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(71) Applicant: **MERZ PHARMA GMBH & CO. KGAA** [DE/DE]; Eckenheimer Landstraße 100, 60318 Frankfurt am Main (DE).

(72) Inventors: **BRÜNN, Cornelia**; Gonzenheimer Str. 10, 60437 Frankfurt (DE). **MANDER, Gerd**; Bertha-Bagge Straße 46, 60438 Frankfurt (DE).

(74) Agent: **HERZOG FIESSER & PARTNER PATENTANWÄLTE PARTG MBB**; DICK Alexander, Dudenstraße 46, 68167 Mannheim (DE).

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(54) Title: MEANS AND METHODS FOR THE DETERMINATION OF THE BIOLOGICAL ACTIVITY OF BONT/E IN CELLS

(57) Abstract: The present invention pertains to a polyclonal or monoclonal antibody specifically binding to BoNT/E-cleaved SNAP-25. Further, the invention provides a method for directly determining the biological activity of BoNT/E in cells, comprising the steps of: a) incubating cells susceptible to BoNT/E intoxication with BoNT/E for a time and under conditions which allow for the BoNT/E to exert its biological activity; b) fixing the cells and, optionally, permeabilizing the cells with a detergent; c) contacting the cells with at least a first capture antibody specifically binding to non-cleaved and BoNT/E-cleaved SNAP-25, and with at least a second capture antibody specifically binding to BoNT/E-cleaved SNAP-25, wherein the second capture antibody is an antibody of the invention, under conditions which allow for binding of said capture antibodies to the indicated substrates; d) contacting the cells with at least a first detection antibody specifically binding to the first capture antibody, under conditions which allow for binding of said first detection antibody to said first capture antibody, thus forming first detection complexes, and with at least a second detection antibody specifically binding to the second capture antibody, under conditions which allow for binding of said second detection antibody to said second capture antibody, thus forming second detection complexes, and wherein the first detection antibody is different from the second detection antibody; e) determining the amount of the first and second detection complexes of step d); and f) calculating the amount of SNAP-25 cleaved by BoNT/E in said cells by means of the second detection complexes, thereby determining the biological activity of BoNT/E in said cells. Furthermore, the invention relates to a kit for carrying out the method of the invention.

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Means and Methods for the determination of the biological activity of BoNT/E in cells

[0001] The present invention pertains to a polyclonal or monoclonal antibody specifically binding to BoNT/E-cleaved SNAP-25. Further, the invention provides a method for directly determining the biological activity of BoNT/E in cells, comprising the steps of: a) incubating cells susceptible to BoNT/E intoxication with BoNT/E for a time and under conditions which allow for the BoNT/E to exert its biological activity; b) fixing the cells and, optionally, permeabilizing the cells with a detergent; c) contacting the cells with at least a first capture antibody specifically binding to non-cleaved and BoNT/E-cleaved SNAP-25, and with at least a second capture antibody specifically binding to BoNT/E-cleaved SNAP-25, wherein the second capture antibody is an antibody of the invention, under conditions which allow for binding of said capture antibodies to the indicated substrates; d) contacting the cells with at least a first detection antibody specifically binding to the first capture antibody, under conditions which allow for binding of said first detection antibody to said first capture antibody, thus forming first detection complexes, and with at least a second detection antibody specifically binding to the second capture antibody, under conditions which allow for binding of said second detection antibody to said second capture antibody, thus forming second detection complexes, and wherein the first detection antibody is different from the second detection antibody; e) determining the amount of the first and second detection complexes of step d); and f) calculating the amount of SNAP-25 cleaved by BoNT/E in said cells by means of the second detection complexes, thereby determining the biological activity of BoNT/E in said cells. Furthermore, the invention relates to a kit for carrying out the method of the invention.

[0002] Clostridium botulinum and Clostridium tetani produce highly potent Neurotoxins, i.e. Botulinum toxins (BoNTs) and Tetanus toxin (TeNT), respectively. These Clostridial Neurotoxins (CNTs) specifically bind to neuronal cells and disrupt neurotransmitter release. Each toxin is synthesized as an inactive unprocessed approximately 150 kDa single-chain protein. The posttranslational processing involves formation of disulfide bridges, and limited proteolysis (nicking) by the bacterial protease(s).

[0003] Alternatively, Clostridial Neurotoxins can be produced in heterologous cells, i.e. be produced recombinantly by expressing nucleic acid sequences encoding a Neurotoxin in appropriate host cells. Methods for the recombinant expression of Clostridial Neurotoxins in

E. coli are well known in the art; see, for example, WO 00/12728, WO 01/14570, WO 2006/076902 or WO 2013/091895. In certain cases, the light and heavy chains are separately obtained, and then reconstituted in vitro; see WO 95/32738.

[0004] Furthermore, Clostridial Neurotoxins have been expressed in eukaryotic expression systems, such as in Pichia pastoris, Pichia methanolica, S. cerevisiae, insect cells and mammalian cells; see WO 2006/017749.

[0005] In all these expression systems, a proteolytic cleavage of the single chain Neurotoxin precursor is required, either by host cell enzymes during fermentation, or by adding proteolytic enzymes to the raw protein material isolated after fermentation, in order to generate the final biologically active Clostridial Neurotoxin protein comprising a light chain and a heavy chain, linked by a disulfide bond.

[0006] Active Neurotoxin consists of two chains, an N-terminal light chain of approx. 50 kDa and a C-terminal heavy chain of approx. 100 kDa linked by a disulfide bond. CNTs structurally and functionally consist of three domains, i.e. the catalytic light chain, the heavy chain encompassing the translocation domain (N-terminal half) and the receptor binding domain (C-terminal half); see, e.g., Krieglstein 1990, Eur. J. Biochem. 188, 39; Krieglstein 1991, Eur. J. Biochem. 202, 41; Krieglstein 1994, J. Protein Chem. 13, 49. The Botulinum Neurotoxins are synthesized as molecular complexes comprising the 150 kDa Neurotoxin protein and associated non-toxic proteins. The complex sizes differ based on the Clostridial strain and the distinct Neurotoxin serotypes ranging from 300 kDa, over 500 kDa, and 900 kDa. The non-toxic proteins in these complexes stabilize the Neurotoxin and protect it against degradation; see Silberstein 2004, Pain Practice 4, S19 – S26.

[0007] Clostridium botulinum secretes seven antigenically distinct serotypes designated A to G of the Botulinum Neurotoxin (BoNT). All serotypes together, with the related Tetanus Neurotoxin (TeNT) secreted by Clostridium tetani, are Zn^{2+}-endoproteases that block synaptic exocytosis by cleaving SNARE proteins; see Couesnon, 2006, Microbiology, 152, 759. CNTs cause the flaccid muscular paralysis seen in botulism and tetanus; see Fischer 2007, PNAS 104, 10447.

[0008] Despite its toxic effects, Botulinum toxin complex has been used as a therapeutic agent in a large number of diseases. Botulinum toxin serotype A was approved for human use in the United States in 1989 for the treatment of strabism, blepharospasm, and other disorders. It is commercially available as Botulinum toxin A (BoNT/A) protein preparation, for example, under the trade name BOTOX (Allergan, Inc.) or under the trade name DYSPORT/RELOXIN (Ipsen, Ltd). An improved, complex-free Botulinum toxin A preparation is commercially available under the trade name XEOMIN (Merz Pharmaceuticals,

GmbH). For therapeutic applications, the preparation is injected directly into the muscle to be treated. At physiological pH, the toxin is released from the protein complex and the desired pharmacological effect takes place. The effect of Botulinum toxin is only temporary, which is the reason why repeated administration of Botulinum toxin may be required to maintain a therapeutic effect.

[0009] The Clostridial Neurotoxins weaken voluntary muscle strength and are effective therapy for strabism, focal dystonia, including cervical dystonia, and benign essential blepharospasm. They have been further shown to relief hemifacial spasm, and focal spasticity, and moreover, to be effective in a wide range of other indications, such as gastrointestinal disorders, hyperhidrosis, and cosmetic wrinkle correction; see Jost 2007, Drugs 67, 669.

[0010] During the manufacturing process of Clostridial Neurotoxins, the qualitative and quantitative determination of said Neurotoxins as well as the quality control of the biologically active Neurotoxin polypeptides is of particular importance. In addition, governmental agencies accept only simple, reliable, and validated Botulinum toxin activity assays. At present the mouse LD_{50} bioassay, a lethality test, remains the "gold standard" used by pharmaceutical manufacturers to analyze the potency of their preparations; see Arnon et al. (2001), JAMA 285, 1059-1070. However, in recent years, considerable effort has been undertaken to seek for alternative approaches to alleviate the need for animal testing and all the disadvantages, costs and ethical concerns associated with this type of animal-based assays. In addition, the regulatory agencies are engaging pharmaceutical companies to apply the "three Rs" principle to the potency testing of Botulinum Neurotoxins: "Reduce, Refine, Replace"; see Straughan, Altern. Lab. Anim. (2006), 34, 305-313. As a consequence, cell-based test systems have been developed in order to provide reasonable alternatives to methods using live animals. Yet, only a few cellular test systems are available for the determination of Neurotoxin biological activity thus far which have been shown to be sufficiently sensitive to Neurotoxin polypeptides. These cell-based test systems include the use of primary neurons isolated from rodent embryos which are differentiated in vitro (Pellett et al. (2011), Biochem. Biophys. Res. Commun. 404, 388-392), neuronal differentiated induced pluripotent stem cells (Whitemarsh et al. (2012), Toxicol. Sci. 126, 426-35), and a subclone of the SiMa cell line (WO 2010/105234 A1).

[0011] However, the isolation of primary neurons requires the killing of animals and is laborious and time consuming. Further, test systems using different primary neurons show large variances. Similarly, the generation of neuronal differentiated induced pluripotent stem cells is difficult and time consuming. In addition, storage of such cells is very problematic. Assays using tumor cell lines are frequently not sensitive enough to BoNT. Moreover,

complex differentiation protocols are required for said tumor cell lines which result in large variances and/or high failure rates of assays using said cell lines.

[0012] Assays for determining the biological activity of Clostridial Neurotoxins described in the art include Western blot analysis in which the Neurotoxin activity is quantified by the amount of cleaved Neurotoxin substrate in cell lysates. In other assays, the activity of Clostridial Neurotoxins is measured by an electrochemoluminescence (ECL) sandwich ELISA; see WO 2009/114748 A1. Also in this case, the biological activity of the Clostridial Neurotoxin is determined by the detection of cleaved Clostridial Neurotoxin substrate after isolation from the cell lysate. Further, the Neurotoxin substrate has to be concentrated, in both assays.

[0013] In light of the above, further test systems for the determination of Neurotoxin polypeptide activity acceptable to governmental agencies and/or providing for an alternative to animal-based test systems are highly desirable.

[0014] Thus, the technical problem underlying the present invention may be seen as the provision of means and methods complying with the aforementioned needs. The technical problem is solved by the embodiments characterized in the claims and herein below.

[0015] The present invention relates, in a first aspect, to a polyclonal or monoclonal antibody specifically binding to BoNT/E-cleaved SNAP-25. Further, the invention pertains to a deposited hybridoma cell line generating a monoclonal antibody specifically binding to BoNT/E-cleaved SNAP-25.

[0016] The present invention provides a novel antibody specifically binding to the cleavage site of the BoNT/E-cleaved SNAP-25, i.e. to BoNT/E-cleaved SNAP-25. In addition, the invention provides the hybridoma cell line pCNEI 32-7-1, 3614-000, producing the monoclonal antibody of the invention specifically binding to BoNT/E-cleaved SNAP-25. This hybridoma cell line has been deposited by the Applicant under the Budapest Treaty on December 17, 2014, at DSMZ – Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH, Inhoffenstraße 7 B, 38124 Braunschweig, Germany under the accession number DSM ACC3261. As known in the art, SNAP-25 is a substrate of, inter alia, the BoNT/E neurotoxin. SNAP-25 has a total length of 206 amino acid residues. The BoNT/E cleavage site in SNAP-25 is positioned between Arginine (R) 180 and Isoleucine (I) 181, also referred to as "$R_{180}I$". Accordingly, the cleavage of SNAP-25_{206} by BoNT/E reveals two fragments, i.e. an N-terminal fragment from amino acid residues 1 to 180, in the following also referred to as "SNAP-25_{180} cleavage product" and a C-terminal fragment from amino acid residues 181 to 206. The antibody of the invention has been generated and characterized as described in the following Examples. Briefly, a mouse monoclonal antibody has been produced by

immunizing mice with the peptide "C-NEIDTQNRQIDR-OH" (SEQ ID NO: 1) coupled to an immunization protein. The shown data indicate that this antibody detects specifically the SNAP-25_{180} cleavage product. Thus, this antibody is particularly suitable for assays for measuring the biological activity of BoNT/E by the detection of BoNT/E-cleaved SNAP-25. Specifically, it can be used as second capture antibody for the method of the invention which allows for determining the biological activity of BoNT/E directly in cells, due to its high affinity and specificity for the SNAP-25_{180} cleavage product, relative to the SNAP-25_{206} uncleaved substrate. Such an antibody is not yet commercially available. Further envisaged by the present invention is a polyclonal antiserum or antibody which can be generated, e.g., by coupling the peptide "C-NEIDTQNRQIDR-OH" (SEQ ID NO: 1) to an immunization protein and immunizing species including but not limited to, e.g., rabbit, goat, horse, donkey, mouse, rat, or llama.

[0017] As used herein, the term "antibody" refers to a molecule generated by an immune system that was made in response to a particular antigen that specifically binds to that antigen, and includes both naturally occurring antibodies and non-naturally occurring antibodies. An "antibody" as used herein encompasses a monoclonal antibody, a polyclonal antiserum or antibody, a single chain antibody, a dimer or a multimer, a chimerized antibody, a bispecific antibody, a bispecific single chain antibody, a multispecific antibody, a synthetic antibody, a humanized antibody, a bifunctional antibody, a cell-associated antibody like an Ig receptor, a linear antibody, a diabody, a minibody, or a fragment of any of said antibodies. Fragments of said antibodies include, e.g., Fab, Fv, or scFv fragments, or chemically modified derivatives of any of these fragments. Antibodies can be manufactured by using methods which are described in the art; see, for example, Harlow and Lane "Antibodies, A Laboratory Manual", CSH Press, Cold Spring Harbor, 1988. Monoclonal antibodies can be prepared by the techniques originally described in Köhler 1975, Nature 256, 495, and Galfré 1981, Meth. Enzymol. 73, 3. Said techniques comprise the fusion of mouse myeloma cells to spleen cells derived from immunized mammals. Antibodies can be further improved by techniques well known in the art. For example, surface plasmon resonance as employed in the Biacore system can be used to increase the efficiency of phage antibodies which bind to the epitope; see, e.g., Schier 1996, Human Antibodies Hybridomas 7, 97; Malmborg 1995, J. Immunol. Methods 183, 7. Antibodies as used herein also comprise functional equivalents of antibodies, i.e. agents which are capable of specifically binding to the desired epitope(s) or parts of the BoNT/E-cleaved SNAP-25 substrate. In an aspect, such functional equivalents comprise binding proteins specifically binding to the BoNT/E-cleaved SNAP-25 or domains thereof which are capable of mediating the said specific binding. An antibody as used herein can be a full-length immunoglobulin molecule comprising the VH and VL domains, as well as a light chain constant domain (CL) and heavy chain constant domains, CH1, CH2 and CH3, or an immunologically active fragment of a full-length immunoglobulin molecule, such as, e.g., a

Fab fragment, a $F(ab')_2$ fragment, a Fc fragment, a Fd fragment, or a Fv fragment. An antibody can be derived from any vertebrate species (e.g., human, monkey, goat, horse, donkey, mouse, rat, rabbit, or chicken), and can be of any type (e.g., IgG, IgE, IgM, IgD, or IgA), class (e.g., IgA, IgD, IgE, IgG, or IgM) or subclass (IgG1, IgG2, IgG3, IgG4, IgA1 or IgA2). For general disclosure on the structure of naturally occurring antibodies, non-naturally occurring antibodies, and antigenic compound-binding fragments thereof, it is referred to, e.g., Plueckthun in The Pharmacology of Monoclonal Antibodies, vol. 113, Rosenburg and Moore eds., Springer-Verlag, New York, pp. 269-315 (1994); Borrabeck, Antibody Engineering 2nd ed. (Oxford University Press). Naturally occurring antibodies are usually heterotetrameric glycoproteins of about 150,000 Daltons, composed of two identical light (L) chains and two identical heavy (H) chains. Each light chain is linked to a heavy chain by one covalent disulfide bond, while the number of disulfide linkages varies among the heavy chains of different immunoglobulin isotypes. Each heavy and light chain also has regularly spaced intra-chain disulfide bridges. Each heavy chain has at one end a variable domain (VH) followed by a number of constant domains. Each light chain has a variable domain at one end (VL) and a constant domain at its other end. The constant domain of the light chain is aligned with the first constant domain of the heavy chain, and the light-chain variable domain is aligned with the variable domain of the heavy chain. Particular amino acid residues are believed to form an interface between the light chain and heavy chain variable domains.

[0018] The complete antigen-recognition and antigen-binding site is contained within the variable domains of the antibody, i.e., the Fv fragment. This fragment includes a dimer of one heavy chain variable domain (VH) and one light chain variable domain (VL) in tight, non-covalent association. Each domain comprises four framework regions (FR), which largely adopt a beta-sheet configuration, connected by three hypervariable regions, which form loops connecting, and in some cases form part of, the beta-sheet structure. Each hypervariable region comprises an amino acid sequence corresponding to a complementarity determining region (CDR). Collectively, it is the three-dimensional configuration of the six CDR regions (three CDR regions on the light chain, i.e. CDR-L1, CDR-L2 and CDR-L3 and three CDR regions on the heavy chain, i.e. CDR-H1, CDR-H2 and CDR-H3) that defines an antigen-binding site on the surface of the VH-VL dimer that confers antigen-binding specificity. See e.g., Cyrus Chothia, et al., Conformations of Immunoglobulin Hypervariable Regions, Nature 342(6252): 877-883 (1989); Elvin A. Kabat, et al. Sequences of Proteins of Immunological Interest, 5th Ed. Public Health Service, National Institutes of Health, Bethesda, Md. (1991). The constant domains of the antibody are not involved directly in binding an antibody to an antigen, but exhibit various effector functions, such as participation of the antibody in antibody dependent cellular cytotoxicity.

[0019] "Selective binding" or "specific binding" as used herein means that the antibody of the present invention specifically binds to BoNT/E-cleaved SNAP-25 but does not cross-react to a significant extent with non-cleaved SNAP-25, or with other polypeptides in general. Epitope specificity is an important characteristic of the antibody of the present invention. The antibody of the invention specifically binds to an epitope consisting of a peptide having an amino acid sequence as shown in SEQ ID NO: 1, 2, 3, 4, 5, 6, 7 or 8. Specific binding can be tested by various well known techniques including, e.g., competition studies. Another important characteristic is the sensitivity of the antibody. Sensitivity shall be, in one aspect of the invention, such that at least 70%, at least 80%, at least 90%, at least 95% of the BoNT/E-cleaved SNAP-25 comprised by a sample or cell is bound. Sensitivity can be tested by well known techniques. Those skilled in the art will be able to determine operative and optimal assay conditions for each determination by employing routine experimentation. Conventional techniques for binding studies include radioimmunoassay, ELISA, equilibrium dialysis, isothermal microcalorimetry, BIACORE® assays (surface plasmon reasonance, SPR) or other surface adsorption methods. The BIACORE® SPR system measures the antibody-antigen interaction. SPR response reflects a change in mass concentration at the detector surface as analytes bind or dissociate. Based on SPR, real-time BIACORE® measurements monitor interactions directly as they occur, see BIAapplications Handbook, version AB (reprinted 1998), BIACORE® code No: BR-1001-86; BIAtechnology Handbook, version AB (reprinted 1998), BIACORE® code No: BR-1001-84. The binding properties such as sensitivity of an antibody of the present invention may, in principle, be determined by binding studies using an immobilized antigen such as a peptide having an amino acid sequence as shown in SEQ ID NO: 2 ("NEIDTQNRQIDR") (the ligand) presented on a sensor surface. The antibody to be tested (the analyte) will be provided in the mobile phase, i.e. in a solution. In some cases, the antigen is attached indirectly to the surface through binding to another immobilized molecule which is referred as the "capturing molecule". When the antibody is injected in a discrete pulse across the surface with the immobilized antigens, essentially three phases can be subdivided: (i) association of antibody with the antigen during sample injection; (ii) equilibrium or steady state during sample injection, where the rate of antibody binding is balanced by dissociation from the antibody-antigen complex; (iii) dissociation of the antibody from the surface during buffer flow. It will be understood that such an assay can alternatively be performed with immobilized antibodies to be investigated and an antigen containing solution as the mobile phase. The association and dissociation phases provide information on the kinetics of analyte-ligand interaction (k_a and k_d, the rates of complex formation and dissociation, $k_d/k_a=K_D$). The equilibrium phase provides information on the affinity of the analyte-ligand interaction (K_D). Accordingly, "selective binding" or "specific binding" as used herein includes binding properties such as, e.g., binding affinity, binding specificity, and binding avidity; see, e.g., David J. King, Applications and Engineering of Monoclonal

Antibodies, pp. 240 (1998). Binding affinity refers to the length of time the antibody resides at its epitope binding site, and can be viewed as the strength with which an antibody binds its epitope. Binding affinity can be described an antibody's equilibrium dissociation constant (KD), which is defined as the ratio Kd/Ka at equilibrium. Ka is the antibody's association rate constant and Kd is the antibody's dissociation rate constant. Binding affinity is determined by both the association and the dissociation and alone neither high association nor low dissociation can ensure high affinity. The association rate constant (Ka), or on-rate constant (Kon), measures the number of binding events per unit time, or the propensity of the antibody and the antigen to associate reversibly into its antibody-antigen complex. The association rate constant is expressed in M^{-1} s^{-1}, and is symbolized as follows: [Ab] x [Ag] x Kon. The larger the association rate constant, the more rapidly the antibody binds to its antigen, or the higher the binding affinity between antibody and antigen. The dissociation rate constant (Kd), or off-rate constant (Koff), measures the number of dissociation events per unit time propensity of an antibody-antigen complex to separate (dissociate) reversibly into its component molecules, namely the antibody and the antigen. The dissociation rate constant is expressed in s^{-1}, and is symbolized as follows: [Ab + Ag] x Koff. The smaller the dissociation rate constant, the more tightly bound the antibody is to its antigen, or the higher the binding affinity between antibody and antigen. The equilibrium dissociation constant (KD) measures the rate at which new antibody-antigen complexes formed equals the rate at which antibody-antigen complexes dissociate at equilibrium. The equilibrium dissociation constant is expressed in M, and is defined as Koff/Kon = [Ab] x [Ag] / [Ab+Ag], where [Ab] is the molar concentration of the antibody, [Ag] is the molar concentration of the antigen, and [Ab+Ag] is the of molar concentration of the antibody-antigen complex, where all concentrations are of such components when the system is at equilibrium. The smaller the equilibrium dissociation constant, the more tightly bound the antibody is to its antigen, or the higher the binding affinity between antibody and antigen.

[0020] A target antigen such as the BoNT/E substrate SNAP-25 generally has one or more binding sites, also called epitopes, which are recognized by the CDR-formed antigen-binding site of the antibody. As used herein, an “epitope” is synonymous with “antigenic determinant” and refers to the site on a target antigen, such as, e.g., a peptide, polypeptide, polysaccharide or lipid-containing molecule, capable of specific binding to an immunoglobulin or T-cell receptor or otherwise interacting with a molecule. Each antibody that specifically binds to a different epitope has a different structure. Thus, one antigen may have more than one corresponding antibody. “Specific binding” as referred to herein can be tested by various well known techniques including, e.g., competition experiments and Western blots. An epitope as used in accordance with the invention relates to the antigenic determinant in the BoNT/E-cleaved SNAP-25, which can be localized near, adjacent to or in the BoNT/E cleavage site of SNAP-25 which is recognized by the antibody. As used herein, the term “specifically” means

selectively and refers to having a unique effect or influence or reacting in only one way or with only one thing. As used herein, the term "specifically binds" or "selectively binds" when made in reference to an antibody or binding protein or binding domain, refers to the discriminatory binding of the antibody or binding protein/domain to the indicated target epitope such that the antibody or binding protein/domain does not substantially cross-react with non-target epitopes. The minimal size of a peptide epitope, as defined herein, is about five amino acid residues, and a peptide epitope typically comprises at least 5, at least 6, at least 7, at least 8, at least 9, at least 10, at least 11, at least 12, at least 13, at least 14, at least 15, at least 16, at least 17, at least 18, at least 19, at least 20, at least 21, at least 22, at least 23, at least 24, at least 25, or at least 30 amino acid residues. A peptide epitope may be a linear or a discontinuous epitope. A discontinuous epitope comprises amino acid residues that are not adjacent in the primary structure of the peptide but are brought together into an epitope by way of the secondary, tertiary or quaternary structure of the peptide. Furthermore, it is also noted that an epitope may comprise a portion of a molecule other than an amino acid sequence such as, e.g., carbohydrate moiety, lipid moiety like glycolipids or lipoproteins, or a chemically modified amino acid moiety like a phosphorylated amino acid.

[0021] In another aspect of the polyclonal or monoclonal antibody of the invention, the antibody specifically binds to an epitope consisting of a peptide having the amino acid sequence shown in SEQ ID NO: 1 ("C-NEIDTQNRQIDR-OH"). Preferably, the antibody of the invention recognizes and specifically binds to the epitope SNAP-$25_{169-180}$ "NEIDTQNRQIDR" shown in SEQ ID NO: 2 and/or to SNAP-25_{180}, i.e. BoNT/E-cleaved SNAP-25. More preferably, the antibodies of the invention recognize and specifically bind to the epitope SNAP-$25_{170-180}$ "EIDTQNRQIDR" shown in SEQ ID NO: 3 and/or to SNAP-25_{180}, to the epitope SNAP-$25_{171-180}$ "IDTQNRQIDR" of the sequence shown in SEQ ID NO: 4 and/or to SNAP-25_{180}, to the epitope SNAP-$25_{172-180}$ "DTQNRQIDR" shown in SEQ ID NO: 5 and/or to SNAP-25_{180}, to the epitope SNAP-$25_{173-180}$ "TQNRQIDR" shown in SEQ ID NO: 6 and/or to SNAP-25_{180}, to the epitope SNAP-$25_{174-180}$ "QNRQIDR" shown in SEQ ID NO: 7 and/or to SNAP-25_{180}, or to the epitope SNAP-$25_{175-180}$ "NRQIDR" shown in SEQ ID NO: 8 and/or to SNAP-25_{180}.

[0022] In one aspect of the monoclonal antibody of the invention, the monoclonal antibody is produced by the hybridoma cell line pCNEI 32-7-1, 3614-000 which has been deposited by the Applicant under the Budapest Treaty on December 17, 2014, at DSMZ – Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH, Inhoffenstraße 7 B, 38124 Braunschweig, Germany under the accession number DSM ACC3261.

[0023] In a further aspect of the polyclonal or monoclonal antibody of the invention, the antibody has an equilibrium dissociation constant for BoNT/E-cleaved SNAP-25 of less than

100 nM, less than 50 nM less than 10 nM, less than 5 nM, less than 2 nM, less than 1 nM or preferably less than 0.5 nM.

[0024] In a still further aspect of the polyclonal or monoclonal antibody of the invention, the equilibrium dissociation constant of the antibody for BoNT/E-cleaved SNAP-25 is at least 10-fold, at least 50-fold or preferably at least 100-fold higher than for SNAP-25 not cleaved by BoNT/E, i.e. non-cleaved SNAP-25.

[0025] In another aspect of the polyclonal or monoclonal antibody of the invention, the antibody comprises at least one of the complementarity determining regions (CDRs) selected from CDR-L1 (SEQ ID NO. 15), CDR-L2 (SEQ ID NO. 16), CDR-L3 (SEQ ID NO. 17), CDR-H1 (SEQ ID NO. 18), CDR-H2 (SEQ ID NO. 19) and CDR-H3 (SEQ ID NO. 20) comprised by the monoclonal antibody produced by the hybridoma cell line pCNEI 32-7-1, 3614-000 deposited under the accession number DSM ACC3261. Preferably, the antibody comprises two, three, four, five or all six of the indicated CDRs.

[0026] In still another aspect of the polyclonal or monoclonal antibody of the invention, the antibody comprises the VH domain or VH region (SEQ ID NO. 22) and/or the VL domain or VL region (SEQ ID NO. 21) comprised by the monoclonal antibody produced by the hybridoma cell line pCNEI 32-7-1, 3614-000 deposited under the accession number DSM ACC3261.

[0027] In these aspects, the present invention relates to an antibody or a fragment thereof, which specifically binds to the cleavage site of the BoNT/E-cleaved SNAP-25 and which comprises a heavy chain variable region (VH) comprising an amino acid sequence shown in SEQ ID NO. 22 and/or a light chain variable region (VL) comprising an amino acid sequence shown in SEQ ID NO. 21, comprised by the monoclonal antibody produced by the hybridoma cell line pCNEI 32-7-1, 3614-000 deposited under the accession number DSM ACC3261. Further encompassed by the invention are antibodies or fragments thereof which comprise one, two or three complementarity determining regions (CDRs) of said heavy chain and/or light chain variable region(s) or domain(s). The corresponding sequences of the CDR-H1 (SEQ ID NO. 18), CDR-H2 (SEQ ID NO. 19) and CDR-H3 (SEQ ID NO. 20) and the corresponding sequences of the CDR-L1 (SEQ ID NO. 15), CDR-L2 (SEQ ID NO. 16) and CDR-L3 (SEQ ID NO. 17), respectively, are comprised by the monoclonal antibody produced by the hybridoma cell line pCNEI 32-7-1, 3614-000 deposited under the accession number DSM ACC3261.

[0028] Preferably, the antibody of the invention is a monoclonal antibody. More preferably, the monoclonal antibody is the mouse monoclonal antibody generated and characterized in the following Examples, i.e. the monoclonal antibody produced by the hybridoma cell line

pCNEI 32-7-1, 3614-000 deposited under the accession number DSM ACC3261. The above mentioned CDR, VH and VL sequences are the corresponding sequences of said antibody.

[0029] In a further aspect, the invention provides for a method for directly determining the biological activity of BoNT/E in cells, comprising the steps of:

a) incubating cells susceptible to BoNT/E intoxication with BoNT/E for a time and under conditions which allow for the BoNT/E to exert its biological activity;

b) fixing the cells and, optionally, permeabilizing the cells with a detergent;

c) contacting the cells with at least a first capture antibody specifically binding to non-cleaved and BoNT/E-cleaved SNAP-25, and with at least a second capture antibody specifically binding to BoNT/E-cleaved SNAP-25, under conditions which allow for binding of the first capture antibody to non-cleaved and BoNT/E-cleaved SNAP-25 and for binding of the second capture antibody to BoNT/E-cleaved SNAP-25;

d) contacting the cells with at least a first detection antibody specifically binding to the first capture antibody, under conditions which allow for binding of said first detection antibody to said first capture antibody, thus forming first detection complexes and with at least a second detection antibody specifically binding to the second capture antibody, under conditions which allow for binding of said second detection antibody to said second capture antibody, thus forming second detection complexes, and wherein the first detection antibody is different from the second detection antibody;

e) determining the amount of the first and second detection complexes of step d); and

f) calculating the amount of SNAP-25 cleaved by BoNT/E in said cells by means of the second detection complexes,

thereby determining the biological activity of said BoNT/E in said cells.

[0030] In one aspect of the method of the invention, the second capture antibody used in step c) is the polyclonal or monoclonal antibody of the invention. In another aspect of the method of the invention, the second capture antibody used in step c) is a BoNT/E cleavage site-specific antibody as described in Jones et al., Journal of Immunological Methods 329 (2008), p. 92-101.

[0031] In the method of the invention, the BoNT/E-cleaved SNAP-25 can be directly detected in the cell(s). To this end, cells which are susceptible to BoNT/E intoxication as defined in more detail elsewhere herein are incubated with a BoNT/E Neurotoxin polypeptide for a time and under conditions which allow for the BoNT/E Neurotoxin polypeptide to exert

its biological activity. In a next step, the cells are fixed and, depending on the used fixation agent, permeabilized, for example, by addition of a fixation agent such as methanol, ethanol, acetone, formaldehyde or mixtures of the mentioned fixation agents. Optionally, the cells can be additionally permeabilized by using at least one detergent as defined elsewhere herein such as Triton X-100, Tween 20, Saponin, Digitonin or n-Octyl-ß-glucopyranoside. The detergent can be comprised in an appropriate buffer such as PBS. Thereafter, the cells are contacted with at least a first capture antibody which specifically binds to the BoNT/E non-cleaved and BoNT/E-cleaved SNAP-25 and with at least a second capture antibody specifically binding to BoNT/E-cleaved SNAP-25, e.g. an antibody specifically binding to the cleavage site of the BoNT/E-cleaved SNAP-25, under conditions which allow for binding of said first capture antibody to the non-cleaved and BoNT/E-cleaved SNAP-25 and the second capture antibody to BoNT/E-cleaved SNAP-25. Suitable epitopes, BoNT/E cleavage sites in SNAP-25 and methods for the generation of antibodies specifically binding to BoNT/E-cleaved SNAP-25 are described elsewhere herein. In addition, the present inventors have generated and characterized a monoclonal antibody which specifically binds to BoNT/E-cleaved SNAP-25, in the following Examples. Said antibody has high binding specificity for the SNAP-25_{180} cleavage product that allows for the preferential recognition of this cleavage product relative to the SNAP-25_{206} uncleaved substrate. The first capture antibody is able to determine the total content or amount of the BoNT/E substrate SNAP-25 in the cells, by binding specifically to an appropriate epitope present in both the BoNT/E non-cleaved and BoNT/E-cleaved SNAP-25. The second capture antibody recognizes and binds specifically to an epitope present only in the BoNT/E-cleaved SNAP-25 but not in the non-cleaved SNAP-25. Alternatively, the cells can be contacted with a mixture of said first and second capture antibodies, i.e. the cells are contacted with at least a first capture antibody and at least a second capture antibody simultaneously, under the mentioned conditions. In the next step, the cells are contacted with at least a first detection antibody specifically binding to the first capture antibody under conditions which allow for binding of said first detection antibody to said first capture antibody, thus forming first detection complexes. In a subsequent step, the cells are contacted with at least a second detection antibody specifically binding to the second capture antibody, under conditions which allow for binding of said second detection antibody to said second capture antibody, thus forming second detection complexes. Alternatively, the cells can be contacted with a mixture of said first and second detection antibodies, i.e. the cells are contacted with at least a first detection antibody and at least a second detection antibody simultaneously, under the mentioned conditions. Alternatively, permeabilized cells can be contacted with a mixture of said first and second capture antibodies and said first and second detection antibodies simultaneously, under the mentioned conditions. In the next step, the amounts of the first and second detection complexes are determined. Finally, the amount of SNAP-25 cleaved by BoNT/E in said cells is calculated by means of the second detection

complexes. The term „calculating“ as used in accordance with the method of the present invention relates to mathematical operations which allow for determining the amount of BoNT/E-cleaved SNAP-25 in the cell. Thereby, the biological activity of BoNT/E is determined directly in the cells. This means that no lysis of the cells and no isolation or concentration of the BoNT/E-cleaved SNAP-25 from cell lysates is necessary any longer, as in the methods described in the art. Further, the method of the invention is less time consuming, less laborious and more precise than, e.g., FRET-based assays used in the art.

[0032] The method of the invention is described in more detail, in the following. For cell culture, the cells susceptible to BoNT/E Neurotoxin polypeptide intoxication as defined herein, such as neuronal cells, SiMa cells or induced pluripotent stem cell (iPS)-derived neurons, are first seeded on 96 well microtiter plates. SiMa cells are differentiated to a neuronal phenotype, for example, according to the procedures disclosed in WO 2010/105234, and iPS-derived neurons are differentiated to a neuronal phenotype, e.g., according to assays described in WO 2012/135621. If necessary, the sensitivity, respectively homogeneity of the sensitivity of the cells susceptible to BoNT/E neurotoxin polypeptide could be optimized by using particular cell cultivation methods as disclosed in WO 2015/124618. Then, the cells are intoxicated with a BoNT/E Neurotoxin polypeptide for about 72 hours. In the subsequent step, the cells are fixed on the microtiter plate, prior to the ELISA assay. For fixing the cells, for example ice-cold methanol (-20 °C) can be added to the cells for 20 minutes at -20 °C.

[0033] For performing the ELISA assay, the cells are first washed. As a wash buffer, e.g., 10 mM PBS buffer (pH 7.4) can be used. Thereafter, endogenous proteases are quenched by a quenching buffer such as 0.6% H_2O_2 in 10 mM PBS (pH 7.4), followed by another wash step. In the following step, free binding sites on the microtiter plate are blocked by an appropriate blocking buffer such as, for instance, 2 % BSA in 10 mM PBS buffer (pH 7.4). Thereafter, the cells are washed by washing buffer as mentioned above.

[0034] In the next step, the fixed and permeabilized cells are incubated, e.g., with a mixture of two different antibodies. The mixture comprises a first capture antibody specifically binding to the BoNT/E non-cleaved and BoNT/E-cleaved substrate SNAP-25 and a second capture antibody specifically binding to the BoNT/E-cleaved SNAP-25, e.g. an antibody specifically binding to the BoNT/E cleavage site in the BoNT/E-cleaved SNAP-25. For this purpose, the polyclonal or monoclonal antibody of the invention is particularly suitable. Said first and second capture antibodies can also be applied subsequently. For example, the first capture antibody can specifically bind to both non-cleaved and BoNT/E-cleaved SNAP-25, thereby allowing for the quantification of the total amount or content of SNAP-25, i.e. BoNT/E-non-cleaved and BoNT/E-cleaved SNAP-25, in the cells. Further, this first capture antibody can be used for the normalization of the amount of BoNT/E-cleaved SNAP-25 in the

cells, upon evaluation as described herein. The second capture antibody specifically binds to BoNT/E-cleaved SNAP-25 and therefore allows for the determination and detection of the BoNT/E-cleaved SNAP-25.

[0035] The following detection of the total (BoNT/E-non-cleaved and BoNT/E-cleaved) SNAP-25 and the BoNT/E-cleaved SNAP-25 in the method of the invention can be carried out directly on the microtiter plate or cell culture dish, i.e. within the cells. Advantageously, it is therefore not necessary to prepare cell extracts and to isolate and/or concentrate the BoNT/E-cleaved SNAP-25 from the cell lysate in the method of the invention, as in the methods described in the art. Thereafter, the cells are washed in order to remove excess antibody not bound to the respective antigen. In the subsequent step, the permeabilized cells are contacted with at least a first detection antibody and at least a second detection antibody. Said antibodies can be applied as a mixture, i.e. simultaneously, or subsequently. The first detection antibody specifically binds to the first capture antibody. Thereby, first detection complexes are being formed. The first detection antibody can be directed against the species from which the first capture antibody is derived from. For example, in case the rabbit polyclonal anti-SNAP-25 antibody S9684 (Sigma) is used as a first capture antibody specifically binding to the BoNT/E-non-cleaved and BoNT/E-cleaved substrate SNAP-25, an anti-rabbit alkaline phosphatase-conjugated antibody can be used as a first detection antibody. The second detection antibody specifically binds to the second capture antibody. Thereby, second detection complexes are being formed. The second detection antibody can be directed against the species from which the second capture antibody is derived from. For instance, in case the mouse monoclonal antibody (mAb) generated and characterized in the following Examples is used as a second capture antibody specifically binding to the BoNT/E-cleaved SNAP-25, an anti-mouse horseradish peroxidase (HRP)-conjugated antibody can be used as a second detection antibody. It is clear for those skilled in the art that the first detection antibody and the second detection antibody are conjugated with different enzymes in order to allow for the specific detection of the respective first and second capture antibody as used in the method of the invention. For instance, the HRP-based detection as described elsewhere herein can be used for the BoNT/E-cleaved SNAP-25 and the alkaline phosphatase-based detection for the total (BoNT/E-cleaved and BoNT-E-non-cleaved) SNAP-25. Thereafter, the cells are washed again. In a subsequent step, a fluorogenic HRP substrate is added to the cells. As a HRP substrate, e.g., Amplex UltraRed (Invitrogen) can be used which is excited at 540 nm and which emits at 600 nm. Incubation with the HRP substrate is carried out for a time sufficient for sufficient conversion of substrate by the horseradish peroxidase. Subsequent to the incubation with the HRP substrate, for example, the AP substrate DiFMUP (6,8-difluoro-4-methylumbelliferyl phosphate; excitation 360 nm; emission 450 nm) can be added to the HRP substrate and the cells are incubated with a mixture of said two substrates. Incubation with said AP substrate is carried out for a time which allows for sufficient

conversion of substrate by the alkaline phosphatase. As known in the art, a substrate has to be converted in an amount which is sufficient so that the measured signal is at least as high as the mean value of the blank plus three standard deviations of the mean, according to the definition of limit of detection. The limit of detection can be determined as described in the literature; see, e.g., Armbruster and Pry, Clinical Biochem. Rev. 2008, 29 (Supplement 1): S49-S52. Because the pH optimum of the alkaline phosphatase is in the alkaline region, the corresponding substrate buffer is strongly alkaline. If the alkaline phosphatase substrate is added to the HRP substrate, the reaction of the horseradish peroxidase is stopped by the alkaline pH and the alkaline phosphatase converts DiFMUP. Converted HRP substrate is not influenced by the alkaline pH. Finally, the fluorescence of the two substrates is measured as follows:

Amplex UltraRed: Excitation 540 nm; emission 600 nm

DiFMUP: Excitation 360 nm; emission 450 nm

[0036] As appreciated by those skilled in the art, only those fluorogenic substrates are appropriate for detection of the first and second capture antibody in the method of the invention which exhibit different excitation/emission wave lengths of the used substrates. Only in this case, they allow for the specific detection of each antigen, i.e. the total SNAP-25 (BoNT/E non-cleaved and BoNT/E-cleaved SNAP-25) and the BoNT/E-cleaved SNAP-25. Thereby, it is possible to quantify the total content of SNAP-25 and the content of BoNT/E-cleaved SNAP-25 in every well or cell culture dish at the same time. In light of this, it is advantageously possible to automatize the method of the invention. As set forth elsewhere herein it is envisaged that the fluorogenic substrates chosen for the method of the invention exhibit a sufficient shift between the excitation/emission spectra in order to allow for the specific detection of the respective substrate. This requirement is fulfilled, for example, for the HRP substrate Amplex and its derivatives and for the AP substrate DiFMUP. Whereas, in an optimal case, there is no overlap between the excitation/emission spectra of the used fluorogenic substrates, it has been experienced that an overlap of up to 30 % in the peak area of the excitation spectra of the used fluorogenic substrates is tolerable.

[0037] As further acknowledged by those skilled in the art, the method of the present invention allows for the direct detection and quantification of the substrate SNAP-25 cleaved by the Neurotoxin polypeptide BoNT/E in the cells, thereby determining the biological activity of said BoNT/E Neurotoxin polypeptide in said cells. Advantageously, the method of the invention does not require the preparation of cell lysates or extracts and the isolation or concentration of the BoNT/E-cleaved SNAP-25 from the cell lysates/extracts, which is necessary for the methods and assays known in the art. As a consequence of this, sample material can be saved. Further, the sample preparation and the number of samples can be

reduced by the method of the invention since the amount of total SNAP-25 and the amount of BoNT/E-cleaved SNAP-25 in the sample can be determined at the same time. In the assays described in the art, the samples have to be subdivided in order to detect both antigens, i.e. total Neurotoxin substrate and cleaved Neurotoxin substrate, separately from each other. The method of the invention renders the subdivision of the sample unnecessary. Thereby, inhomogeneities resulting from the subdivision of samples can be avoided and sample material can be saved. Furthermore, antigens can be degraded in the assays described in the art which can falsify the detection of the cleaved Neurotoxin substrate. This is because in the assays described in the art, the cells are incubated with detergent-containing lysis buffers which, however, are not able to inactivate the Neurotoxin polypeptide or other endogenous proteases resulting in degradation of the Neurotoxin substrate upon longer storage of the samples. Stronger lysis buffers cannot be used in the ECL sandwich ELISA described in the prior art due to the required use of the cell lysate in said assay. This is because the aggregation of the above-mentioned antigens can result in unspecific adsorption of the antigens to the plastic surface of the cell culture dishes or microtiter plates which in turn disturbs the detection of the antigens by appropriate antibodies. Since the antibodies for the detection of the antigens get into contact with the lysate, too, the antibodies can also aggregate. In this case, no reliable and accurate detection of the antigen is possible anymore. The present inventors have experienced such degradation reactions by using Western blot assays for the detection of the biological activity of Neurotoxin activity described in the art. Upon longer storage of lysates at -20 °C, in comparison to fresh lysate samples, the detection signal of total SNAP-25 has been found to be strongly reduced thereby reducing the sensitivity of the test system. It has been found by the present inventors that the degradation of SNAP-25 and/or the instability of the samples can be avoided by directly fixing the cells on the cell culture dish because both the BoNT/E Neurotoxin substrate SNAP-25 and the BoNT/E Neurotoxin or other endogenous proteases are inactivated immediately by aggregation on the cell culture dish. This can be achieved by using, for example, fixing of the cells by methanol or other fixatives or fixation agents known in the art, such as ethanol, acetone, formaldehyde or mixtures thereof or other fixation agents described herein. The analysis of the stability of, e.g., parental SiMa cells (human neuroblastoma cells; DSMZ no.: ACC 164) and iPS-derived neurons (Whitemarsh et al. (2012), Toxicol. Sci. 126, 426-35) using this fixation method did not reveal any differences between fresh and cell culture dishes stored seven days in the refrigerator.

[0038] As used herein, the singular forms “a”, “an” and “the” include both singular and plural reference unless the context clearly dictates otherwise. By way of example, “a cell” refers to one or more than one cell.

[0039] As used herein, the term "about" when qualifying a value of a stated item, number, percentage, or term refers to a range of plus or minus 10 percent, 9 percent, 8 percent, 7 percent, 6 percent, 5 percent, 4 percent, 3 percent, 2 percent or 1 percent of the value of the stated item, number, percentage, or term. Preferred is a range of plus or minus 10 percent.

[0040] The terms "comprising", "comprises" and "comprised of" as used herein are synonymous with "including", "includes" or "containing", "contains", and are inclusive or open-ended and do not exclude additional, non-recited members, elements or method steps. Evidently, the term "comprising" encompasses the term "consisting of". More specifically, the term "comprise" as used herein means that the claim encompasses all the listed elements or method steps, but may also include additional, unnamed elements or method steps. For example, a method comprising steps a), b) and c) encompasses, in its narrowest sense, a method which consists of steps a), b) and c). The phrase "consisting of" means that the composition (or device, or method) has the recited elements (or steps) and no more. In contrast, the term "comprises" can encompass also a method including further steps, e.g., steps d) and e), in addition to steps a), b) and c).

[0041] In case numerical ranges are used herein such as "in a concentration between 1 and 5 micromolar", the range includes not only 1 and 5 micromolar, but also any numerical value in between 1 and 5 micromolar, for example, 2, 3 and 4 micromolar.

[0042] The term "in vitro" as used herein denotes outside, or external to, the animal or human body. The term "in vitro" as used herein should be understood to include "ex vivo". The term "ex vivo" typically refers to tissues or cells removed from an animal or human body and maintained or propagated outside the body, e.g., in a culture vessel. The term "in vivo" as used herein denotes inside, or internal to, the animal or human body. Preferably, the method of the invention is an in vitro method.

[0043] The term "Neurotoxin polypeptide" as used herein denotes Clostridium botulinum and Clostridium tetani Neurotoxins, i.e. Botulinum toxins (BoNTs) and Tetanus toxin (TeNT). More specifically, said term means the BoNT/E Neurotoxin polypeptide or BoNT/E-MDM2 polypeptide if not stated otherwise. BoNT/E-MDM2 polypeptides and nucleic acid sequences encoding them have been defined and characterized in WO 2013/068476 the disclosure content of which is enclosed herewith by reference. Accordingly, the Neurotoxin polypeptide and, in particular, its light chain and heavy chain is derivable from BoNT/E. In an aspect, said light and heavy chain of the neurotoxin polypeptide are the light and heavy chain of a BoNT/E Neurotoxin. In another aspect, the polynucleotide encoding said Neurotoxin polypeptide comprises a nucleic acid sequence as shown in SEQ ID NO: 9 (nucleic acid sequence encoding BoNT/E), SEQ ID NO: 11 (nucleic acid sequence encoding a BoNT/E-MDM2 polypeptide) or SEQ ID NO: 13 (nucleic acid sequence encoding BoNT/E-MDM2

polypeptide). Moreover, encompassed is, in an aspect, a polynucleotide comprising a nucleic acid sequence encoding an amino acid sequence as shown in SEQ ID NO: 10 (BoNT/E), SEQ ID NO: 12 (BoNT/E-MDM2 polypeptide) or SEQ ID NO: 14 (BoNT/E-MDM2 polypeptide). Further encompassed is in an aspect of the means and methods of the present invention, a Neurotoxin polypeptide comprising or consisting of an amino acid sequence shown in SEQ ID NO: 10 (BoNT/E), SEQ ID NO: 12 (BoNT/E-MDM2 polypeptide) or SEQ ID NO: 14 (BoNT/E-MDM2 polypeptide). In a further aspect, the botulinum neurotoxin is a BoNT/E1 obtainable by using the codon-optimized nucleic acid sequence disclosed in WO 2014/068317.

[0044] In another aspect, the said polynucleotide is a variant of the aforementioned polynucleotide comprising one or more nucleotide substitutions, deletions and/or additions which in still another aspect may result in a polypeptide having one or more amino acid substitutions, deletions and/or additions. Moreover, a variant polynucleotide of the invention shall in another aspect comprise a nucleic acid sequence variant being at least 40%, at least 50%, at least 60%, at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 95%, at least 96%, at least 97%, at least 98% or at least 99% identical to the nucleic acid sequence as shown in SEQ ID NO: 9, 11 or 13, or a nucleic acid sequence variant which encodes an amino acid sequence being at least 40%, at least 50%, at least 60%, at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 95%, at least 96%, at least 97%, at least 98% or at least 99% identical to the amino acid sequence as shown in SEQ ID NO: 10, SEQ ID NO: 12 or SEQ ID NO: 14. The term "identical" as used herein refers to sequence identity characterized by determining the number of identical amino acids between two nucleic acid sequences or two amino acid sequences wherein the sequences are aligned so that the highest order match is obtained. It can be calculated using published techniques or methods codified in computer programs such as, for example, BLASTP, BLASTN or FASTA (Altschul 1990, J Mol Biol 215, 403). The percent identity values are, in one aspect, calculated over the entire amino acid sequence. A series of programs based on a variety of algorithms is available to the skilled worker for comparing different sequences. In this context, the algorithms of Needleman and Wunsch or Smith and Waterman give particularly reliable results. To carry out the sequence alignments, the program PileUp (Higgins 1989, CABIOS 5, 151) or the programs Gap and BestFit (Needleman 1970, J Mol Biol 48; 443; Smith 1981, Adv Appl Math 2, 482), which are part of the GCG software packet (Genetics Computer Group 1991, 575 Science Drive, Madison, Wisconsin, USA 53711), may be used. The sequence identity values recited above in percent (%) are to be determined, in another aspect of the invention, using the program GAP over the entire sequence region with the following settings: Gap Weight: 50, Length Weight: 3, Average Match: 10.000 and Average Mismatch: 0.000, which, unless otherwise specified, shall always be used as standard settings for sequence alignments. In an aspect, each of the aforementioned variant polynucleotides

encodes a polypeptide retaining one or more and, in another aspect, all of the biological properties of the BoNT/E Neurotoxin polypeptide or the BoNT/E-MDM2 polypeptide. Those of skill in the art will appreciate that full biological activity is maintained only after proteolytic activation, even though it is conceivable that the unprocessed precursor can exert some biological functions or be partially active. "Biological properties" as used herein refers to (a) receptor binding, (b) internalization, (c) translocation across the endosomal membrane into the cytosol, and/or (d) endoproteolytic cleavage of proteins involved in synaptic vesicle membrane fusion. In vivo assays for assessing biological activity include the mouse LD50 assay and the ex vivo mouse hemidiaphragm assay as described by Pearce et al. (Pearce 1994, Toxicol. Appl. Pharmacol. 128: 69-77) and Dressler et al. (Dressler 2005, Mov. Disord. 20:1617-1619, Keller 2006, Neuroscience 139: 629-637). The biological activity is commonly expressed in Mouse Units (MU). As used herein, 1 MU is the amount of neurotoxic component, which kills 50% of a specified mouse population after intraperitoneal injection, i.e. the mouse i.p. LD50. In a further aspect, the variant polynucleotides can encode BoNT/E Neurotoxins or BoNT/E-MDM2 polypeptides having improved or altered biological properties, e.g., they may comprise cleavage sites which are improved for enzyme recognition, may be improved for receptor binding, may have an altered, e.g., prolonged or reduced duration of biological activity, or any other property specified above.

[0045] Accordingly, the term “biological activity of a BoNT/E Neurotoxin polypeptide or a BoNT/E-MDM2 polypeptide” as used herein means the biological properties characteristic for a BoNT/E Neurotoxin polypeptide, namely, a) receptor binding, (b) internalization, (c) translocation across the endosomal membrane into the cytosol, and/or (d) endoproteolytic cleavage of proteins involved in synaptic vesicle membrane fusion. It is envisaged that the BoNT/E Neurotoxin polypeptide or BoNT/E-MDM2 polypeptide as used herein exhibits at least one of the properties a) to d) mentioned above, preferably endoproteolytic cleavage of proteins involved in synaptic vesicle membrane fusion, or two or three or all four biological properties listed in a) to d).

[0046] Aspects of the present disclosure comprise, in part, a cell from an established cell line. As used herein, the term “cell” refers to any eukaryotic cell susceptible to intoxication by a BoNT/E Neurotoxin polypeptide or BoNT/E-MDM2 polypeptide or any eukaryotic cell that can uptake a BoNT/E Neurotoxin polypeptide or BoNT/E-MDM2 polypeptide. The term cell encompasses cells from a variety of organisms, such as, e.g., murine, rat, porcine, bovine, equine, primate and human cells; from a variety of cell types such as, e.g., neuronal and non-neuronal; and can be isolated from or part of a heterogeneous cell population, tissue or organism. As used herein, the term “established cell line” is synonymous with “immortal cell line” or “transformed cell line” and refers to a cell culture of cells selected for indefinite propagation from a cell population derived from an organism, tissue, or organ source. By

definition, an established cell line excludes a cell culture of primary cells. As used herein, the term "primary cells" are cells harvested directly from fresh tissues or organs and do not have the potential to propagate indefinitely. For example, primary neuronal cells can be used in the method of the invention. An established cell line can comprise a heterogeneous population of cells or a uniform population of cells. An established cell line derived from a single cell is referred to as a clonal cell line. An established cell line can be one whose cells endogenously express all component necessary for the cells to undergo the overall cellular mechanism whereby a Neurotoxin polypeptide, such as BoNT/E, proteolytically cleaves a substrate, such as SNAP-25, and encompasses the binding of a Neurotoxin to a Neurotoxin receptor, such as BoNT/E to a BoNT/E receptor, the internalization of the neurotoxin/receptor complex, the translocation of the BoNT/E Neurotoxin light chain from an intracellular vesicle into the cytoplasm and the proteolytic cleavage of the BoNT/E Neurotoxin substrate SNAP-25. Alternatively, an established cell line can be one whose cells have had introduced from an exogenous source at least one component necessary for the cells to undergo the overall cellular mechanism whereby a Neurotoxin, such as BoNT/E, proteolytically cleaves a substrate, such as SNAP-25, and encompasses the binding of a Neurotoxin to a receptor, such as BoNT/E to a BoNT/E receptor, the internalization of the neurotoxin/receptor complex, the translocation of the BoNT/E Neurotoxin light chain from an intracellular vesicle into the cytoplasm and the proteolytic cleavage of the BoNT/E Neurotoxin substrate SNAP-25. Also referred to as a genetically-engineered cell line, cells from such an established cell line may, e.g., express an exogenous FGFR2, an exogenous FGFR3, an exogenous SV2, an exogenous Neurotoxin substrate SNAP-25, or any combination thereof.

[0047] The term "cell(s) susceptible to BoNT/E Neurotoxin intoxication" as denoted herein means a cell that can undergo the overall cellular mechanisms whereby a BoNT/E Neurotoxin polypeptide cleaves the BoNT/E Neurotoxin substrate SNAP-25 and encompasses the binding of the BoNT/E Neurotoxin to a BoNT/E receptor, the internalization of the Neurotoxin/receptor complex, the translocation of the BoNT/E Neurotoxin light chain from an intracellular vesicle into the cytoplasm and the proteolytic cleavage of the BoNT/E Neurotoxin substrate SNAP-25. Assays for determining the biological activity of BoNT/E Neurotoxin polypeptides are well known in the art and also described elsewhere herein; see, e.g., Pellett et al. (2011), Biochem. Biophys. Res. Commun. 404, 388-392; Whitemarsh et al. (2012), Toxicol. Sci. 126, 426-35. Accordingly, a "cell susceptible to BoNT/E Neurotoxin intoxication" as used herein means a BoNT/E Neurotoxin sensitive cell. The mentioned term comprises a cell or a cell line, for example, an isolated, primary cell or a cell line thereof or a cell of an established cell line or an established cell line, for example, tumor cells or tumor cell lines which are capable of differentiating to neuronal cells, such as neuroblastoma cells or neuroblastoma cell lines as defined elsewhere herein. For example, said neuroblastoma cell line can be a SiMa cell line which is commercially available from DSMZ (ACC 164).

Specific clones of the cell line SiMa are furthermore disclosed in WO 2010/105234. Other neuroblastoma cell lines which can be used in the method of the invention can be obtained from ATCC or DSMZ, under the following ATCC or DSMZ numbers: Cell line N1E-115 under CRL-2263, cell line Neuro2a under CCL-131, cell line SH-SY5Y under CRL-2266, cell line PC12 under CRL-1721, cell line MHH-NB-11 under ACC 157 (DSMZ) and cell line SK-N-BE(2) under CRL-2271. Other tumor cells which are susceptible to Neurotoxin intoxication are P-19 cells (murine embryonal carcinoma cell line) (DSMZ no. ACC 316). Further encompassed by cells susceptible to BoNT/E Neurotoxin intoxication are induced pluripotent stem cell (iPS)-derived neurons, preferably human induced pluripotent stem cell (iPS)-derived neurons; see, e.g., Whitemarsh et al. (2012), loc. cit. Such human iPS-derived neurons are also commercially available, for instance, from Cellular Dynamics. Methods of generating iPS cells are described, for example, in Yu et al. (Science 2009 May 8; 324(5928): 797-801. Epub 2009), WO 2011/056971 and WO 2011/025852. In some aspects, iPS are differentiated into neurons using suitable methods, e.g., those described in WO 2012/135621 and U.S. Patent Applications US 2010/0279403 and US 2010/0216181.

[0048] The term “fixing the cells” or “fixation of cells” means fixing the cells using methods described in the art. Generally, fixation is a chemical process by which biological tissues are preserved from decay, thereby preventing autolysis. Fixation terminates any ongoing biochemical reactions, and may also increase the mechanical strength or stability of the treated tissues. Fixation preserves a sample of biological material such as a tissue or cells as close to its natural state as possible in the process of preparing said tissue or cells for examination or analysis. To this end, a fixative usually acts to disable intrinsic biomolecules - particularly proteolytic enzymes – which otherwise digests or damages the sample. Further, a fixative typically protects a sample from extrinsic damage. Fixatives are toxic to most common microorganisms including bacteria that might exist in a tissue or cell culture or which might otherwise colonize the fixed tissue or cell culture. In addition, many fixatives chemically alter the fixed material to make it less palatable either indigestible or toxic to opportunistic microorganisms. Finally, fixatives often alter the cells or tissues on a molecular level to increase their mechanical strength or stability. This increased strength and rigidity can help preserve the morphology such as shape and structure of the sample as it is processed for further analysis. It is evident to those skilled in the art that the choice of fixative and fixation protocol may depend on the additional processing steps and final analyses that are planned. For example, immunohistochemistry uses antibodies that bind specifically to a specific protein target, the antigen. Prolonged fixation can chemically mask these targets and prevent antibody binding. In these cases, for example, a quick fixation method using cold formalin can be used. Alternatively, the cells can be fixed by adding ice-cold methanol (-20 °C). Besides aldehydes such as formaldehyde or glutaraldehyde and alcohols such as ethanol or methanol, oxidizing agents, HEPES-glutamic acid buffer-mediated organic solvent protection

effect (HOPE) fixative, acetone, or mixtures thereof, such as a mixture of methanol and acetone, methanol and ethanol, paraformaldehyde and Triton X-100, or paraformaldehyde and methanol, can be used in fixation protocols. In one aspect of the method of the invention, fixing the cells is carried out by the addition of a fixation agent selected from the group consisting of: methanol, ethanol, acetone, formaldehyde or mixtures thereof. To ensure and/or support free access of the antibody to its antigen, the cells can, optionally, be permeabilized by using an appropriate permeabilization buffer comprising at least one detergent, such as Triton X-100. A permeabilization buffer which can be used in the method of the invention is, e.g., 0.5% Triton X-100 in 10mM PBS buffer. In other aspects of the methods of the invention, the cells can be permeabilized by using a permeabilization buffer such as PBS comprising at least one detergent selected from Tween 20, Saponin, Digitonin or n-Octyl-ß-glucopyranoside. In other aspects, mixtures of two or more of the detergents mentioned herein can be used in the said permeabilization buffer. In general, fixation strengths and times are considerably shorter for cells than on the thicker, structurally complex tissue sections. For immunocytochemistry, sample preparation essentially entails fixing the target cells to the slide, cell culture dish or microtiter plate. Perfect fixation would immobilize the antigens, while retaining authentic cellular and subcellular architecture and permitting unhindered access of antibodies to all cells and subcellular compartments. Wide ranges of fixatives as exemplified above are commonly used, and the correct choice of method will depend on the nature of the antigen being examined and on the properties of the antibody used. Fixation methods fall generally into two classes: organic solvents and cross-linking reagents. Organic solvents such as alcohols and acetone remove lipids and dehydrate the cells, while precipitating the proteins on the cellular architecture. Cross-linking reagents such as paraformaldehyde form intermolecular bridges, normally through free amino groups, thus creating a network of linked antigens. Cross-linkers preserve cell structure better than organic solvents, but may reduce the antigenicity of some cell components, and often require the addition of a permeabilization step as indicated above, to allow access of the antibody to the specimen. Fixation with both methods may denature protein antigens, and for this reason, antibodies prepared against denatured proteins may be more useful for cell staining. The appropriate fixation method should be chosen according to the relevant application. Fixing methods of cells are well described in the art and thus known to those skilled in the art; see, e.g., Methods in cell biology, Volume 37: Antibodies in cell biology; Edited by David J. Asai; 1993, Academic Press Inc.

[0049] The term “contacting” as used in accordance with the method of the invention means bringing the cells and the respective antibodies in physical proximity as to allow physical and/or chemical interaction. Suitable conditions which allow for such specific interaction are well known to the person skilled in the art. Evidently, said conditions will depend on the antibodies and the cells to be applied in the method of the present invention and can be

adapted routinely by the person skilled in the art. Moreover, a time being sufficient to allow interaction can also be determined by the skilled worker without further ado. It is to be understood that between the individual steps of contacting the cells and the respective antibodies recited in the method of the present invention, washing steps may be performed in order to obtain suitable conditions for contacting. For example, after contacting the cells with at least a first capture antibody specifically to the BoNT/E non-cleaved and BoNT/E-cleaved substrate SNAP-25 and with at least a second capture antibody specifically binding to the BoNT/E-cleaved substrate SNAP-25 in step c) of the method of the invention, a washing step can be incorporated to remove the remaining solution and/or excess first and second capture antibody, prior to applying the first detection antibody and/or second detection antibody. Similarly, after bringing the cells into contact with the first and/or second detection antibody in the method of the invention, a wash step can be included. An appropriate wash buffer is, for example, 10 mM PBS buffer (pH 7.4). More specifically, the term „contacting" used herein, refers to bringing the cells into contact with at least a first capture antibody specifically binding to the BoNT/E non-cleaved and BoNT/E-cleaved substrate SNAP-25 and with at least a second capture antibody specifically binding to BoNT/E-cleaved SNAP-25, under conditions which allow for binding of said capture antibodies to said SNAP-25, in step c) of the method of the invention. The first and second capture antibody can be applied to the cells simultaneously, for example, as a mixture, or subsequently. "Contacting" further refers to bringing into contact the cells with at least a first detection antibody specifically binding to the first capture antibody, under conditions which allow for binding of said first detection antibody to said first capture antibody, and at least a second detection antibody specifically binding to the second capture antibody, under conditions which allow for binding of said second detection antibody to said second capture antibody, in step d) of the method of the invention. Thereby, first and second detection complexes are being formed. Alternatively, the first and second detection antibodies can also be applied subsequently.

[0050] According to the method of the present invention, the "first capture antibody" specifically binds to an epitope comprised by the BoNT/E non-cleaved and BoNT/E-cleaved substrate SNAP-25. SNAP-25 is a known substrate of BoNT/E. Said first capture antibody allows for the determination of the total amount, i.e. complete content of SNAP-25 in the cells in that it specifically binds to an epitope available both in uncleaved SNAP-25 and in BoNT-E-cleaved SNAP-25. For BoNT/E, an epitope positioned N-terminally to the BoNT/E cleavage site (Arg (R) 180 – Ile (I) 181), i.e. between amino acid residues 1 and 180 of SNAP-25 can be used for the first capture antibody.

[0051] In an aspect of the method of the invention, SNAP-25 is human SNAP-25A or B or a homolog, paralog or ortholog thereof from rat, mouse, bovine, Danio, Carassius, Xenopus, Torpedo, Strongylocentrotus, Loligo, Lymnaea, Macaca mulatta (Rhesus macaque), Pan

troglodytes or Aplysia. The corresponding amino acid sequences of murine and human SNAP-25 are shown, e.g., in UniProt accession no. P60879 and P60880, respectively. SNAP-25 can be used as a naturally occurring, recombinant, exogenous or endogenous nucleic acid molecule or polypeptide. BoNT/E cleavage sites in the above-indicated SNAP-25 proteins are disclosed, for example, in EP 1 926 744 B1.

[0052] Examples for appropriate antibodies which can be used as first capture antibodies in the method of the invention include, for example, the rabbit polyclonal anti-SNAP-25 antibody S9684 (Sigma) (Fernández-Salas E, Wang J, Molina Y, Nelson JB, Jacky BPS, et al. (2012) Botulinum Neurotoxin Serotype a Specific Cell-Based Potency Assay to Replace the Mouse Bioassay. PLoS ONE 7(11): e49516. doi:10.1371/journal.pone.0049516), the rabbit polyclonal anti-SNAP25 antibody PA5-19708 (Pierce Antibodies), the rabbit monoclonal anti-SNAP25 antibody ab108990 (Abcam), or the rabbit polyclonal anti-SNAP25 antibody PA5-19701 (Pierce Antibodies)

[0053] In another aspect of the method of the invention, the first capture antibody specifically binding to the BoNT/E non-cleaved and BoNT/E-cleaved substrate SNAP-25 can have an association rate constant of, e.g., less than 1 x 10^5 M^{-1} s^{-1}, less than 1 x 10^6 M^{-1} s^{-1}, less than 1 x 10^7 M^{-1} s^{-1} or less than 1 x 10^8 M^{-1} s^{-1}. In another aspect, the first capture antibody specifically binding to the BoNT/E non-cleaved and BoNT/E-cleaved substrate SNAP-25 can have an association rate constant of, e.g., more than 1 x 10^5 M^{-1} s^{-1}, more than 1 x 10^6 M^{-1} s^{-1}, more than 1 x 10^7 M^{-1} s^{-1} or more than 1 x 10^8 M^{-1} s^{-1}. In a further aspect, the first capture antibody specifically binding to the BoNT/E non-cleaved and BoNT/E-cleaved substrate SNAP-25 can have a dissociation rate constant of, e.g., less than 1 x 10^{-3} s^{-1}, less than 1 x 10^{-4} s^{-1}, less than 1 x 10^{-5} s^{-1} or less than 1 x 10^{-6} s^{-1}. In a still further aspect, the first capture antibody specifically binding to the BoNT/E non-cleaved and BoNT/E-cleaved substrate SNAP-25 can have a dissociation rate constant of, e.g., more than 1 x 10^{-3} s^{-1}, more than 1 x 10^{-4} s^{-1}, more than 1 x 10^{-5} s^{-1} or more than 1 x 10^{-6} s^{-1}. As known in the art, the association rate constant is a constant used to characterize how quickly the antibody binds to its target. The dissociation rate constant is a constant used to characterize how quickly the antibody dissociates from its target.

[0054] In a further aspect, the first capture antibody is used for normalization of the BoNT/E-cleaved SNAP-25 in the cell.

[0055] In a further aspect of the method of the invention, the second capture antibody specifically binding to the BoNT/E-cleaved SNAP-25 is a polyclonal or monoclonal antibody of the invention. Accordingly, the definitions and embodiments with respect to the antibody of the invention apply mutatis mutandis to the second capture antibody used in the method of the present invention. In another aspect of the method of the invention, the second capture

antibody is a BoNT/E cleavage site-specific antibody as described in Jones et al., Journal of Immunological Methods 329 (2008), p. 92-101.

[0056] The term "first detection antibody" as used herein is an antibody specifically binding to the first capture antibody. Said first detection antibody allows for the specific detection of the first capture antibody. By measuring the amount of bound first detection antibody, the amount of first detection complexes can be determined since the amount of bound first detection antibody in the first detection complex correlates with the amount of first capture antibody (and accordingly the amount of total SNAP-25, i.e. BoNT/E-cleaved and non-cleaved SNAP-25) comprised by the first detection complex. For example, an appropriate species-specific antibody can be used as a first detection antibody: If a mouse antibody has been used as a first capture antibody, said first detection antibody can be an anti-mouse antibody specifically binding to the mouse antibody. The first detection antibody can be, for instance, an alkaline phosphatase (AP)-conjugated antibody, a horseradish-peroxidase (HRP)-conjugated antibody or an antibody conjugated to a fluorescence dye. Conjugation of enzymes to antibodies, for example, by using glutaraldehyde is well known in the art.

[0057] Enzyme linked immunosorbent assays (ELISA) have been used to quantitate a wide range of compounds and pathogens for almost 40 years. Initially, radioactivity was used to quantitate the assays, but radio-immunoassays (RIA) have been replaced with assays utilizing enzymes to obtain colorimetric results. Recently, new substrates have been developed to produce fluorescent and luminescent products. The basic tenet of the new assays remains the same as colorimetric assays: The substrate is converted into a measurable compound by the enzymatic activity of proteins conjugated to an antibody, which confers specificity.

[0058] Commonly used enzyme conjugates in ELISA are alkaline phosphatase or horseradish peroxidase. Accordingly, in one aspect, the first detection antibody can be, for instance, conjugated to alkaline phosphatase or horseradish peroxidase. Further examples of enzyme conjugates which can be used as a first detection antibody in the method of the invention include glucose oxidase which uses glucose as substrate, tyrosinase which converts the substrate 1-(4-Methyl-coumarin-7-yl)-3-(4-hydroxyphenyl)urea) (PAP-AMC) (Stratis Avrameas, Immunochemistry, Volume 6, Issue 1, January 1969, Pages 43–48, IN9–IN11, 49–52) or ß-galactosidase which converts the substrate 6,8-difluoro-4-methylumbelliferyl ß-d-galactopyranoside (DiFMUG) (Gee et al., Analytical Biochemistry, Volume 273, Issue 1, August 1999, pages 41-48). Upon addition of a substrate, said substrate is converted by the enzyme to a detectable form. For example, alkaline phosphatase catalyzes the cleavage of esters of phosphoric acid. If an alkaline phosphatase (AP)-conjugated antibody is used as a first detection antibody, an appropriate substrate such as a 4-methylumbelliferryl phosphate derivative, e.g., 6,8-Difluoro-4-methylumbelliferyl phosphate (DiFMUP), or fluorescein

diphosphate (FDP). 6,8-difluoro-4-methylumbelliferyl phosphate (DiFMUP) is converted by the AP to a detectable form, i.e. the fluorogenic product 6,8-difluoro-4-methylumbelliferone. Said substrate is provided, e.g., by Molecular Probes. Fluorescence intensities of this reaction product of DiFMUP can be measured using excitation/emission maxima of about 358/450 nm. Further substrates which can be used for this purpose are 9H-(1,3-dichloro-9,9-dimethylacridin-2-one-7-yl) phosphate (DDAO-phosphate; Invitrogen), fluorescein diphosphate (FDP; Sigma Aldrich) or 4-methylumbelliferyl phosphate (MUP; Invitrogen). DDAO-phosphate is converted by the AP to the fluorogenic product dimethylacridinone (DDAO), having an excitation/emission maxima of about 646/659 nm. If FDP is used as substrate for the AP, the reaction product is fluorescein, having an excitation/emission maximum of about 490/514 nm. For MUP, the corresponding reaction product is 4-methylumbelliferone (7-hydroxy-4-methylcoumarin), having an excitation/emission maxima of about 360/449 nm. Also these substrates are commercially available, e.g. from Molecular Probes. Alternatively, horseradish peroxidase can be used as enzyme conjugate in the first detection antibody of the method of the invention. Horseradish peroxidase (HRP) catalyzes the reduction of hydrogen peroxide (H_2O_2) to water (H_2O). In the presence of specific substrates, which act as hydrogen donors, the action of HRP converts colorless or non-fluorescent molecules into colored and/or fluorescent moieties respectively. For instance, Amplex® Red (Life Technologies) is a substrate for use with HRP containing assays. Amplex Red, in the presence of peroxidase enzyme, reacts with H_2O_2 in a 1:1 stoichiometry to produce resorufin, a red fluorescent compound which has an absorption and fluorescence emission maxima of 563 nm and 587 nm, respectively. Another example for a HRP substrate is Amplex® UltraRed (Life Technologies). It has been reported that Amplex® UltraRed reagent (excitation/emission of ~570/585 nm) improves upon the performance of the Amplex® Red reagent, offering brighter fluorescence and enhanced sensitivity on a per-mole basis in horseradish peroxidase or horseradish peroxidase-coupled enzyme assays. Fluorescence of the oxidized Amplex® UltraRed reagent (Amplex® UltroxRed reagent) is also less sensitive to pH, and the substrate and its oxidation product exhibit greater stability that the Amplex® Red reagent in the presence of hydrogen peroxide (H_2O_2) or thiols such as dithiothreitol (DTT). Further appropriate HRP substrates which can be used in the method of the invention include, e.g., 10-Acetyl-3,7-Dihydroxyphenoxazine (ADHP; AnaSpec) or 3-(4-Hydroxyphenyl) propionic acid (HPPA; AnaSpec) (Tuuminen et al. 1991, J. Immunoassay 12, 29-46).

[0059] Alternatively, the first detection antibody can carry an appropriate, detectable label which allows for the detection of the first capture antibody. Labeling may be done by direct or indirect methods. Direct labeling involves binding of the label directly (covalently or non-covalently) to the first detection antibody. Indirect labeling involves binding (covalently or non-covalently) of an agent which specifically binds to the first detection antibody and which

carries a detectable label. Such an agent may be, e.g., a secondary (higher order) antibody which specifically binds to the first detection antibody. The secondary antibody in such a case will be coupled to a detectable label. It will be understood that further higher order antibodies can be used in addition for detection of the first detection complex. The higher order antibodies are often used to increase the signal. Suitable higher order antibodies may also include the well-known streptavidin-biotin system (Vector Laboratories, Inc.), and the well-known Dako LSAB™2 and LSAB™+ (labeled streptavidin-biotin), or Dako PAP (Peroxidase Anti-Peroxidase). In a further aspect, the said label of the first detection antibody is a fluorescent dye, i.e. the first antibody is conjugated to a fluorescent dye. In this case, the fluorescence can be directly measured by a fluorescence reader. Typical fluorescent labels include fluorescent proteins such as GFP and its derivatives, Cy dyes such as Cy3, or Cy5, Texas Red, Fluorescein, and the Alexa dyes, e.g. Alexa 568.

[0060] The "second detection antibody" as used herein is an antibody specifically binding to the second capture antibody. The second detection antibody can be, for instance, conjugated to an enzyme such as alkaline phosphatase, horseradish peroxidase, glucose oxidase or tyrosinase. Accordingly, in one aspect, the second detection antibody is an alkaline phosphatase (AP)-conjugated antibody, a horseradish-peroxidase (HRP)-conjugated antibody, an glucose oxidase-conjugated antibody or a tyrosinase-conjugated antibody. Said second detection antibody allows for the specific detection of the second capture antibody. By measuring the amount of bound second detection antibody, the amount of second detection complexes can be determined since the amount of bound second detection antibody in the second detection complex correlates with the amount of second capture antibody (and accordingly the amount of BoNT/E-cleaved SNAP-25) comprised by the second detection complex. For example, if a mouse antibody has been used as a second capture antibody, an anti-mouse antibody can be used as a second detection antibody. The second detection antibody can carry an enzyme as set forth above or a label such as a fluorescent dye (i.e. the second detection antibody is conjugated to a fluorescent dye) as mentioned elsewhere herein with respect to the first detection antibody. In one aspect of the method of the invention, the enzyme conjugated to the first detection antibody differs from the enzyme conjugated to the second detection antibody in order to allow the specific detection of the respective first and second capture antibody in the method of the invention. For instance, if the first detection antibody is an AP-conjugated antibody, the second detection antibody can be a horseradish peroxidase (HRP)-conjugated antibody or vice versa. Further, the excitation/emission spectra of the fluorogenic substrates of the AP and HRP do not substantially overlap but differ from each other, i.e. they show a clear shift so as to allow the distinction of the fluorescence intensities generated by the respective product. For example, DiFMUP exhibits excitation/emission at ~358/450 nm, whereas Amplex UltraRed exhibits excitation/emission of ~570/585 nm, thereby allowing for accurate measurements of the fluorescence intensities

generated by the conversion of said fluorogenic substrates by the respective enzyme. In a further aspect, the alkaline phosphatase (AP)-conjugated antibody is used as a first detection antibody for the antigen which is present in excess in the cell, i.e. for the measurement of the amount of the total (BoNT/E-cleaved and non-cleaved) SNAP-25, in the cell. The horseradish peroxidase (HRP)-conjugated antibody is used as a second detection antibody for the antigen which is present in the cell in a lower amount, i.e. for the measurement of the amount of the BoNT/E-cleaved SNAP-25, in the cell. As known in the art, HRP substrates are more sensitive than AP substrates meaning that lower amounts of analytes can be detected. If an HRP antibody is used as secondary antibody for the detection of BoNT/E-cleaved SNAP-25, lower amounts of BoNT/E-cleaved SNAP-25 are detectable. In turn, lower amounts of BoNT/E can be determined, thereby increasing the sensitivity of the assay. Because the AP antibody measures the total amount of SNAP-25 in the cell, high sensitivity for the substrate is not required, due to the excess of analyte.

[0061] The term "at least" as used herein such as, for example, "at least a first capture antibody" means that in addition to an antibody specifically binding to the non-cleaved and BoNT/E-cleaved substrate, one or more further antibodies with the mentioned specificity can be used in the method of the invention. Similarly, "at least a second capture antibody" means that in addition to an antibody of the invention specifically binding to the cleavage site of the BoNT/E-cleaved SNAP-25, one or more further antibodies with the mentioned specificity can be used in the method of the invention. Further, one or more first detection antibodies specifically binding to the first detection antibody (or first detection antibodies) can be used in the method of the invention. Similarly, one or more second detection antibodies specifically binding to the second detection antibody (or second detection antibodies) can be used in the method of the invention.

[0062] The term "first detection complex" refers to a complex comprising a first capture antibody and a first detection antibody which specifically binds to the non-cleaved and BoNT/E-cleaved SNAP-25, thereby allowing for the determination of the total content of SNAP-25 in the cell. The amount of first detection complex can be measured by determination of the amount of specifically bound first detection antibody. This can be achieved dependent on the nature of the enzyme or the label of the first detection antibody, e.g. by measuring the intensity of fluorescence.

[0063] The term "second detection complex" refers to a complex comprising the second capture antibody and the second detection antibody which specifically binds to the cleavage site of the BoNT/E-cleaved SNAP-25, thereby allowing for the determination of the content of BoNT/E-cleaved SNAP-25 in the cell. The amount of second detection complex can be measured by determination of the amount of specifically bound second detection antibody.

This can be achieved dependent on the nature of the enzyme or the label of the second detection antibody, e.g. by measuring the intensity of fluorescence.

[0064] It is envisioned that instead of enzyme-linked immunosorbent analysis (ELISA), any detection system can be used to practice aspects of the method of the invention, with the provision that the signal to noise ratio can distinguish to a statistically significant degree the signal from the formed antibody-antigen complexes from the background signal. Non-limiting examples of immuno-based detection systems include immunoblot analysis, like Western blotting and dot-blotting, immunoprecipitation analysis, and sandwich ELISA. The detection of the signal can be achieved using autoradiography with imaging or phosphorimaging (AU), bioluminescence (BL), fluorescence, resonance energy transfer, plane polarization, colormetric, or flow cytometry (FC). Descriptions of immuno-based detection systems are disclosed, for example, in Commonly Used Techniques in Molecular Cloning, pp. A8.1-A8-55 (Sambrook & Russell, eds., Molecular Cloning A Laboratory Manual, Vol. 3, 3.sup.rd ed. 2001); Detection Systems, pp. A9.1-A9-49 (Sambrook & Russell, eds., Molecular Cloning A Laboratory Manual, Vol. 3, 3.sup.rd ed. 2001).

[0065] In one aspect of the method of the invention, the method is a fluorescence method.

[0066] In a further aspect, the cells, antibodies such as the antibody of the invention, Neurotoxin polypeptides such as BoNT/E and Neurotoxin substrates such as SNAP-25 or any other product as referred to herein are isolated cells, antibodies, Neurotoxin polypeptides, Neurotoxin substrates or products, respectively. As used herein, the term “isolated” such as an isolated antibody refers to a molecule separated from its natural environment by the use of human intervention.

[0067] In one aspect of the method of the invention, the BoNT/E Neurotoxin polypeptide comprises an amino acid sequence selected from the group consisting of:

a) an amino acid sequence as shown in SEQ ID NO: 10, SEQ ID NO: 12 or SEQ ID NO: 14; and

b) an amino acid sequence which has at least 50%, 60%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98%, 99% or 100% sequence identity to the amino acid sequence as shown in SEQ ID NO: 10, SEQ ID NO: 12 or SEQ ID NO: 14.

[0068] In a further aspect of the method of the invention, the cells are neuronal cells or neuronal differentiated cells selected from the group consisting of: primary neuronal cells, tumor cells which are capable of differentiating to neuronal cells such as neuroblastoma cells, P19 cells or induced pluripotent stem cell (IPS)-derived neurons.

[0069] In a still further aspect of the method of the invention, fixing the cells is carried out by the addition of a fixation agent selected from the group consisting of: methanol, ethanol, acetone, formaldehyde or mixtures thereof.

[0070] In another aspect of the method of the invention, said first capture antibody specifically binding to the non-cleaved and BoNT/E-cleaved substrate is the rabbit polyclonal anti-SNAP-25 antibody S9684, the rabbit polyclonal anti-SNAP25 antibody PA5-19708 (Pierce Antibodies), the rabbit monoclonal anti-SNAP25 antibody ab108990 (Abcam) or the rabbit polyclonal anti-SNAP25 antibody PA5-19701 (Pierce Antibodies).

[0071] In one aspect of the method of the invention, the first detection antibody is an alkaline phosphatase (AP)-conjugated antibody, a horseradish-peroxidase (HRP)-conjugated antibody or an antibody conjugated to a fluorescence dye.

[0072] In one aspect of the method of the invention, the second detection antibody is an alkaline phosphatase (AP)-conjugated antibody, a horseradish-peroxidase (HRP)-conjugated antibody, a glucose oxidase-conjugated antibody, a tyrosinase-conjugated antibody or a ß-Galactosidase antibody. Preferably, the second detection antibody is different from the first detection antibody.

[0073] In a further aspect of the method of the invention, the HRP substrate is Amplex UltraRed, 10-Acetyl-3,7-Dihydroxyphenoxazine (ADHP) or 3-(4-Hydroxyphenyl) propionic acid (HPPA).

[0074] In a still further aspect of the method of the invention, wherein the AP substrate is a 4-methylumbelliferryl phosphate derivative such as 6,8-Difluoro-4-methylumbelliferyl phosphate (DiFMUP), or fluorescein diphosphate (FDP).

[0075] The invention also pertains to a kit for carrying out the method of the invention, comprising:

a) an arrangement of a first capture antibody, a second capture antibody which is preferably a polyclonal or monoclonal antibody of the invention, a first detection antibody and a second detection antibody, wherein said arrangement allows for carrying out the methods of the invention;

b) means for calculating the amount of SNAP-25 cleaved by BoNT/E based on the amount of the second detection complexes determined by the arrangement according to a); and

c) instructions for carrying out said method of the invention.

[0076] The term “kit” as used herein refers to a collection of the aforementioned means or reagents of the present invention which may or may not be packaged together. The

components of the kit may be comprised by separate vials (i.e. as a kit of separate parts) or provided in a single vial. Moreover, it is to be understood that the kit of the present invention is to be used for practicing the method referred to herein above. In one aspect, it is envisaged that all components are provided in a ready-to-use manner for practicing the method referred to herein. In a further aspect, the kit contains instructions for carrying out the said method. The instructions can be provided by a user manual in paper- or electronic form. For example, the manual may comprise instructions for interpreting the results obtained when carrying out the aforementioned methods using the kit of the present invention.

[0077] Finally, the invention relates in another aspect to a method for manufacture of a formulated BoNT/E Neurotoxin product or BoNT/E-MDM2 Neurotoxin product for use in pharmaceutical or cosmetic applications, comprising (i) determining the biological activity of a BoNT/E Neurotoxin or BoNT/E-MDM2 Neurotoxin polypeptide by the method of the invention and (ii) formulating the BoNT/E Neurotoxin or BoNT/E-MDM2 Neurotoxin polypeptide for use in pharmaceutical or cosmetic applications so that a formulated BoNT/E Neurotoxin product or BoNT/E-MDM2 Neurotoxin product is being obtained. The BoNT/E Neurotoxin or BoNT/E-MDM2 Neurotoxin polypeptide can be formulated to a BoNT/E Neurotoxin product or BoNT/E-MDM2 Neurotoxin product by various techniques dependent on the desired application purposes which are known in the art. For example, the (biologically active) BoNT/E Neurotoxin polypeptide can be used in combination with one or more pharmaceutically acceptable carriers as a pharmaceutical composition. The pharmaceutically acceptable carrier(s) must be acceptable in the sense of being compatible with the other ingredients of the formulation and being not deleterious to the recipient thereof. The pharmaceutical carrier employed may include a solid, a gel, or a liquid. Exemplary of solid carriers are lactose, terra alba, sucrose, talc, gelatine, agar, pectin, acacia, magnesium stearate, stearic acid and the like. Exemplary of liquid carriers are glycerol, phosphate buffered saline solution, water, emulsions, various types of wetting agents, and the like. Suitable carriers comprise those mentioned above and others well known in the art, see, e.g., Remington's Pharmaceutical Sciences, Mack Publishing Company, Easton, Pennsylvania. In an aspect, the pharmaceutical composition can be dissolved in a diluent, prior to administration. The diluent is also selected so as not to affect the biological activity of the BoNT/E or BoNT/E-MDM2 Neurotoxin polypeptide. Examples of such diluents are distilled water or physiological saline. In addition, the pharmaceutical composition or formulation may also include other carriers or non-toxic, non-therapeutic, non-immunogenic stabilizers and the like. Thus, the formulated BoNT/E Neurotoxin product or BoNT/E-MDM2 Neurotoxin product can be present, in an aspect, in liquid or lyophilized form. In an aspect, it can be present together with glycerol, protein stabilizers (HSA) or non-protein stabilizers such as polyvinyl pyrrolidone (PVP), hyaluronic acid or free amino acids. In an aspect, suitable non-proteinaceous stabilizers are disclosed in WO 2005/007185 or WO 2006/020208. In one aspect, the biological activity

determined according to step (i) by the method of the invention corresponds to a BoNT/E Neurotoxin or BoNT/E-MDM2 Neurotoxin polypeptide activity of 25, 50, 75, 100, 125, 150 or 200 U (Mouse LD50 units). The formulated BoNT/E Neurotoxin product or BoNT/E-MDM2 Neurotoxin product may be used for human or animal therapy of various diseases or disorders in a therapeutically effective dose or for cosmetic purposes.

[0078] The disease or disorder as referred to herein is selected from the group consisting of voluntary muscle strength, focal dystonia, including cervical, cranial dystonia, and benign essential blepharospasm, hemifacial spasm, and focal spasticity, gastrointestinal disorders, hyperhidrosis, and cosmetic wrinkle correction, Blepharospasm, oromandibular dystonia, jaw opening type, jaw closing type, bruxism, Meige syndrome, lingual dystonia, apraxia of eyelid, opening cervical dystonia, antecollis, retrocollis, laterocollis, torticollis, pharyngeal dystonia, laryngeal dystonia, spasmodic dysphonia/adductor type, spasmodic dysphonia/abductor type, spasmodic dyspnea, limb dystonia, arm dystonia, task specific dystonia, writer's cramp, musician's cramps, golfer's cramp, leg dystonia, thigh adduction, thigh abduction knee flexion, knee extension, ankle flexion, ankle extension, equinovarus, deformity foot dystonia, striatal toe, toe flexion, toe extension, axial dystonia, pisa syndrome, belly dancer dystonia, segmental dystonia, hemidystonia, generalised dystonia, dystonia in lubag, dystonia in corticobasal degeneration, dystonia in lubag, tardive dystonia, dystonia in spinocerebellar ataxia, dystonia in Parkinson's disease, dystonia in Huntington's disease, dystonia in Hallervorden-Spatz disease, dopa-induced dyskinesias/dopa-induced dystonia, tardive dyskinesias/tardive dystonia, paroxysmal dyskinesias/dystonias, kinesiogenic non-kinesiogenic action-induced palatal myoclonus, myoclonus myokymia, rigidity, benign muscle cramps, hereditary chin trembling, paradoxic jaw muscle activity, hemimasticatory spasms, hypertrophic branchial myopathy, masseteric hypertrophy, tibialis anterior hypertrophy, nystagmus, oscillopsia supranuclear gaze palsy, epilepsia, partialis continua, planning of spasmodic torticollis operation, abductor vocal cord paralysis, recalcitant mutational dysphonia, upper oesophageal sphincter dysfunction, vocal fold granuloma, stuttering Gilles de la Tourette syndrome, middle ear myoclonus, protective larynx closure, postlaryngectomy, speech failure, protective ptosis, entropion sphincter Odii dysfunction, pseudoachalasia, nonachalsia, oesophageal motor disorders, vaginismus, postoperative immobilisation tremor, bladder dysfunction, detrusor sphincter dyssynergia, bladder sphincter spasm, hemifacial spasm, reinnervation dyskinesias, mentalis dimples, stiff person syndrome, tetanus prostate hyperplasia, adipositas, treatment infantile cerebral palsy strabismus, mixed paralytic concomitant, after retinal detachment surgery, after cataract surgery, in aphakia myositic strabismus, myopathic strabismus, dissociated vertical deviation, as an adjunct to strabismus surgery, esotropia, exotropia, achalasia, anal fissures, exocrine gland hyperactivity, Frey syndrome, Crocodile Tears syndrome, hyperhidrosis, axillar palmar plantar rhinorrhea, relative hypersalivation in stroke, in Parkinson’s, in amyotrophic lateral

sclerosis, spastic conditions, in encephalitis and myelitis autoimmune processes, multiple sclerosis, transverse myelitis, Devic syndrome, viral infections, bacterial infections, parasitic infections, fungal infections, in hereditary spastic paraparesis postapoplectic syndrome hemispheric infarction, brainstem infarction, myelon infarction, in central nervous system trauma, hemispheric lesions, brainstem lesions, myelon lesion, in central nervous system hemorrhage, intracerebral hemorrhage, subarachnoidal hemorrhage, subdural hemorrhage, intraspinal hemorrhage, in neoplasias, hemispheric tumors, brainstem tumors, myelon tumor and vaginism. A cosmetic use is selected from treatment or reduction of wrinkles like crow's feet or GFL, frowning, facial asymmetries.

[0079] All references cited in this specification are herewith incorporated by reference with respect to their entire disclosure content and the disclosure content specifically mentioned in this specification.

[0080] The Figure shows:

Figure 1: Diagram representing the mode of action of the cell-based assay of the invention. Cells susceptible to BoNT/E intoxication are seeded in multiwell plates, Thereafter, the cells are intoxicated with BoNT/E and after a given intoxication period the cells are fixated. The specific antibody for BoNT/E-cleaved SNAP-25 and the specific antibody for uncleaved SNAP-25 bind to the specific binding sites on SNAP-25. Using enzyme-coupled anti-host specific secondary antibodies, these binding events can be used to generate measurable signals which correlate with the concentration of BoNT/E-cleaved SNAP-25 and the total amount of SNAP-25 within the well. With increasing BoNT/E concentration, the amount of measured cleaved SNAP-25 increases resulting in a gain of signal.

[0081] The invention will now be illustrated by the following Examples which shall, however, not be construed as limiting the scope of the present invention.

Example 1: Generation of monoclonal antibodies specifically binding to the cleavage site of the BoNT/E-cleaved substrate SNAP-25

Mouse monoclonal antibodies specifically binding to the cleavage site of the BoNT/E-cleaved substrate SNAP-25 have been generated using the hybridoma standard technique. To this end, Balb/c mice (female, 8 weeks) have been immunized with the peptide "C-NEIDTQNRQIDR-OH" (SEQ ID NO: 1). The N-terminal Cysteine residue is not derived from the SNAP-25 amino acid sequence but has been introduced for linking the peptide to the keyhole limpet hemocyanin (KLH). Hybridoma cells have been obtained by the fusion of mouse spleen cells with the myeloma cell line SP2/0-Ag14 (SP2/0) purchased from the German Collection of Microorganisms and Cell Culture (DSMZ GmbH, Braunschweig, ACC 146); see also

Hemmerlein et al., Molecular Cancer 2006, 5, 41. Antibodies specifically binding to the cleavage site of the BoNT/E-cleaved substrate SNAP-25 were screened in ELISA. The obtained clones have been selected with respect to their specificity and affinity to BoNT/E-cleaved SNAP-25. As a negative control, the clones have been tested for their non-binding to non-cleaved SNAP-25_{206}. As a result, the mouse monoclonal antibody produced by hybridoma pCNEI 32-7-1, 3614-000 was found to be highly specific for BoNT/E-cleaved SNAP-25, with no detectable cross-reactivity to $SNAP25_{206}$ in ELISA and Western blots.

The hybridoma cell line pCNEI 32-7-1, 3614-000 producing the monoclonal antibody of the invention specifically binding to BoNT/E-cleaved SNAP-25 has been deposited by the Applicant under the Budapest Treaty on December 17, 2014, at DSMZ – Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH, Inhoffenstraße 7 B, 38124 Braunschweig, Germany under accession number DSM ACC3261. The amino acid sequences of CDR-H1, CDR-H2 and CDR-H3 of this monoclonal antibody are shown in SEQ ID NOs. 18, 19 and 20, respectively. The amino acid sequences of CDR-L1, CDR-L2 and CDR-L3 of this monoclonal antibody are shown in SEQ ID Nos. 15, 16 and 17, respectively. The amino acid sequence of the VH region of this monoclonal antibody is depicted in SEQ ID NO. 22, and the amino acid sequence of the VL region of this monoclonal antibody is shown in SEQ ID NO. 21.

Example 2: Double-Fluorescence-CB-BoNT/E activity ELISA

Fixation of cells

1. Remove the media/toxin solution. Add 100 µl/well ice-cold methanol (-20 °C) and incubate for 20 min at -20 °C.

Note: Perform all subsequent steps at room temperature.

After cell fixation:

1. Remove the methanol solution and add 100 µl/well PBS buffer. For longer storage (> 1 day) one should add 300 µl/well PBS buffer and seal the plates with parafilm. The plates should be stored in the refrigerator.

2. Remove the PBS Buffer and wash the cells 3 times with 300 µl/well of PBS buffer. Each step should be performed for 1 minute with gentle shaking.

3. Remove the PBS buffer and add 100 µl/well of quenching buffer and incubate for 20 minutes with gentle shaking.

4. Remove the quenching buffer and wash the cells once with 300 µl/well of PBS buffer for 3 minutes under gentle shaking.

5. Remove the PBS buffer, and add 200 µl/well of blocking buffer and incubate for 1 hour with gentle shaking.

6. Remove the blocking buffer and add 100 µl of the primary antibody mixture (antibody dilution in blocking buffer) to each well. Incubate overnight (16-18 h) with gentle shaking. The cells are simultaneously incubated with two primary antibodies: a mouse antibody specific for the BoNT/E-cleaved SNAP25 and a polyclonal rabbit antibody that recognizes SNAP-25 (antibody for determining the total amount of SNAP-25 for normalization).

7. Remove the primary antibody mixture and wash the cells 4 times with 300 µl of PBS buffer. Each step should be performed for 3 minutes with gentle shaking.

9. Remove the PBS buffer, and add 100 µl of the secondary antibody mixture: HRP-conjugated anti-mouse and AP-conjugated anti-rabbit secondary antibodies (antibody dilution in blocking buffer) to each well and incubate for 2.5 - 3 hours with gentle shaking.

10. Remove the secondary antibody mixture and wash the cells 6 times with 300 µl/well of HEPES buffer. Each wash step should be performed for 3 minutes with gentle shaking.

11. Remove the HEPES buffer from the plate and add 75 µl of a fluorogenic substrate for horseradish-peroxidase (HRP substrate) to each well. Incubate for 50 minutes with gentle shaking. Protect the plates from direct light.

12. Add 75 µl of a fluorogenic substrate for alkaline phosphatase (AP substrate) to each well and incubate for an additional 50 minutes at with gentle shaking. Protect the plates from direct light.

13. Read the plates using a fluorescence plate reader:

excitation at 540 nm; emission at 600 nm.
excitation at 360 nm; emission at 450 nm.

15. Calculation

For normalization, the RFU value for BoNT/E-cleaved SNAP-25 (fluorescence at 600 nm) is normalized to RFU of total SNAP-25 (450 nm) in each well. For better illustration of RFUs in a diagram all values are multiplied with a factor 1000 using the following equation:

$$\frac{\text{RFU (600 nm)}}{\text{RFU (450 nm)}} \times 1000$$

Subsequently the resulting RFU values are averaged for each standard or sample.

Reagent Preparation

PBS Buffer (10 mM):
Phosphate buffered saline (Sigma, # P5368) (pH 7.4)

Quenching buffer:
0.6 % H_2O_2 in 10 mM PBS buffer (pH 7.4)

Blocking buffer:
2 % BSA in 10 mM PBS buffer (pH 7.4)

HEPES buffer:
50 mM HEPES (pH 7,4)

HRP substrate:
50 mM HEPES (pH 7.4)
0.007% H_2O_2
150 µM Amplex UltraRed

AP substrate:
25 mM Diethanolamine (pH 9.8)
2 mM $MgCl_2$
100 µM DiFMUP

Claims

1. A polyclonal or monoclonal antibody specifically binding to BoNT/E-cleaved SNAP-25.

2. The polyclonal or monoclonal antibody of claim 1, wherein the antibody specifically binds to an epitope consisting of a peptide having an amino acid sequence as shown in SEQ ID NO: 1 ("C-NEIDTQNRQIDR") or SEQ ID NO: 2 ("NEIDTQNRQIDR").

3. The polyclonal or monoclonal antibody of claim 1 or 2, wherein the antibody comprises at least one of the complementarity determining regions (CDRs) selected from the group consisting of CDR-L1 (SEQ ID NO. 15), CDR-L2 (SEQ ID NO. 16), CDR-L3 (SEQ ID NO. 17), CDR-H1 (SEQ ID NO. 18), CDR-H2 (SEQ ID NO. 19) and CDR-H3 (SEQ ID NO. 20), comprised by the monoclonal antibody produced by hybridoma cell line pCNEI 32-7-1, 3614-000 deposited on December 17, 2014, at DSMZ – Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH, Inhoffenstraße 7 B, 38124 Braunschweig, Germany, under the accession number DSM ACC3261.

4. The polyclonal or monoclonal antibody of any of claims 1 to 3, wherein the antibody comprises the VH region (SEQ ID NO. 22) and/or the VL region (SEQ ID NO. 21) comprised by the monoclonal antibody produced by hybridoma cell line pCNEI 32-7-1, 3614-000 deposited on December 17, 2014, at DSMZ – Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH, Inhoffenstraße 7 B, 38124 Braunschweig, Germany, under the accession number DSM ACC3261.

5. A method for directly determining the biological activity of BoNT/E in cells, comprising the steps of:
   a) incubating cells susceptible to BoNT/E intoxication with BoNT/E for a time and under conditions which allows for the BoNT/E to exert its biological activity;
   b) fixing the cells and, optionally, permeabilizing the cells with a detergent;
   c) contacting the cells with at least a first capture antibody specifically binding to non-cleaved and BoNT/E-cleaved SNAP-25, and with at least a second capture antibody specifically binding to BoNT/E-cleaved SNAP-25, under conditions which allow for binding of the first capture antibody to non-cleaved and

BoNT/E-cleaved SNAP-25 and for binding of the second capture antibody to BoNT/E-cleaved SNAP-25, wherein the second capture antibody is a polyclonal or monoclonal antibody of any of claims 1 to 4;

d) contacting the cells with at least a first detection antibody specifically binding to the first capture antibody, under conditions which allow for binding of said first detection antibody to said first capture antibody, thus forming first detection complexes and with at least a second detection antibody specifically binding to the second capture antibody, under conditions which allow for binding of said second detection antibody to said second capture antibody, thus forming second detection complexes, and wherein the first detection antibody is different from the second detection antibody;

e) determining the amount of the first and second detection complexes of step d); and

f) calculating the amount of SNAP-25 cleaved by BoNT/E in said cells by means of the second detection complexes,

thereby determining the biological activity of said BoNT/E in said cells.

6. The method of claim 5, wherein the BoNT/E comprises an amino acid sequence selected from the group consisting of:

a) an amino acid sequence as shown in SEQ ID NO: 10, SEQ ID NO. 12 or SEQ ID NO: 14; and

b) an amino acid sequence which has at least 50%, 60%, 70%, 75%, 80%, 85%, 90%, 95%, 96%, 97%, 98%, 99% or 100% sequence identity to the amino acid sequence as shown in SEQ ID NO: 10, SEQ ID NO. 12 or SEQ ID NO: 14.

7. The method of claim 5 or 6, wherein the cells are neuronal cells or neuronal differentiated cells selected from the group consisting of: primary neuronal cells, tumor cells which are capable of differentiating to neuronal cells such as neuroblastoma cells, P19 cells or induced pluripotent stem cell (IPS)-derived neurons.

8. The method of any of claims 5 to 7, wherein fixing the cells is carried out by the addition of a fixation agent selected from the group consisting of: methanol, ethanol, acetone, formaldehyde or mixtures thereof.

9. The method of any of claims 5 to 8, wherein said first capture antibody specifically binding to the non-cleaved and BoNT/E-cleaved SNAP-25 is the rabbit polyclonal anti-SNAP-25 antibody S9684, the rabbit polyclonal anti-SNAP25 antibody PA5-19708 (Pierce Antibodies), the rabbit monoclonal anti-SNAP25 antibody ab108990

(Abcam), or the rabbit polyclonal anti-SNAP25 antibody PA5-19701 (Pierce Antibodies).

10. The method of any of claims 5 to 9, wherein the first detection antibody is an alkaline phosphatase (AP)-conjugated antibody, a horseradish-peroxidase (HRP)-conjugated antibody or an antibody conjugated to a fluorescence dye.

11. The method of any of claims 5 to 10, wherein the second detection antibody is an alkaline phosphatase (AP)-conjugated antibody, a horseradish-peroxidase (HRP)-conjugated antibody, a glucose oxidase-conjugated antibody, a tyrosinase-conjugated antibody or a ß-Galactosidase antibody.

12. The method of any of claims 5 to 11, wherein the HRP substrate is Amplex UltraRed, 10-Acetyl-3,7-Dihydroxyphenoxazine (ADHP) or 3-(4-Hydroxyphenyl) propionic acid (HPPA).

13. The method of any of claims 5 to 12, wherein the AP substrate is a 4-methylumbelliferryl phosphate derivative such as 6,8-Difluoro-4-methylumbelliferyl phosphate (DiFMUP), or fluorescein diphosphate (FDP).

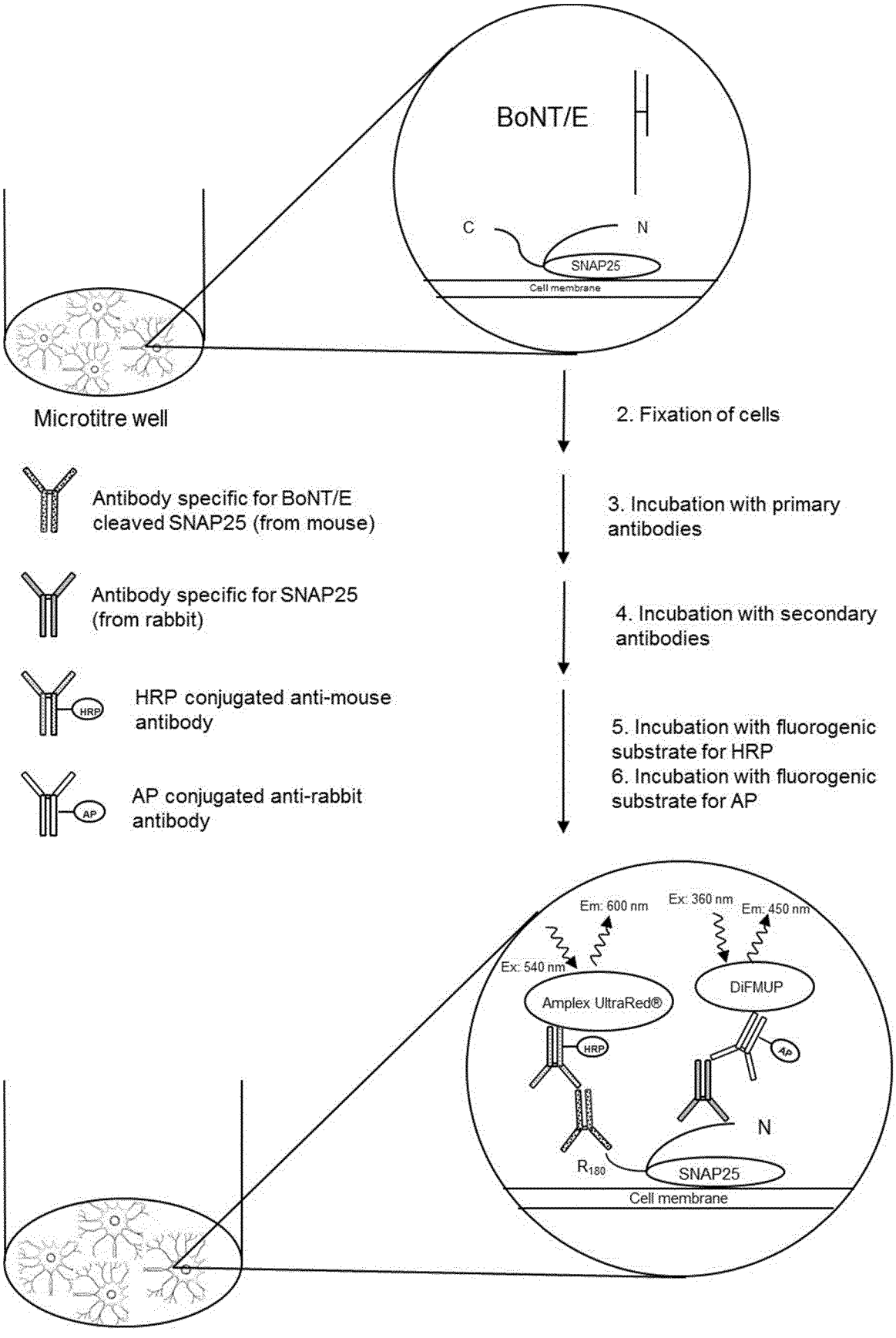
14. A kit for carrying out the method of any of claims 5 to 13, comprising:

a) an arrangement of a first capture antibody, a second capture antibody which is an antibody of any of claims 1 to 4, a first detection antibody and a second detection antibody, wherein said arrangement allows for carrying out the methods of any one of claims 5 to 13;

b) means for calculating the amount of SNAP-25 cleaved by BoNT/E based on the amounts of the first and second detection complexes determined by the arrangement according to a); and

c) instructions for carrying out said method.

Figure 1


BoNT/E
C
N
SNAP25
Cell membrane
Microtitre well
2. Fixation of cells
Antibody specific for BoNT/E cleaved SNAP25 (from mouse)
3. Incubation with primary antibodies
Antibody specific for SNAP25 (from rabbit)
4. Incubation with secondary antibodies
HRP
HRP conjugated anti-mouse antibody
5. Incubation with fluorogenic substrate for HRP
6. Incubation with fluorogenic substrate for AP
AP
AP conjugated anti-rabbit antibody
Em: 600 nm
Ex: 360 nm
Em: 450 nm
Ex: 540 nm
Amplex UltraRed®
DiFMUP
HRP
AP
N
R180
SNAP25
Cell membrane

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2015/080395

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

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

   a. [X] forming part of the international application as filed:

      [X] in the form of an Annex C/ST.25 text file.

      [ ] on paper or in the form of an image file.

   b. [ ] furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. [ ] furnished subsequent to the international filing date for the purposes of international search only:

      [ ] in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      [ ] on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

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

3. Additional comments:

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/080395

A. CLASSIFICATION OF SUBJECT MATTER
INV. C07K16/18 G01N33/50 G01N33/94
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C07K G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, BIOSIS, EMBASE, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JONES ET AL: "Development of improved SNAP25 endopeptidase immuno-assays for botulinum type A and E toxins", JOURNAL OF IMMUNOLOGICAL METHODS, ELSEVIER SCIENCE PUBLISHERS B.V.,AMSTERDAM, NL, vol. 329, no. 1-2, 23 October 2007 (2007-10-23), pages 92-101, XP022389333, ISSN: 0022-1759	1-4
Y	page 93, right-hand column, paragraph 4; figures 1-4	5-14
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 March 2016	15/04/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Cilensek, Zoran

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/080395

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2009/114748 A1 (ALLERGAN INC [US]; FERNANDEZ-SALAS ESTER [US]; WANG JOANNE [US]; GARAY) 17 September 2009 (2009-09-17) cited in the application paragraph [0015] - paragraph [0020]; examples I-XII -----	5-14
Y	ESTER FERNÁNDEZ-SALAS ET AL: "Botulinum Neurotoxin Serotype a Specific Cell-Based Potency Assay to Replace the Mouse Bioassay", PLOS ONE, vol. 7, no. 11, 21 November 2012 (2012-11-21), page e49516, XP055070996, DOI: 10.1371/journal.pone.0049516 figures 1-8; tables 1, 2 -----	5-14
A	US 2005/100973 A1 (STEWARD LANCE E [US] ET AL) 12 May 2005 (2005-05-12) the whole document -----	1-14
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2015/080395

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