "patient" is intended to denote a mammalian individual, and is so used throughout the specification and in the claims.

A fifth aspect of the invention provides a peptide or peptide derivative of the first or second aspects or a dual peptide of the third aspect of the invention for treating a patient having a deficiency in FV, FVII, FVIII, FX and/or FXI.

A sixth aspect of the invention provides a use of a peptide or peptide derivative of the first or second aspects or a dual peptide of the third aspect of the invention in the manufacture of a medicament for the treatment of a deficiency in FV, FVII, FVIII, FX and/or FXI in a patient.

An seventh aspect of the invention provides a method of treating a patient having a deficiency in FV, FVII, FVIII, FX and/or FXI comprising administering a therapeutically effective amount of the pharmaceutical composition of the fourth aspect.

The peptides, peptide derivatives and dual peptides of the present invention can be used for the treatment of a deficiency in FV, FVII, FVIII, FX and/or FXI for both the prophylaxis and for treatment of acute bleeds. Patients with FVIII deficiency (hemophilia A) often develop inhibitor antibodies to FVIII. Inhibitor development (to FIX) is also known in FIX deficiency (hemophilia B). Since FV, FVII, FXI and FX deficiencies are very rare congenital disorders little is known about inhibitor

development, although it is feasible that patients having such disorders might develop inhibitors. Treatment of inhibitor patients is a preferred embodiment of the fifth, sixth and seventh aspects. Such inhibitor patients may have either a high titer response of greater than 5BU or a low titer response of between 0.5 and 5 BU. Typically, the inhibitors are directed against FVIII and the patients have hemophilia A.

The magnitude of the antibody response to FVIII can be quantified using a functional inhibitor assay, such as that described in [0]Kasper CK et al (1975) Proceedings: A more uniform measurement of factor VIII inhibitors. Thromb Diath Haemorrh. 34(2):612. FXI inhibitors could be quantified by an aPTT assay as described by Kasper. Inhibitors of FV, FVII and FX could be quantified by a PT based assay following the procedure of Kasper.

A peptide or peptide derivative according to the eighth, ninth or tenth aspects of the invention is not FVIII or a fragment thereof. Typically, it does not consist of or comprise the amino acid sequence of any FVIII protein, whether of human, mammalian or vertebrate origin. Neither does it consist of a fragment of a FVIII protein. Typically, it comprises fewer than 50, fewer than 20, fewer than 10, fewer than 5 contiguous amino acids of a FVIII protein, such as a human FVIII protein. Preferred peptides and peptide derivatives are the peptides and peptide derivatives of the first and second aspects of the invention, or the dual peptides of the third aspect of the invention. Alternative peptides and peptide derivative may be synthesised and tested for procoagulant activity as described in relation to the exemplified peptides and peptide derivatives.

Peptides and peptide derivatives of the eighth, ninth or tenth aspects of the invention may be formulated as pharmaceutical compositions, as described above, and may be used in medicine as described above.

The present invention will be further illustrated in the following examples, without any limitation thereto.

Example 1: Synthesis and identification of compounds with thrombin generating activity

Compounds were screened using the "Defined intrinsic thrombin generation assay" in which thrombin generation was quantified *in vitro* in FVIII-inhibited human plasma in the presence of Factor XIa and phospholipid vesicles. Further compounds were screened in the above assay, and in the "Defined dual-pathway thrombin generation assay" using tissue factor and phospholipids instead of Factor XIa and phospholipids, as described in the specific description.

The compounds, which are peptides and peptide derivatives, were synthesised by classical solid phase peptide synthesis or SPOT-Synthesis at 50-100 nmol peptide per spot, which allows positionally addressable, chemical synthesis of peptides on continuous cellulose membranes. Peptides were dissolved in either 10% or 50% DMSO in water.

PEGylation of peptides and peptide derivatives was carried out as follows. PEG5000 NHS-ester was coupled to the N-terminus of the HPLC-purified peptides in solution. If lysine was present in the peptide sequence, this amino acid was protected with the ivDde protecting group in order to avoid PEGylation at the ε-amino group. After coupling of the PEG5000 to the N-terminus, the ivDde protecting group was cleaved off by 3% hydrazine hydrate in dimethyl formamide followed by repurification of the final product by HPLC.

Compounds deemed to promote thrombin generation were identified, as indicated in Tables 7 and 8 below.

Table 7: Compounds based on A01

	Peptide	**Sequence**
SEQ ID NO: 2	A01	Ac-RMKFDVWDLYFEIVW-NH_2
SEQ ID NO: 2	A02	Ac-PMKFDVWDLYFEIVW-NH_2
SEQ ID NO: 2	A03	Ac-RMDFDVWDLYFEIVW-NH_2
SEQ ID NO: 2	A04	Ac-RMEFDVWDLYFEIVW-NH_2
SEQ ID NO: 1	A05	Ac-WDLYFEIVW-NH_2
SEQ ID NO: 3	A06	Ac-WDLYFEIVWE

	Peptide	Sequence	
SEQ ID NO: 1	A07	Ac-WDLYFEIVW-O-E	
SEQ ID NO: 2	A08	O-RMEFDVWDLYFEIVW-O-NH_2	
SEQ ID NO: 4	A09	ERMEFDVWDLYFEIVW-NH_2	
SEQ ID NO: 34	A10	EPMKFDVWDLYFEIVW-NH_2	
SEQ ID NO: 2	A11	O-RMDFDVWDLYFEIVW-O-NH_2	
SEQ ID NO: 5	A12	ERXEFDVWDLYFEIVW-NH_2	X is Nva
	A13	O-RMEFDVWDLYXEIVW-O-NH_2	X is Phg
SEQ ID NO: 6	A14	Ac-WSLYFEIVWE	
SEQ ID NO: 1	A15	Ac-WDLYFEISW-O-E	
SEQ ID NO: 2	A16	PEG5000-RMKFDVWDLYFEIVW-NH_2	
SEQ ID NO: 6	A17	PEG5000-WSLYFEIVWE	
SEQ ID NO: 4	A18	PEG5000-ERMEFDVWDLYFEIVW-NH_2	
SEQ ID NO: 7	A19	Ac-VWDLYFEIVW-NH_2	
SEQ ID NO: 1	A20	Ac-WDLYFEIVW-O-K	

In the above table, O- is 4,7,10-trioxa-1,13-tridecanediamine (ttds)

Table 8: Compounds based on B01

Peptide	Sequence
B01	Ac-(cimfwydc)-ye-NH_2
B02	Ac-(cymfwydc)-ye-NH_2
B03	Ac-cimfwydeye-NH_2
B04	Disulphide-Dimer(Ac-cimfwydeye-NH_2)$_2$
B05	Ac-O-(cymfwydc)-ye-NH_2
B06	K-O-(cymfwydc)-ye-NH_2
B07	Ac-simfwydeye-NH_2

In the above table, -O- is 4,7,10-trioxa-1,13-tridecanediamine (ttds). The actual peptides used in this study, designated B01, B02, B05 and B06, were cyclic.

Example 2: Testing of compounds in Intrinsic and Dual-Pathway Thrombin generation assays

Various concentrations of each peptide were tested in the defined intrinsic thrombin generation assay using human FVIII inhibited plasma. Results are given in the table below.

Table 9: Activity of peptide compounds in the defined intrinsic thrombin generation assay (triggered by FXIa). Thrombin peak time is given as FEIBA equivalent activity (mU/ml) calculated based on a FEIBA standard calibration curve.

Compound	Concentration (μM)					
	200	**100**	**50**	**25**	**12.5**	**6.25**
A01		338	227	160	138	97
A03		1396	1069	762	639	477
A05		816	631	562	487	390
A19		826	663	525	495	383
B01		103	89	62	35	
A02		1305	1018	780	674	577
B03		1394	1030	738	602	454
B05	1089	649	270	152	126	
B06	902	378	172	157	95	
A06		879	919	843	750	571
A20		1101	873	597	501	391
A07		1129	965	750	585	415
A08		1213	958	764	656	563
A09		1365	1170	896	742	600

An *in vitro* thrombin generation assay based on the cleavage of Z-GGR-AMC to release the fluorophore AMC was developed using normal human plasma, i.e. the Defined Dual-Pathway Thrombin Generation Assay. Tissue factor dependency of peak thrombin generation and thrombin peak time was characterised in a composition containing a fixed concentration of phospholipid (namely 3.2 μM). Phospholipid dependency was characterised in a composition containing a fixed concentration of tissue factor (namely 7.2 pM). Peak time (time to peak thrombin generation) was dependent on the concentration of phospholipid or tissue factor. The final version of this assay is as described in the specific description, in which 10 μl reagent C high containing (32 μM phospholipid and 71.6 pM tissue factor) is used in a total volume of 100 μl.

Further studies were conducted using 3.2 μM phospholipid and 7.2 pM tissue factor in FVIII deficient or inhibited plasma, to characterise the effect on peak thrombin generation and thrombin peak time of various coagulation factor preparations. These studies provided a basis from which to compare the efficacy of the compounds in the assay. Briefly, rFVIII (Recombinate® FVIII from Baxter) was tested at 0, 5, 10, 20, 40 and 80 mU/ml in FVIII deficient plasma. FEIBA was tested at 0, 8, 16, 31, 63 and 125 mU/ml in FVIII inhibited plasma. FVIIa was tested at 0, 0.1, 0.4, 1.6, 6.3 and 25 nM in FVIII inhibited plasma. Results are shown in Figure 1. For recombinant FVIII (Recombinate®) in FVIII deficient plasma and for both FEIBA and FVIIa in FVIII-immuno inhibited plasma a concentration dependent improvement of thrombin generation parameters is observed. Peak thrombin increased and both the lag time and the thrombin peak time decrease.

The compounds were tested in this Defined Dual-Pathway Thrombin Generation Assay (DDPTGA) using reagent C high (Technoclone) for triggering thrombin generation. Results are given in the table below. Even though this assay is less sensitive for FVIII-like activity than the Defined Intrinsic Thrombin Generation Assay (DITGA), several compounds possessed detectable activity.

Table 10: Summary results

		DDPTGA FVIII inhibited plasma				DDPTGA FVIII deficient plasma	
Peptide	**Conc [μM]**	**Peak Time FEIBA EU (mU/ml)**	**Peak IIa FEIBA EU (mU/ml)**	**Peak Time FVIIa EU (nM)**	**Peak IIa FVIIa EU (nM)**	**Peak Time FVIII EU (mU/ml)**	**Peak IIa FVIII EU (mU/ml)**
A02	50	10.2	BLS	0.4	BLS	BLS	BLS
A03	100	BLS	BLS	BLS	BLS	BLS	BLS
A03	50	BLS	BLS	BLS	BLS	BLS	BLS
A05	100	BLS	BLS	BLS	BLS	BLS	BLS
A05	50	BLS	BLS	BLS	BLS	BLS	BLS
A08	50	9.1	BLS	0.4	BLS	BLS	BLS
A09	50	BLS	8.6	BLS	BLS	27.2	BLS

		DDPTGA FVIII inhibited plasma				DDPTGA FVIII deficient plasma	
Peptide	**Conc [μM]**	**Peak Time FEIBA EU (mU/ml)**	**Peak IIa FEIBA EU (mU/ml)**	**Peak Time FVIIa EU (nM)**	**Peak IIa FVIIa EU (nM)**	**Peak Time FVIII EU (mU/ml)**	**Peak IIa FVIII EU (mU/ml)**
A09	25	7.9	BLS	0.2	BLS	15.6	BLS
A18	100	BLS	BLS	BLS	BLS	17.1	BLS
A18	50	BLS	BLS	BLS	BLS	BLS	BLS
A01	90	BLS	BLS	BLS	BLS	BLS	BLS
A01	50	BLS	BLS	BLS	BLS	BLS	BLS
A16	100	BLS	BLS	BLS	BLS	BLS	BLS
A16	50	BLS	BLS	BLS	BLS	BLS	BLS
B03	100	BLS	12.3	BLS	0.6	7.5	5.3
B03	40	BLS	7.2	BLS	0.2	8.7	4.8
B04	100	BLS	13.3	BLS	0.7	1.6	5.0
B04	40	BLS	12.8	BLS	0.6	7.3	4.8
B04	16	BLS	BLS	BLS	0.1	4.1	4.4
A07	100	BLS	BLS	BLS	0.1	BLS	BLS
A07	50	BLS	BLS	BLS	BLS	BLS	BLS
A15	100	BLS	13.6	BLS	0.7	12.7	5.0
A15	50	BLS	BLS	BLS	BLS	14.4	4.3
A06	100	BLS	BLS	0.4	BLS	BLS	BLS
A06	50	BLS	BLS	BLS	BLS	BLS	BLS
A14	100	BLS	BLS	BLS	BLS	BLS	BLS
A14	50	BLS	BLS	BLS	BLS	BLS	BLS
A17	100	BLS	BLS	0.1	BLS	5.9	BLS
A17	50	BLS	BLS	BLS	BLS	5.1	BLS

"Peak IIa" is the amount of thrombin generated at the peak of the thrombin generation curve. "Peak time" is the time from start of the thrombin generation reaction to when the maximum amount is generated. BLS = below lowest standard.

Thrombin is still generated in this assay even in the absence of added peptide. Thus, where Peak IIa is "BLS" at a particular peptide concentration, there is still a thrombin peak, but it is lower than that achieved by the lowest concentration of standard, which is 5 mU/ml FVIII, 8 mU/ml FEIBA or 0.1 nM FVII. Similarly, when peak time is "BLS", the time to peak thrombin generation is greater than the peak time achieved by the lowest concentration of standard. A peptide can have a significant effect on peak time but not peak IIa, or vice versa. However, it is preferred that a peptide has an effect on both peak time and peak IIa. B03, B04 and A15 positively affected both aspects of thrombin generation. In the case of some peptides, concentration dependency of an effect on thrombin generation was not seen at high peptide concentration, which might be explained by non-specific interactions.

Example 3: Testing of compounds in thrombin generation assays with several depleted plasmas

The *in vitro* thrombin generation assay based on the cleavage of Z-GGR-AMC to release the fluorophore AMC, described in the specific description, i.e. the Defined Dual-Pathway Thrombin Generation Assay was used to characterise the effect of the compounds in several depleted human plasmas. In these experiments, each 100 µl reaction contained 10 µl reagent B, which comprises phospholipid vesicles Phosphatidylcholine / Phosphatidylserine 80% / 20% (3.2µM) and 17.9pM recombinant human tissue factor. 10 µl peptide dilution, 40 µl TGA substrate and 40 µl plasma were used as described in the specific description.

The plasmas used in the experiments were fresh frozen and were deficient in Factor V, Factor VII / VIIa, Factor VIII, Factor X or Factor XI (George King Bio-Medical, Inc.). Residual coagulation factor levels of deficient plasmas were specified as less than 1%.

For each depleted plasma used in the experiments, compounds were tested at two concentrations, namely 50 µM and 80, 90 or 100 µM. A negative control was used, in which no test compound was included. Results are summarised in the table below.

Table 11: Summary results of effect of compounds on thrombin generation in various depleted plasmas

Depleted plasma	Compounds								
	Control	A01	A02	A05	B03	A06	A07	A08	A09
FV	-	-	-	-	-	+	-		-
FVII	-	+	+	+	+	+	+		+
FVIII	-	+	+	+	+	+	+	+	+
FX	-	-	+	+	+	+	+		+
FXI	-	+	+	+	+	+	+		+

Stimulation of thrombin generation: "+" means stimulates; "-" means does not stimulate. In control experiments, no peptide was included.

All depleted plasmas tested showed no or very low thrombin generation in the absence of peptides, indicating that at the tissue factor concentration used the interplay of all coagulation factors is important for thrombin generation. Several peptides stimulated thrombin generation in all zymogen depleted plasmas (FVII, FX or FXI) whereas thrombin generation in FV depleted plasmas is low, indicating that the common pathway is important for peptide stimulated thrombin generation.

Example 4: Activity of compounds in Defined Fibrin Deposition Assay

Various peptides were tested for the ability to stimulate fibrin deposition in the Defined Fibrin Deposition Assay as described in the specific description. Results are shown in the table below.

Table 12: Compound characterization in the Defined Fibrin Deposition Assay

Compound	Concentration (µM)	FEIBA EU (mU/ml)
A01	100	145
A01	50	127
A01	25	80
B01	100	94
B01	50	47
B01	25	31

Compound	Concentration (μM)	FEIBA EU (mU/ml)
A05	50	219
A05	25	193
A05	10	119
B03	25	325
B03	12.5	291
B03	6.3	264
A06	25	168
A06	12.5	232
A06	6.3	251
A07	50	199
A07	25	246
A07	12.5	268

All test compounds shortened the clotting time and fibrin formation of FVIII inhibited plasma. In combination with the thrombin generation experiments this confirms the procoagulant activities of the test compounds. Most compounds acted in a concentration dependent manner, although a small number had reduced activity at higher concentrations, which may be due to non-specific interactions.

Example 5: *In vitro* assays for the characterisation of compounds

Compounds are characterised not only for activity in the thrombin generation assays but also for pharmacokinetics, solubility, HERG inhibition and molecular weight.

Pharmacokinetic (PK) Studies

PK studies are required for the design and interpretation of *in vivo* efficacy studies. Plasma protein binding, plasma stability and microsomal stability are all included in this category.

1. Plasma protein binding

The extent of compound binding to human plasma (Bioreclamation, Hicksville, NY), mouse plasma (Lampire Laboratory, Pipersville, PA) or mouse serum albumin (Sigma, St. Louis, MO), referred to as matrices, was determined in a 96-well micro-equilibrium dialysis block system (HDT-96; HTDialysis, LLC,

Gales Ferry, CT). Briefly, each unit of the system comprises a donor chamber and a receiver chamber separated by a semi-permeable membrane. The principle of the experiment is that proteins (and compound bound to the proteins) are retained in the donor chamber and cannot cross the membrane. Free compound can diffuse between both chambers via the membrane and reaches equilibrium during the experiment. In these experiments, the semi-permeable membrane was made of regenerated cellulose and had a molecular weight cut-off of 12-14 kD (cat. no 1101, HTDialysis, LLC).

A protease inhibitor cocktail (P2714-1BTL), purchased from Sigma, was included in the assay to inhibit proteolysis of test compounds. It was freshly prepared at 50× stock solution in distilled water. Mouse serum albumin was freshly prepared in phosphate buffered saline (PBS) at 40 g/L. The PBS was purchased from Invitrogen (Carlsbad, CA), and it was adjusted to a pH of 7.4 prior to use. Plasmas were used without dilution. The protease inhibitor stock solution was added to each matrix (i.e. mouse serum albumin in PBS) at a final 1× concentration. Stock solutions of each test compound were prepared in DMSO with the control compound, warfarin. Warfarin, which is a high protein-binding compound, was included in each stock solution to ensure the integrity of the membrane during the experiment. An aliquot of the stock solution was added to each matrix to yield a final concentration of 5 μM of the test compound and 10 μM of warfarin. The final concentration of DMSO was 0.72% (v/v). The dilution of the matrices by the addition of the other components was negligible (less than 4%). The membrane strips were hydrated in distilled water for 1 hour; the membrane was soaked in 30% ethanol aqueous solution for 20 minutes, and then the membrane was rinsed twice with distilled water. After the rinse, the membrane was placed in PBS and was ready for use. The assembly of the dialysis block followed the manufacturer's protocol. After the assembly, an aliquot of 150 μl of each matrix / test compound was added to a separate donor chamber and 150 μl of PBS was added to the corresponding receiver chamber on the other side of the membrane. The remainder of each matrix / test compound was stored at -80°C for further analysis. The concentrations of the test compounds and warfarin in these matrices were measured and the values were used in the recovery calculations. The 96-well dialysis block was then placed in an enclosed, heated rocker, which was pre-warmed to 37°C, and allowed to incubate for 6

hours. After the incubation, both sides were sampled. The concentrations of the test compounds, as well as warfarin, were measured by LC/MS/MS analysis.

The recovery and protein binding values were calculated as follows:

% Recovery = [(Conc. in Donor + Conc. in Receiver) / (Measured Conc. in Matrix)] × 100% (1)

% Bound = [(Conc. in Donor – Conc. in Receiver) / (Conc. in Donor)] × 100% (2)

"% Recovery" is a measure of how much of the compound added to the matrix is recoverable from the donor and receiver chambers. Where recovery is less than 100%, a proportion of the compound may have bound to the membrane or the plastic surfaces of the chambers or it may have degraded. "% Bound" is a measure of how much of the compound has bound to the matrix and is therefore unable to equilibrate between donor and receiver chambers.

Results are shown for A01 and warfarin (control) in the tables below.

Table 13: Protein Binding of A01 in Tested Matrices

Matrix	A01 Conc. in Matrix (μM)	Receiver Concentrations (μM)			Donor Concentrations (μM)			Average % Bound	Average % Recovery
		Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3		
Human plasma	1.69	<0.025	<0.025	<0.025	1.47	1.57	1.45	>98.3	>88.6
Mouse plasma	4.48	<0.025	<0.025	<0.025	3.18	3.43	3.24	>99.2	>73.3
Mouse serum albumin	1.42	<0.005	<0.005	<0.005	1.50	1.43	1.47	>99.7	>103

Table 14: Protein Binding of warfarin in Tested Matrices

Matrix	Warfarin Conc. in Matrix (μM)	Receiver Concentrations (μM)			Donor Concentrations (μM)			Average % Bound (StDev)	Average % Recovery (StDev)
		Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3		
Human plasma	9.88	0.0749	0.0765	0.0791	9.86	9.43	9.91	99.2 (0.03)	99.3 (2.68)
Mouse plasma	10.1	0.457	0.403	0.400	8.37	8.72	8.50	95.1 (0.462)	88.6 (1.53)
Mouse serum albumin	9.61	0.365	0.354	0.347	9.78	9.14	8.34	96.1 (0.218)	98.3 (7.60)

2. Plasma stability

Half-life of compounds in human or mouse plasma, or percentage of compound remaining after an incubation in human or mouse plasma, is determined as follows. In the experimental procedure, test compound concentrations are 5 μM, prepared from test compound stock solutions of 10 mM in DMSO. Propantheline is used as a standard. To prepare tests samples, a 1/20 dilution of the test compound stock solution in DMSO is prepared in 50% acetonitrile/50% H_2O, and this is then diluted 1/100 in pre-warmed (37°C) plasma (5 μl compound [1/20 dilution] + 495 μl plasma) in a 1.5 ml Eppendorf-tube. The standard compound 2 mM propantheline is diluted 1/4 in DMSO and subsequently 1/100 in pre-warmed plasma (5 μl compound [1/4 dilution] + 495 μl plasma) in a 1.5 ml Eppendorf-tube. All of the samples are incubated in a water bath at 37°C. 500 μl acetonitrile is added immediately after compounds, or propantheline standard, have been mixed with plasma (designated as t = 0 min). After a chosen duration of incubation (generally at t = 60 min) each sample is mixed with a further 500 μl acetonitrile. The samples are mixed on a vortex mixer for 30 s and placed on ice for 10 min and collected for centrifugation. Samples are centrifuged at 20 000 g for 10 min at 4°C. 500 μl supernatant is transferred into a new 1.5 ml Eppendorf tube and an equal volume of acetonitrile is added. The sample is mixed again for 30 s using a vortex mixer. After a second centrifugation step (20 000 g, 10 min, 4°C) 250 μl of the supernatant is transferred into HPLC glass vials for HPLC-MS analysis. Conditions for performing HPLC are as follows: Injection-volume is set to 20 μl. Temperature is set to 25 °C. A linear gradient from 95:5 to 5:95 water:acetonitrile both containing 0.05% trifluoroacetic acid (TFA) (v/v) is applied at a flow rate of 0.3 ml/min for 10 min. The PDA-detector is scanning from 210-

400 nm. The ion-trap is equipped with an ESI-source with temperature at 280 °C, mass-scanning is done in full scan-mode from 50-2000 amu followed by dynamic exclusion MS^2-experiment with 1.5 V collision energy (105 as min. count of parent ion). Percent-stability is calculated from area-under-curve (AUC) ratio monitoring the protonated molecular-mass ion of the target compound in the total-ion-current (tic) in full-scan mode at 60 min incubation time (or time of choice) vs. 0 min incubation time.

Results are shown in the table below. Decreases in compound concentration over time might be due to proteolytic degradation and/or chemical modification.

Table 15: Plasma stability of compounds

Peptide	% remaining in human plasma (30 min)
A01	58
A19	99
A07	117
A20	95
A06	98
A02	84
A03	92
A08	70
A09	67
B07	89
B06	93
B05	112
A05	93

3. Microsomal stability

Tests were used to determine the stability of compounds in microsomal preparations of human or animal origin. The microsomal stability is measured either in assays provided by Cerep (France, Catalog ref. 900-8h) or by the protocol described below. Compound solutions of 10 mM/5mM (test compound, standards verapamil, imipramine, and terfenadine) are prepared in 100% DMSO. They are diluted by distilled H_2O/MeOH resulting in a final concentration of 1 µM in the assay, with less then 0.4% DMSO (v/v) in the final mixture. The mastermix for the stability assay is prepared in a 10ml Falcontube (total volume 4.4 ml):

3414 µl distilled water, 440µl 500 mM $NaPO_4$-buffer pH 7.4, 440µl NADP (10 mM), 22 µl Glc-6-P (1 M), 17.6 µl Glc-6-P-DH of a 1 U/ml solution, 66 µl liver microsomes (rat or mouse, final concentration in the assay 300µg/ml). The mastermix is preincubated at 37°C for 10 minutes in the water bath. 5µl of 60µM compound solution is added per well in a 96-well-U-Plate (PP- Nunc) together with 300µl of reaction mixture (pre-incubated mastermix). All wells must be carefully mixed to ensure a homogenous suspension before the next steps. 75µl samples (duplicates) at t = 0 minutes are taken for each compound. The plate is sealed and returned to the water bath/thermomixer for 30minutes. The test compounds / standards are extracted by addition of 200 µl methanol, also including an internal standard. The internal standard is "Pep770" (Jerini AG, Berlin, Germany) and is used at a final concentration of 6.25 ng/ml. The samples are centrifuged at 1300 g for 10 min at 4°C. 200 µl of the supernatant is transferred into a 96-well plate with 10 µl DMSO per well. Compound stability is measured by HPLC-MS analysis (triplicates). The same procedure is repeated after 30 min. The ratio of the mean "AUC t=0 min" and "AUC t=30 min" is calculated and the percentage of the amount of remaining compound after 30 min is determined. The signal to noise ratio for all peaks must be 5:1 or better. The ratio $AUC_{analyte}$: $AUC_{standard}$ at the different timepoints must be used. The calculated stability for the control compound must fall in a certain range to validate the assay.

Results are shown in the table below.

Table 16: Stability of compounds in mouse microsomes

Peptide	Stability after 30 min [%], duplicates
A01	27 / 32
A02	44 / 45
A06	51 / 47
A07	39 / 28
A09	22 / 23
Terfenadine	63 / 68

Solubility

Aqueous solubility is measured in PBS at pH 7.4 either in an assay provided by Cerep (France, Catalog ref. 900-11a) or according to the following protocol. The

aim of this procedure is to determine the solubility of a drug candidate (analyte) in a buffer, by estimating the saturation concentration of the candidate in the buffer using HPLC. A known concentration of the candidate in an organic solvent is used as a standard. A stock solution of the test compound in DMSO must be prepared as the initial step. Depending on the maximum solubility of the compound, a concentration of 50 mM in DMSO should be reached. DMSO stock-solutions are diluted to a final concentration of 50 µM with DMSO (100% reference-solution) and buffer (test-solution) to provide a minimum volume of 500 µL of each. Both solutions are shaken at 25°C at 950 rpm in an Eppendorf "thermomixer comfort" for at least 60 min. The suspension is centrifuged at 22 330 g for at least two min and 100 µL of the supernatant is transferred into polypropylene-inserts placed in glass vials and closed by snap-ring caps. Alternatively the solutions can be prepared in microtiter plates with half of the previously described starting solvent volume. For the determination of the solubility all samples are analyzed by HPLC in triplicate. Injection volume is at least 10 µL. The obtained data are analyzed by "Chemstation-software" (Agilent, Waldbronn, Germany). The peaks from the analyses of the organic solutions are integrated and the arithmetic mean is reported as "AUC 1" (reference area of known amount injected at the HPLC). The same procedure is applied to the spectra obtained from the analyses of the buffer solution to give "AUC 2" (area of the unknown amount of compound dissolved in buffer). In general the AUC must be greater then 20 area units and signal to noise (height of the peak) must be better than 3. The ratio of the mean "AUC 2" and "AUC 1" is calculated and thus the percentage of the dissolved amount of compound in buffer is obtained and solubility can be reported in µM.

Results are shown in the table below.

Table 17: Solubility of compounds in PBS

Compound	Solubility in PBS [µM]
A09	63
B03	114
B07	195
B06	48
B05	174

Compound	Solubility in PBS [µM]
A01	9
A08	11
A05	6
A19	14
A07	165
A20	166
A06	164
A02	35
A03	110
A16	> 200

HERG inhibition

QT prolongation is assessed by HERG inhibition measured by patch-clamp techniques or Rb^+ efflux.

The Rb+ efflux method (Cerep, France, Catalog. Ref. 900-36rb) is used for initial screening. For the Rb+ efflux assay, the reference compound (Astemizole) was tested concurrently with the test compounds in order to assess the assay suitability. It was tested at 10µM and the data were compared with historical values determined at Cerep.

For rigorous characterization of HERG inhibition the patch clamp assay is applied (Cerep, France, Catalog ref. 900-36). The general potency ranking system is adopted from Roche *et al.*, 2002, *Chem Bio Chem* 3:455-459. To ensure that no change in the sensitivity of the assay has occurred, separate experiments conducted on the same (clone) batch of cells using 10nM E-4031 (Wako, cat. no.052-06523) yielded results (56.7 ± 1.8% inhibition, Mean ± SEM, n=3) comparable to historically obtained data (58.4 ± 2.0% inhibition, Mean ± SEM, n=3) at Cerep. The test compounds (10 mM stock solutions) were dissolved in dimethylsulfoxide (DMSO). The solutions at 1 µM contained 0.01 % DMSO. Bath solutions containing up to 1 % DMSO have no significant effect on the HERG-encoded tail currents.

Screening of several compounds by the Rb+ efflux method at 10µM indicated no inhibition of HERG channel activity. In the more sensitive patch clamp assay compounds A01, A05 and A16 can be classified as low-potency

HERG-channel blockers whereas B03 was identified as a high potency HERG-channel blocker. Results are provided in the table below.

Table 18: HERG inhibition results

Compound	HERG inhibition patch-clamp (% Inhibition of Tail Current at 1μM)	HERG inhibition Rb+ efflux (% Inhibition at 10μM)
A01	16.5	
A02		-3.3
A05	14.5	
B03	84.5	-2.1
A06		-6.4
A07		-3.4
A09		-1.6
A16	22.2	
Astemizole		73.5

Molecular weight

The molecular weight is defined as the theoretical mass of the monomeric molecule exclusive of any counter ions or adducts. The molecular weights of the compounds are indicated in the table below.

Table 19: Molecular weights of compounds

Compound	Molecular weight (g/mol)
A09	2175
B03	1439
B07	1423
B06	1849
B05	1763
A01	2087
A08	2175
A05	1311
A19	1410
A07	1743
A20	1742
A06	1741

Compound	Molecular weight (g/mol)
A02	2028
A03	2074
A16	2087

Example 6: ADME-Tox

ADME-Tox analyses of various compounds were performed as described in Example 5. Summary results are shown in the table below.

Table 20: Summary ADME-Tox data

	A01	**A02**	**A05**	**B03**	**A06**	**A07**	**A09**	**A16**	**A17**
Aqueous solubility	9	35	6	114	164	165	63	220	2000
Proteolytic stability (human)	58	84	94		98	117	67		
Microsomal stability	30	45			49	34	23		
HERG channel	17		15	85				22	

Briefly, aqueous solubility was tested in PBS pH 7.4. Results are given in µM. Proteolytic stability was tested in human plasma for 30 minutes. Results for each are given as % stability. Microsomal stability was tested in a mouse microsomal preparation for 30 minutes. Results are given as % stability. HERG channel inhibition was tested using the patch clamp method in which the peptide or peptide derivative at 1 µM and are given as % inhibition.

Example 7: Animal models

The following assays are performed in animals.

1. Acute Toxicology

Toxicology studies involved monitoring of attitude changes due to toxic effects immediately after application and twice daily; monitoring of body weight;

histopathology of brain, heart, kidney, liver, lung. Experiments were performed in C57Bl/6 mice.

2. Pharmacokinetics

Pharmacokinetics of compounds were tested in C57Bl/6 mice or Wistar rats at 1 – 30 mg/kg. Compound concentrations in the blood stream were monitored at appropriate intervals using LC-MS.

3. Circulation Analysis

Blood pressure and heart rate were monitored and electrocardiogram taken in C57Bl/6 mice.

4. Animal Disease Model

A tail clip model was used in FVIII -/- (E17) mice, FIX -/- mice and C57Bl/6 control mice. Parameters quantified were total blood loss, bleeding time, bleeding rate and survival.

Example 8: Acute toxicology

C57Bl/6 mice weighing 18-20g were administered with compounds in a suitable vehicle i.v. in the tail vein or i.p. or s.c at 10 ml/kg. Quantities of the compounds administered were in the range of 0.075 to 125 mg/kg (i.v.), 15-125 mg/kg (i.p.) and 125 mg/kg (s.c.). There were four mice per group. Attitude changes due to toxic effects were monitored immediately after administration of the compound and for 60 minutes thereafter. Body weight was monitored for five days after administration. At day 5 after administration, mice were culled and autopsy performed. Brain, heart, kidney, liver, lung and spleen were biopsied. Results are described below.

Table 21: Attitude changes due to toxic effects at different compound doses

Compound	route	Max dose (mg/kg) within toxicity category		
		No detected toxicity	Some toxicity	Severe toxicity
A01	i.v.	20		
	i.p.	20		
A02	i.v.	25		
	i.p.	25		

Compound	route	Max dose (mg/kg) within toxicity category		
		No detected toxicity	Some toxicity	Severe toxicity
A05	i.v.		1.5	15
	i.p.	15		
B03	i.v.	1.5		15
	i.p.	15		
A06	i.v.	1	5	25
	i.p.	25		
A07	i.v.	1	5	25
	i.p.	25		
A09	i.v.	15		
	i.p.	15		
A16	i.v.	82		
	i.p.	82		
A17	i.v.	125		
	i.p.	125		
	s.c.	125		

In the above table, the maximum dose tested giving rise to no detected toxicity, some toxicity or severe toxicity over the period of 60 minutes following administration is reported. "No detected toxicity" indicates no acute toxic observations. "Some toxicity" indicates that ataxy or catalepsy were recorded, but no animals died. "Severe toxicity" indicates that one of the animals died within one hour of compound application.

In summary, most of the compounds were tolerated well. Doses of compounds which resulted in severe toxicity when administered by a particular route were not tested in pharmacokinetics, circulation analysis or animal disease models by that route.

For most of the compounds, even at the highest dose, no macroscopic pathological findings were observed in biopsy samples collected at five days from surviving mice, indicating that the compounds were tolerated well. The only pathological changes identified in any animal were minor abnormalities in the liver, kidney, lung or heart. These were spontaneous observations in single animals probably due to non compound-related minor infections or due to culling.

For each compound tested, no effect on average body weight of surviving mice, indicative of a negative response, was noted.

Example 9: Pharmacokinetics of compounds

Pharmacokinetic studies were performed to monitor compound concentrations in plasma following i.v., i.p. or s.c. administration. Studies were conducted in C57Bl/6 mice weighing approximately 20 g.

For each peptide, the same formulations were used for all administration routes and were as follows: A01 was formulated in 5% DMSO, 5% Cremophor EL (Sigma-Aldrich), 0.5% Tween 80; A02 and A09 were each formulated in 5% DMSO, 30% PEG 400 (polyethylene glycol) 50mM sodium phosphate pH 7.4; A05 was formulated in 5% DMSO, 20 mM glycine pH 9.0; A06 and A07 were each formulated in 5% DMSO, 0.9% NaCl, 50 mM sodium phosphate pH 7.4.

Peptide concentrations in the plasma were analysed by HPLC-MS on a Surveyor HPLC combined with mass spectrometer LCQ classic or Advantage (all Thermo Electron, US) equipped with an ESI-source. All HPLC experiments were carried out on a Phenomenex C-18 Luna column (50 mm x 2.0 mm, 5 µl injection volume) using a linear gradient: eluent A 0.05% trifluoracetic acid (TFA) in water; eluent B 0.05% TFA in acetonitrile; flow rate 0.3 mL/min in 10 min. UV spectra were recorded by the PDA from 220 to 400 nm. The internal standard is prepared as a 0.1 µg/ml solution in 100% methanol. 50 µl plasma and 50 µl internal standard are mixed. 100 µl methanol is added and mixed thoroughly. After 30 min incubation on ice the vial is centrifuged for 15 min at 4°C (20820 g). 150 µl of the supernatant are transferred into the HPLC vial

Results following i.v. or i.p. administration are shown in the table below. In brief, peptide clearance from plasma following i.v. administration followed a roughly logarithmic course. Following i.p. administration, Cmax was reached at between 40 and 60 minutes. There then followed a decrease in compound concentration. This profile is typical for i.p. or s.c. administration.

Table 22: Data obtained in pharmacokinetics analyses

	Peptide concentration in plasma (µg/ml) at time intervals after admin.					
[min] i.v.	5	10	15	20	25	30
A01	0.673	0.352	0.454	0.145	0.282	0.115
A02	11.625	7.260	3.182	2.738	1.436	1.308
A05	2.605	2.039	0.173	0.101	0.023	-
A06	49.963	32.610	20.981	15.593	11.267	7.787
A07	12.512	7.796	5.482	2.132	3.309	2.218
A09	0.350	0.184	0.109	0.119	0.064	0.080

[min] i.p.	5	20	40	60	80	100
A02	0.273	0.315	0.289	0.612	0.099	0.176
A05	0.119	0.165	0.185	0.130	0.049	0.050
A06	6.442	7.773	0.547	5.800	4.057	3.024
A07	2.444	2.627	3.180	3.869	2.202	1.678
A09	0.034	0.067	0.060	0.129	0.074	0.068

Example 10: Circulation Analysis following administration of A01

Mean arterial blood pressure and heart rate were monitored and electrocardiogram taken in three groups of three male and three female C57Bl/6 mice, each weighing about 20 g. The groups were assigned to "control" receiving 10 ml/kg NaCl i.v.; "vehicle" receiving 10 ml/kg i.v.; or "compound" receiving A01 in vehicle at 20 mg/kg i.v. "Vehicle" was DMSO 5%, Cremophor EL (Sigma-Aldrich) 5%, Tween 80 0.05% in water for injection.

For each mouse, a catheter filled with saline / heparin was fixed to the aorta carotis. The catheter was linked via a transducer to a blood pressure Plugsys-module (Hugo Sachs Electronik-Harvard Apparatus GmbH, Germany (HSE)). ECG electrodes were implanted s.c. and were linked via a ECG Plugsys-module (HSE) to a PC. Heart rate was calculated from the ECG. After a period of at least ten minutes to stabilize circulation parameters, saline, vehicle or compound was administered as appropriate via a catheter connected to the vena jugularis. Circulation parameters were monitored and recorded for 60 minutes after administration. For each animal, the time course in mean arterial blood pressure and heart rate within the observation period after study drug

administration was estimated using the area under the curve (AUC) using the linear trapezoidal rule. The individual AUCs (A01 20 mg/kg i.v.) were compared with those of vehicle (10 mL/kg i.v.) and saline (10mL/kg i.v.). The null hypothesis (no differences between compound and vehicle or saline) were assessed using the exact Wilcoxon rank sum test. Unadjusted and adjusted two-sided p-values for multiple comparisons were calculated. Adjustment for multiplicity was performed by using the Bonferroni-Holm method. The level of significance was set to 5%. All statistical analyses were performed with R Version 2.4.0. The null hypothesis of no difference was tested against the two-sided alternative. Results are shown in the table below.

Table 23: Statistical results of circulation analysis

Parameter	**Comparison**	**Unadjusted two-sided p-value**	**Adjusted two-sided p-value**
Mean arterial BP	A01 vs. saline	0.5887	1.0000
	A01 vs. vehicle	1.0000	1.0000
Heart rate	A01 vs. saline	0.6991	0.6991
	A01 vs. vehicle	0.2403	0.4805

There were no statistically significant (at the 5% level) differences in AUC of mean arterial blood pressure within 60 min after study drug administration between A01 20mg/kg i.v. and saline 10 ml/kg i.v. as well as between A01 20mg/kg i.v. and vehicle 10 ml/kg i.v. There were no statistically significant (at the 5% level) differences in AUC in heart rate within 60 min after study drug administration between A01 20mg/kg i.v. and saline 10 ml/kg i.v. as well as between A01 20mg/kg i.v. and vehicle 10 ml/kg i.v.

Example 11: Animal disease model – control experiments

Experiments were performed to develop a mouse tail clip assay to characterise bleeding parameters in FVIII (E17)-/-, FIX-/- (Lin HF Blood 1997; 90: 3962-6) and wild-type C57Bl/6 mice and their response to coagulation factor preparations.

Coagulation factor preparations tested were Advate® and Immunine®. Advate® is a rFVIII preparation (Baxter AG, Austria). Immunine® is a purified plasma FIX preparation (Baxter AG, Austria).

Blood loss was monitored in the tail clip assay as described in the specific description for 62 minutes after tail clip. FVIII -/- mice were administered with rFVIII (Advate®) at 25, 50 or 100 U/kg i.v. or with vehicle alone. The vehicle was Advate formulation buffer which is 38 mg/ml mannitol, 10 mg/ml trehalose, 108 mEq/l sodium, 12 mM histidine, 12 mM Tris, 1.9 mM calcium, 0.17 mg/ml Polysorbate-80, 0.1 mg/ml glutathione. As a control, C57Bl/6 mice were administered vehicle alone. Administration of rFVIII resulted in a dose-dependent reduction of blood loss over the 62 minutes. Survival data for the experiment are shown in the table below.

Table 24: Survival of FVIII -/- mice treated with Advate® FVIII in tail clip experiment

	Dose (U/kg)	**Animals (n)**	**Survival (%) 2 hours**	**Survival (%) 4 hours**	**Survival (%) 24 hours**	**Survival (%) 48 hours**
Advate	100	10	100	90	90	90
Advate	50	10	100	100	90	90
Advate	25	10	100	100	90	90
Vehicle	-	10	70	50	50	50
C57Bl/6	-	16	100	100	100	100

Blood loss was monitored for 62 minutes after tail clip of FIX -/- mice administered with Immunine® FIX at 50, 100 or 200 U/kg i.v. or with vehicle alone. As a control, C57Bl/6 mice were administered vehicle alone. Administration of FIX resulted in a dose-dependent reduction of blood loss over the 62 minutes. Survival data for the experiment are shown in the table below.

Table 25: Survival of FIX -/- mice treated with Immunine® FIX in tail clip experiment

	Dose (U/kg)	Animals (n)	Survival (%) 2 hours	Survival (%) 4 hours	Survival (%) 24 hours	Survival (%) 48 hours
Immunine	200	16	100	100	100	100
Immunine	100	16	100	100	94	94
Immunine	50	16	94	69	63	63
Vehicle	-	16	44	19	6	0
C57Bl/6	-	16	100	100	100	100

The data show that in the FVIII -/- model, Advate® FVIII at 25-100 U/kg dose dependently improves bleeding parameters and survival. In the FIX -/- model, Immunine® FIX at 50-200 U/kg dose dependently improves bleeding parameters and survival. Thus, the FVIII -/- model is an appropriate model to test coagulation FVIII activity of the lead compounds. The FIX -/- model is an appropriate model to test coagulation FIX activity of the compounds.

Example 12: Animal disease models – efficacy of A01

The effect of administered A01 on bleeding parameters and survival of FVIII -/- mice was tested in the tail clip model described in the specific description. Similar experiments were performed in FIX -/- mice.

Mean volume of blood loss following tail clip in a group of 8 male and 8 female FVIII -/- mice administered 20 mg/kg of A01 i.v. five minutes before tail clip was significantly different ($p < 0.05$) at most time points compared to mean volume of blood loss by a control group of mice administered vehicle alone. Vehicle was 5% DMSO, 5% Cremophor EL, 0.05% Tween 80 in water for injection. At 52 and 62 minutes after tail clip, the difference was significant at $p < 0.01$. Data are shown in Figure 2 and the table below. A log-rank test used to compare the survival curves of mice in this experiment shows a statistically significant longer survival with A01 20mg/kg i.v. than with vehicle control (p-value = 0.0028).

Table 26: Survival of FVIII -/- mice treated with A01 in tail clip experiment

Treatment	Animals (n)	Survival (%) 2 hours	Survival (%) 4 hours	Survival (%) 24 hours	Survival (%) 48 hours
A01	16	56	25	6	0
Vehicle	16	6	6	0	0

The above experiment was repeated to provide an indication of its reproducibility. Results are shown in the table below. Although variability is observed within these two independently performed experiments animals treated with A01 bleed less and survive longer.

Table 27: Survival of FVIII -/- mice treated with A01 in tail clip experiments

	Exp	Animals (n)	Survival (%) 2 hours	Survival (%) 3 hours	Survival (%) 4 hours	Survival (%) 24 hours
A01	1	16	56	44	25	6
Vehicle	1	16	6	6	6	0
A01	2	16	63	38	31	13
Vehicle	2	16	44	25	25	0

Further data were obtained using the same model, although the tail clip was 1 cm rather than 0.5 cm, and mice were grouped according to gender. Agents were administered i.v. In this experiment, it appeared that A01 was more effective in female than male mice. Results are shown in the table below.

Table 28: Gender effects of A01 in FVIII -/- mouse tail snip experiment

Compound	No. of animals (n)	Survival 2 hours (%)	Survival 24 hours (%)
A01 formulation buffer	20	30	0
A01 formulation buffer	10 female	50	0
A01 formulation buffer	10 male	10	0
A01 20 mg/kg	10 female	80	10
A01 20 mg/kg	10 male	20	0

Compound	No. of animals (n)	Survival 2 hours (%)	Survival 24 hours (%)
Advate formulation buffer	10	10	0
Advate 200 IU/kg	10	90	90
Advate 100 IU/kg	10	70	50

Groups contained equal numbers of male and female mice, unless otherwise stated.

Mean volume of blood loss following tail clip in a group of 16 FIX -/- mice administered 20 mg/kg of A01 i.v. five minutes before tail clip was not significantly different ($p < 0.05$) at any time points compared to mean volume of blood loss by a control group of mice administered vehicle alone. There was no significant difference in survival of mice administered A01 and mice administered vehicle alone.

These results demonstrate that A01 can at least partially compensate for the lack of FVIII in FVIII-/- mice by reducing blood loss and increasing survival following tail clip, but has no effect in FIX-/- mice. A01 is regarded as the most preferred peptide because it has demonstrated efficacy in a hemophilia model.

Example 13: Results of compound testing in FVIII-/- mouse tail clip model

A01 was further tested by i.p. administration in the FVIII -/- tail clip model using a 0.5 cm tail clip. Data are summarised in the table below.

Table 29: Survival of FVIII -/- mice treated with A01 in tail clip experiment

Compound	Treatment dose	Animals (n)	Total blood loss (% of Vehicle)	Survival 2 hours (%)	Survival 4 hours (%)	Survival 24 hours (%)
A01	20 mg/kg i.p. female	8	72	75	25	25
A01	20 mg/kg i.p. male	8	83	38	25	25

Compound	Treatment dose	Animals (n)	Total blood loss (% of Vehicle)	Survival 2 hours (%)	Survival 4 hours (%)	Survival 24 hours (%)
Vehicle control	10 ml/kg i.p. female	8		13	0	0
Vehicle control	10 ml/kg i.p. male	8		13	13	13

Female mice administered with A01 20 mg/kg had a statistically significant (at the 5% level) longer survival than female mice administered with vehicle 10 ml/kg i.p. (two-sided p-value p=0.0073; log-rank test). There was no statistically significant difference (at the 5% level) in survival curves between male mice administered with A01 20 mg/kg i.p. and male mice administered with vehicle 10 ml/kg i.p. In this experiment, the males in the control group seemed to survive better than the females in the control group.

Example 14: Summary of experiments for characterising lead compounds

The following compounds possess activity in the Defined Intrinsic Thrombin Generation Assay: A01, A03, A05, A19, B01, A02, B03, B05, B06, A06, A20, A07, A08, A09 and B07. Of these, A03, A02, B03, A08 and A09 have a thrombin generation activity at 100 µM of at least 1200 mU/mL FEIBA.

The following compounds possess activity in the Defined Dual-Pathway Thrombin Generation Assay: A02, A03, A08, A09, A18, B03, B04, A07, A15, A06 and A17. Of these, A09 had a peak IIa activity at 50 µM of at least 10 mU/mL FEIBA. B03, B04 and A15 had a peak IIa activity at 50 or 100 µM of at least 10 mU/mL FEIBA.

The following compounds possess activity in the Defined Fibrin Deposition Assay: A01, B01, A05, B03, A06 and A07.

The following compounds have a stability of at least 50% following incubation for 30 minutes in human plasma: A01, A19, A07, A20, A06, A02, A03, A08, A09, B07, B06, B05 and A05.

The following compounds have solubility in PBS pH 7.4 of at least 25 µM: A09, B03, B07, B06, B05, A07, A20, A06, A02, A03 and A16. Of these, B03, B07, B05, A07, A20, A06, A03 and A16 have a solubility in PBS pH 7.4 of at least 100 µM.

A01, A05 and A16 were identified as low-potency HERG-channel blockers.

A01 was identified as possessing activity in the tail clip assay in FVIII-/- mice.

Example 15: Treatment of hemophilia A in an adult human subject

It is typical for hemophilia A patients to develop alloantibody inhibitors to FVIII following high dose FVIII therapy. In a typical scenario, the presence of such antibodies in serum prepared from the patient's blood plasma is monitored by a clinician. When the titre of the antibody response becomes unacceptably high, such as about 5 BU, the clinician may decide to stop infusing the patient with FVIII, and start administering a peptide of the invention, such as peptide A01.

The peptide may be formulated as a microparticle of about 10 µm diameter in an albumin shell, suspended in an aqueous medium, as described in US 5,439,686. The patient may self administer the formulation by inhalation using a nebulizer. A daily or twice daily dose of 5 or 10 mg may be inhaled. The clinician may test the partial thromboplastin time shortly after commencement of the peptide therapy, to confirm efficacy. Depending on the result, the dose could be varied accordingly. If it is necessary to substantially increase the dose, smaller microparticles could be used, typically of about 5 µm diameter, and they could be administered intravenously.

CLAIMS

1. A peptide or peptide derivative comprising:

(i) an amino acid sequence comprising imfwydcye; or

(ii) a variant amino acid sequence comprising one, two, three, or four amino acid substitutions in imfwydcye, wherein the variant amino acid sequence comprises an amino acid sequence comprising $X_1X_2mX_4wydX_8ye$, wherein X_1, when present, is c, C or D-Pen, X_2 is i or y, X_4 is f, t, or v and X_8 is c or e;

wherein said peptide or peptide derivative has procoagulant activity, and wherein the peptide or peptide derivative has a molecular weight of between 0.5 and 3.5kD.

2. The peptide or peptide derivative of Claim 1 comprising:

(i) an amino acid sequence comprising cimfwydcye.

3. The peptide or peptide derivative of Claim 1 which is acetylated at the N-terminus, amidated at the C-terminus and/or PEGylated at either terminus.

4. The peptide or peptide derivative of Claim 2 which is acetylated at the N-terminus, amidated at the C-terminus and/or PEGylated at either terminus.

5. The peptide or peptide derivative of Claim 1 or claim 2 which is cyclic.

6. The peptide or peptide derivative of Claim 1 comprising or consisting of:
Ac-cimfwydeye-NH_2, Disulphide-Dimer(Ac-cimfwydeye-NH_2)$_2$, Ac-TTDS-(cymfwydc)-ye-NH_2, K-TTDS-(cymfwydc)-ye-NH_2, Ac-cimtwydcye-NH_2, Ac-cimvwydcye-NH_2, cymfwydcye, Ac-(cymfwydc)-yeG-NH_2, Ac-(D-Pen)imfwydeye-NH_2, O(CH_2-CH_2-O-CH_2-CO-imfwydeye-NH_2)$_2$, Pyridine-3,5-(CO-imfwydeye-NH_2)$_2$, H_2N-E-TTDS-(cymfwydc)-ye-NH_2, Ac-(cymfwydc)-yeK, Ac-(cymfwydc)-ye-TTDS-K, Ac-simfwydeye-NH_2, Ac-simfwydeye-NH_2, Ac-ydmcwcefyi-NH_2, Ac-idmccyfywe-NH_2, Ac-cimfwyddye-NH_2, Ac-(cymfwydc)-ye, Ac-(cymfwydc)-ye-TTDS-NH_2, Ac-TTDS-(cymfwydc)-ye-TTDS-NH_2, K-(cymfwydc)-ye-NH_2, Ac-K-(cymfwydc)-ye-NH_2, E-(cymfwydc)-ye-NH_2, Ac-K-TTDS-(cymfwydc)-ye-NH_2, Ac-(cymfwydc)-yeK-NH_2, Ac-(cymfwydc)-ye-TTDS-K-NH_2, Ac-(cymfwydc)-ye-TTDS-E-NH_2, Ac-timfwydeye-NH_2, Ac-(cimfwydc)-ye-NH_2, Ac-(cymfwydc)-ye-NH_2, Ac-(cwmfwydc)-ye-NH_2, Ac-cicfwydcye-NH_2, Ac-

(D-Nva)imfwydeye-NH_2, Ac-(D-Nle)imfwydeye-NH_2, Ac-(Cys)imfwydeye-NH_2, (cymfwydc)-ye-NH_2, TTDS-(cymfwydc)-ye-TTDS-NH_2, Ac-kimfwydeye-NH_2,
wherein TTDS is 4,7,10-trioxa-1,13-tridecanediamine, (D-Pen) is D-penicillamine, (D-Nva) is D-norvaline, (D-Nle) is D-norleucine.

7. A dual peptide comprising a peptide or peptide derivative as defined in any preceding claim conjugated to a further peptide or peptide derivative as defined in any preceding claim, wherein the peptide or peptide derivative may be the same as or different from the further peptide or peptide derivative, and wherein the dual peptide has procoagulant activity.

8. The peptide or peptide derivative of any one of claims 1-6, wherein the procoagulant activity is a thrombin generation time of 25, 50 or 100 µM of peptide, or peptide derivative equivalent to that of at least 100 mU/mL Factor Eight Inhibitor Bypassing Activity (FEIBA), preferably at least 300 mU/mL FEIBA, more preferably at least 900 mU/mL FEIBA, most preferably at least 1200 mU/mL FEIBA in the Defined Intrinsic Thrombin Generation Assay.

9. The peptide or peptide derivative of any one of claims 1-6, wherein the procoagulant activity is a thrombin generation time of 25, 50 or 100 µM of peptide or peptide derivative in a Defined Intrinsic Thrombin Generation Assay peaking within 30 minutes, preferably within 15 minutes and most preferably within 10 minutes.

10. The peptide or peptide derivative of any one of claims 1-6 which can at least partially compensate for the absence of biologically active FVIII when administered in an animal model of severe human hemophilia A.

11. The peptide or peptide derivative of any one of claims 1-6 which has a stability in human plasma at 30 minutes of at least 50%, preferably at least 70%, more preferably at least 80% and most preferably at least 90%.

12. The peptide or peptide derivative of any one of claims 1-6 which has an aqueous solubility in phosphate buffered saline pH 7.4 of at least 25 µM, preferably at least 60 µM and most preferably at least 100 µM.

13. A pharmaceutical composition comprising the peptide, peptide derivative or dual peptide of any one of claims 1-7 and one or more pharmaceutically acceptable excipients, carriers and/or diluents.

14. The pharmaceutical composition of Claim 13 suitable for subcutaneous, nasal, buccal, oral or pulmonary administration.

15. The pharmaceutical composition of Claim 13 suitable for intravenous administration.

16. The peptide or peptide derivative of any one of claims 1-6 for use in medicine.

17. The peptide or peptide derivative of any one of claims 1-6 for treating a patient having a deficiency in FV, FVII, FVIII, FX and/or FXI.

18. Use of a peptide or peptide derivative of any one of claims 1-6 in the manufacture of a medicament for the treatment of a deficiency in FV, FVII, FVIII, FX and/or FXI.

19. Use of a therapeutically effective amount of the pharmaceutical composition of Claim 13 in the manufacture of a medicament for treating a patient having a deficiency in FV, FVII, FVIII, FX and/or FXI.

20. Use of a therapeutically effective amount of the pharmaceutical composition of Claim 14 in the manufacture of a medicament for treating a patient having a deficiency in FV, FVII, FVIII, FX and/or FXI.

21. Use of a therapeutically effective amount of the pharmaceutical composition of Claim 15 in the manufacture of a medicament for treating a patient having a deficiency in FV, FVII, FVIII, FX and/or FXI.

22. A method of making the peptide or peptide derivative of any one of claims 1-6 by solid phase synthesis.