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(54) Benævnelse: **Anvendelse af plerixafor til behandling og/eller forebyggelse af akutte forværringer af kronisk obstruktiv lungesygdom**

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WO-A1-2013/052844
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"AstraZeneca AZD2423 Mechanism of Action", , 2 May 2013 (2013-05-02), XP055189165, Retrieved from the Internet: URL:https://ncats.nih.gov/files/AZD2423.pd f [retrieved on 2015-05-13]
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DESCRIPTION

FIELD OF INVENTION

[0001] The invention relates to novel compositions and methods for the prevention and/or treatment of chronic obstructive pulmonary disease (COPD) and acute exacerbations of chronic obstructive pulmonary disease (AECOPD).

BACKGROUND OF THE INVENTION

[0002] COPD is a very frequent airway disease that affects more than 200 million people worldwide. The main risk factor for COPD is tobacco smoking. COPD is currently the fourth leading cause of death, but the mortality may reach the third cause of death in 2020. The disease is characterized by chronic bronchial inflammation and remodeling of distal airways, and in particular a bronchial and peri-bronchial fibrosis, leading to persistent airflow limitation. International patent application WO2013/052844 describes compositions of calcium ions optionally combined with therapeutic agents for treating a long list of respiratory diseases, including *inter alia* COPD. Also, international patent application WO2014/132100 discloses the use of combinations of HIF-α potentiating agent and a mobilizer of hematopoietic stem cells and/or progenitor cells, such as G-CSF or plerixafor, for enhancing hematopoiesis, or for stem cell transplantation, for treating/preventing an immunocompromised condition, and/or for treating autoimmune diseases including *inter alia* COPD. Furthermore, AstraZeneca describes in the website: https://ncats.nih.gov.files/AZD2423, the compound AZD24243, which is a CC chemokine receptor 2 (CCR2) antagonist undergoing clinical phases *inter alia* for the treatment of COPD. Finally, antagonists of the CC chemokine receptor 3 (CCR3), such as SB328437 have been described in patent publication US 2012/088769 and the Abstract Mao, Yong et al., (Shanghai Yixue, vol. 30, no. 9, 2007, pages 707-709) for treating allergic rhinitis.

[0003] The chronic course of COPD is however frequently worsened by acute exacerbations (AECOPD), most often related to viral or bacterial infections. These AECOPD are associated with a burst of neutrophilic and sometimes eosinophilic inflammation. AECOPD affect nearly 80% of COPD patients over a 3 year-period and the frequency of exacerbations is mainly related with the presence of previous exacerbations.

[0004] AECOPD result in enormous health-care costs, especially related to hospitalisations. AECOPD dramatically impact the quality of life and play a role in the worsening of the disease: lung function declines more rapidly in patients with frequent exacerbations, with an peripheral blood fibrocytes in patients during COPD exacerbations and understood the need for developing new therapies around of this concept. In particular, they have showed that fibrocytes expressing CXCR4, CCR3, and CCR2, the chemokine receptors for CXCL12, CCL11, CCL7, CCL13 and CCL2, were significantly increased in patients during COPD

exacerbations (AECOPD), and that these specific fibrocytes were highly correlated to mortality and low lung function. Most importantly, Applicants have successfully identified a novel drug discovery pathway and new drugs for the treatment and/or the prevention of COPD by showing that antagonists of CCR2/CCL2, CCR2/CCL7, CCR2/CCL13, CXCR4/CXCL12, and/or CCR3/CCL11 receptor/ligand pairs are useful for the treatment and/or prevention of COPD and AECOPD in preventing fibrocytes recruitment/migration in patients during AECOPD.

SUMMARY OF THE INVENTION

[0005] The present invention is limited to the subject-matter defined in the claims. The following description is subject to this limitation.

BRIEF DESCRIPTION OF THE FIGURES

[0006]

Figure 1 shows the study design with the numbers of patients who were included and had their level of fibrocytes quantified.

Figures 2A-F are graphs showing the percentage of CD45+ ColI+ cells in Peripheral Blood Mononuclear Cell (PBMC) (A) and concentration of fibrocytes in the blood (B) of control subjects ("Cont", n=38), non exacerbating COPD patients ("NEx", n = 9), exacerbating COPD patients ("V1", n=48) *: P <0.05, *** P <0.001, non parametric Kruskal Wallis test. Percentage of CD45+ CD34+ ColI+ cells in PBMC (C) and concentration of fibrocytes in the blood (D) of control subjects ("Cont", n=25), non exacerbating COPD patients ("NEx", n=8), exacerbating COPD patients ("VI", n=29) *: P<0.05, **: P <0.01, non parametric Kruskal Wallis test. Medians are represented as horizontal lines (A-D). Percentage of CD45+ ColI+ cells (E) and concentration of CD45+ ColI+ cells in the blood (F) in each exacerbating COPD patient at the time of exacerbation (VI) and 2 months after (V2) ** P <0.01, Wilcoxon matched pairs test.

Figures 3A-F represent a Kaplan-Meier survival analysis of exacerbating COPD subjects, separated by the threshold percentage of CD45+ ColI+ cells in PBMC of 28 subjects measured at the time of exacerbation (VI). Of the 42 subjects with available survival data, 36 had values below (gray curve) and 6 above the threshold (black curve). Percentage of CD45+ ColI+ cells in PBMC as predictors of mortality in COPD subjects (A). B-F, Relationships between FEV1 (B), FVC (C), FEV1/CVF (D), TLCO (E), pO2 (F) and the percentage of CD45+ ColI+ cells in PBMC in exacerbating COPD patients at V2. FEV1: Forced Expiratory Volume in the 1st second; FVC: forced vital capacity; TLCO: carbon monoxide transfer factor; Pao_2: partial pressure of O_2 in arterial blood. Correlation coefficient (r) and significance level (p value) were obtained using non parametric Spearman analysis.

Figures 4 A-J are graphs showing the percentage of cells expressing CXCR4 (A), CCR2 (C), CCR3 (E), CCR5 (G) and CCR7 (I) in fibrocytes of control subjects ("Cont"), exacerbating

COPD patients ("VI"). Concentration of CXCR4+ (B), CCR2+ (D), CCR3+ (F), CCR5+ (H) or CCR7+ (J) fibrocytes in the blood of control subjects, non exacerbating COPD patients, exacerbating COPD patients. *: P <0.05, *** P <0.001, Mann Whitney test.

Figures 5A-D show A) the fibrocyte migration of control subjects (n=6, gray bars) and exacerbating COPD patients (n=6, black bars) in response to plasma of exacerbating COPD patients in presence (+) or absence (-) of 25 µg/ml Plerixafor. * P<0.05, paired t-test. B) Plasma CXCL12 in individual subjects. Symbols indicate individual subjects and horizontal lines represent medians. C) Fibrocyte migration of control subjects (n=8, gray bars) and exacerbating COPD patients (n=5, black bars) in response to CXCL12. ** P<0.01, two-way ANOVA with Bonferroni post-tests. D) Fibrocyte migration of control patients (n = 6; gray bars) and exacerbating COPD patients (n = 7; black bars) in response to CXCL12 in presence (+) or absence (-) of 25 µg/ml Plerixafor. *: P<0.05, paired t-test.

Figure 6 is a graph showing the percentage of CD45+ ColI+ cells in PBMC of exacerbating COPD patients at V2 without any unscheduled visit (n=4), with one unscheduled visit (n=8), or with two or more unscheduled visit (n=14) the year before VI. Medians are represented as gray horizontal lines. **: p <0.01, non parametric Kruskal Wallis test with multiple z tests.

Figure 7 shows the relationships between FEV1 (L) (A), FVC (L) (B), FEF 25-75 (%) (C), FEF 25-75 (L/s) (D) and the percentage of CD45+ ColI+ cells in PBMC in exacerbating COPD patients at V2.
FEV1: Forced Expiratory Volume in the 1st second; FVC: forced vital capacity; FEF 25-75: the average forced expiratory flow during the mid (25-75%) portion of the FVC. Correlation coefficient (r) and significance level (p values) were obtained using non parametric Spearman analyses.

Figures 8 A-D are graphs showing in (A) fibrocyte migration of control subjects (n =1, gray bars) and exacerbating COPD patients (n=5, black bars) in response to plasma of exacerbating COPD patients in presence (+) or absence (-) of 10 µM SB 328437. (B) Plasma CCL11 in individual subjects. Symbols indicate individual subjects and horizontal lines represent medians. (C) Fibrocyte migration of control subjects (n=2, gray bars) and exacerbating COPD patients (n=6, black bars) in response to CCL11. (D) Fibrocyte migration of control patients (n=2) and exacerbating COPD patients (n=5) in response to CCL11 in presence (+) or absence (-) of 10 µM SB 328437.

DETAILED DESCRIPTION

[0007] The Applicants investigated in a clinical study peripheral blood fibrocytes concentrations in COPD patients during an exacerbation and after the exacerbation at the stable state in comparison to control subjects. Migration properties of these fibrocytes from COPD patients and control subjects were also investigated.

[0008] The Applicants have discovered a significant increased number of circulating fibrocytes in patients during AECOPD as compared to control subjects, and that the number of circulating fibrocytes decreased in same patients two months after AECOPD. The Applicants also showed that a high percentage of circulating fibrocytes during exacerbation was associated with increased risk of death, and that the percentage of fibrocytes after AECOPD was negatively correlated to several obstructive lung disease parameters (*i.e.*, FEV1, FVC, FEV1/FVC, TLCO and PaO_2). In particular, the Applicants discovered that fibrocytes expressed in particular CXCR4, CCR2 and CCR3, the chemokine receptors for CXCL12, CCL2, CCL7, CCL13, and CCL11, respectively.

[0009] Antagonists of chemokine receptors CXCR4, CCR2, and CCR3, such as Plerixafor, a CXCR4 antagonist decreased fibrocytes migration to plasma of exacerbating COPD patients, and may thus be useful according to the present invention for treating and/or preventing COPD and AECOPD.

[0010] The present invention thus provides compounds, pharmaceutical compositions and methods of use of certain compounds that are antagonists or inhibitors of CCR2/CCL2, CCR2/CCL7, CCR2/CCL13, CXCR4/CXCL12, and/or CCR3/CCL11 receptor/ligand pairs for use in the treatment and/or the prevention of COPD or AECOPD. Preferred compounds according to the invention interfere with the binding of the native ligands to the CCR2 and/or CCR3 and/or CXCR4 receptor and inhibit activation of the receptor and subsequent downstream signalling pathways.

[0011] Chronic obstructive pulmonary disease (COPD) is a major cause of morbidity and mortality throughout the world. It is a common preventable and treatable disease characterized by persistent airflow limitation that is usually progressive and associated with an enhanced chronic inflammatory response in the airways and the lung to noxious particles or gases. Exacerbations and co-morbidities contribute to the overall severity in individual patients. There are several anatomic lesions that contribute to the reduced airflow found in COPD patients. These include accumulation of mucous secretions, peri-bronchiolar fibrosis, narrowing of small airways and destruction of alveolar walls, which is the defining characteristic of emphysema.

[0012] Chemokines are a family of proinflammatory mediators that promote recruitment and activation of multiple lineages of leukocytes (*e.g.*, lymphocytes, macrophages). They can be released by many kinds of tissue cells after activation. Continuous release of chemokines at sites of inflammation can mediate the ongoing migration and recruitment of effector cells to sites of chronic inflammation. The chemokines are related in primary structure and share four conserved cysteines, which form disulfide bonds. Based upon this conserved cysteine motif, the family can be divided into distinct branches, including the C-X-C chemokines (a-chemokines), and the C-C chemokines (β-chemokines).

[0013] Chemokine receptor CCR2 refers to the gene symbol approved by the HUGO Gene Nomenclature Committee for chemokine (C-C motif) receptor 2. The HGNC ID for this gene is

1603. The gene is located at chromosome position 3p21. The previous symbol and name for the gene is CMKBR2. Synonyms for this gene include CC-CKR-2, CD192, CKR2, FLJ78302, MCP-1-R. The NCBI Reference Sequence is NM001123041.2 Nucleic acid) and NP001116513.2 (amino acid). CCR2 is a receptor for CCL2, CCL7 and CCL13. The receptor mediates agonist-dependent calcium mobilization and inhibition of adenylyl cyclase. Two alternatively spliced transcript variants are expressed by the human CCR2 gene. The first variant (A) encodes a cytoplasmic isoform. It is alternatively spliced in the coding region resulting in a frameshift and use of a downstream stop codon, compared to variant B. All variants and isoforms are within the scope of the invention.

[0014] The chemokine (C-C motif) ligand 2 (CCL2) is also referred to as monocyte chemotactic protein 1 (MCP1) and small inducible cytokine A2. CCL2 is a small cytokine that belongs to the CC chemokine family. CCL2 recruits monocytes, memory T cells, and dendritic cells to the sites of inflammation produced by either tissue injury or infection.

[0015] CCL7 (monocyte chemoattractant protein-3, MCP-3) is a member of the CC-chemokine family (β-chemokines) characterized by two adjacent cysteine residues at the amino terminal of the mature protein. It is a ligand for CCR2 binding. The accession number of MCP-3 is X72308

[0016] CCL13, also known as Monocyte Chemoattractant Protein-4 (MCP-4), is a CC chemokine that acts as a chemoattractant for monocytes, eosinophils and T cells and as an activator of basophils. It signals through the CCR2 and CCR3 receptors. Human MCP-4 (hMCP-4) sequence was first published in 1996. (Uguccioni et al., 1996, Monocyte Chemotactic Protein 4 (MCP-4), A Novel Structural and Functional Analogue of MCP-3 and Eotaxin, J. Exp. Med. 183:2379-2394). Human MCP-4 is a peptide of 8.6 kDa that consists of 75 amino acid residues. (FIG. 3.) It is also known as CK-β-10, SCY-A13 and NCC-1 (Swiss-Prot accession number Q99616) and was renamed CCL13 in the new chemokine nomenclature. (Zlotnik et al., 2000, Immunity, 12:121-127).CCL13 has the SWISSPROT accession no. Q99616; segment 34-58.

[0017] Chemokine receptor CCR3 refers to the gene symbol approved by the HUGO Gene Nomenclature Committee for chemokine (C-C motif) receptor 3. The HGNC ID for this gene is 1604. The gene is located at chromosome position 3p21 .3. The previous symbol and name for the gene is CMKBR3. Synonyms for this gene include CC-CKR-3, CD193 and CKR3. The Genbank reference sequence for CCR3 is AF247361.1. All variants and isoforms are within the scope of the invention.

[0018] CCL11 also known as eosinophil chemotactic protein and eotaxin-1 is the ligand of CCR2 and CCR3 receptors. It is encoded by the CCL11 gene. This gene is encoded on three exons and is located on chromosome 17. Chemokine receptors for which CCL11 is a ligand include. The HGNC ID for this gene is 10610. The GenBank reference sequence for CCL11 is AB063614.1.

[0019] Chemokine receptor CXCR4 is meant C-X-C chemokine receptor type 4 (CXCR4). It is

also known as fusin or cluster of differentiation 184 (CD 184), which is a seven transmembrane (TM) G-protein coupled receptor (GPCR) belonging to Class I GPCR or rhodopsin-like GPCR family. The CXCR4 structure consists of 352 amino acid residues comprising an N-terminal domain, seven TM domains, three extra-cellular loops (ECL), three intra-cellular loops (ICL) and a C-terminal domain.

[0020] SDF-1 which refers to stromal cell-derived factor 1 is a ligand for CXCR4. It is also known as CXCL12, and present two different isoforms CXCL12-α and CXCL12-β. The amino acid sequence of human SDF-1α has GenBank accession number NP954637. The amino acid sequence of human SDF-1β has GenBank accession number NP000600. Human SDF-1 is also described in U.S. Pat. No. 5,756,084 and U.S. Pat. No. 5,563,048.

[0021] Antagonists or inhibitors are intended to be therapeutic agents that inhibit directly or indirectly the biological activity of CCR2/CCL2, CCR2/CCL7, CCR2/CCL13, CXCR4/CXCL12, and/or CCR3/CCL11 receptor/ligand pairs. Such agents may include small molecules (organic or inorganic), natural products, synthetic compounds, antibodies (*e.g.*, polyclonal sera, monoclonal, chimeric, humanized, human), antibody fragments such as recombinant antibody fragments, single-chain antibodies (scFv), single antibody variable domains, single antibody domain proteins (dAbs), antigen binding fragments, nucleic acid agents such as antisenses, ribozymes, DNAzymes, or RNA interference RNAi, siRNA, or shRNAs, which act by reducing chemokine receptors expression, proteins, peptides, peptide derivatives, peptidomimetics, carbohydrates or any other compound or composition which decreases the activity of the chemokine receptor either by effectively reducing the amount of CCR2 present on a cell, or by inhibiting the interactions of the ligands. Antagonist compounds may also include variants, isoforms, solvates, hydrates, pharmaceutically acceptable salts, tautomers, stereoisomers, and prodrugs of the antagonist compounds.

[0022] Antagonists of chemokine receptor CCR2 prevent the biological functions or bioactivity associated with CCR2, its isoforms or variants including CCR2A or CCR2B, in fibrocytes that display the receptor or antagonists which bind MCP- 1/CCL2 or CCR2 or which prevent the binding of CCR2 with its cognate ligand(s) and thereby inhibit CCR2 biological functions. In particular, antagonists of CCR2 may inhibit the binding of one or more ligands (*e.g.*, MCP-1 , MCP-2, MCP-3, MCP-4 , MCP-5 , CCL2, CCL8, CCL16 and the like) to CCR2 and/or inhibit signal transduction mediated through CCR2 (e.g., GDP/GTP exchange by CCR2 associated G proteins, intracellular calcium flux), thereby inhibiting CCR2-mediated processes and cellular responses and functions.

[0023] Molecules that can antagonize one or more functions of CCR2 are well known in the art. Compositions according to the present invention may comprise small molecule based CCR2 antagonists.

[0024] As CCR2 antagonists, we can cite AZD2423 (ClinicalTrials.gov Identifier: NCT01200524 and Kalliomaki et al, Pain. 2013 May;154(5):761-7. doi: 10.1016/j.pain.2013.02.003. Epub 2013 Feb 13); UCB102405 (http://www.springer.com/978-3-7643-7195-1); Incyte Pharma's

candidates INCB-8696 (Nature Reviews Drug Discovery 8, 23-33 (January 2009) and Matera et al, Expert Opin. Emerging Drugs (2012) 17(1):61-82); pyridinylcyclohexyl-3-pyrrolidinyl derivative INCB-3284(http://investor.incyte.com/phoenix.zhtml?c=69764&p=irol-newsArticle&ID=525656); Benzodioxolhydroxycyclohexyl derivative INCB3344 (http://pubchem.ncbi.nlm.nih.gov/ compound/10008367); CCX140 (ClinicalTrials.gov Identifier : NCT01440257); D-erythro-Pentitol derivative MK-0812 (ClinicalTrials.gov Identifier:NCT00239655); (*S*)-3-aminopyrrolidine CCR2 antagonist PF-4136309 (ClinicalTrials.gov Identifier : NCT01226797); PF-04634817 (ClinicalTrials.gov Identifier : NCT01098877 and http://www.pfizer.com/sites/default/files/product-pipeline/pipeline_2013_1108.pdf); lactam-based compound BMS-741672 (ClinicalTrials.gov Identifier: NCT00699790), BMS-813160 or (S)-1-[(1S,2R,4R)-4-isopropyl(methyl)amino)-2-propylcyclohexyl]-3-(6-(trifluoromethyl) quinazolin-4-ylamino)pyrrolidin-2-one (ClinicalTrials.gov Identifier: NCT01752985) ; JNJ-17166864 (ClinicalTrials.gov Identifier: NCT00604123 and AntiInflammatory Drug Discovery edited by Jeremy I. Levin, Stefan Laufer, Page 378); ((IR, 3S)-3-Isopropyl-3-{[3-(trifluoromethyl)-7,8-dihydro-1,6-naphthyridin-6(5H)-yl] carbonyl}cyclopentyl)[(3S,4S)-3-methoxytetrahydro-2H-pyran-4-yl]amine; CD192 (see http://www.biolegend.com/cd192-ccr2-antibodies-6166/), RS 504393 (see Mirzadegan et al, August 18, 2000 The Journal of Biological Chemistry, 275, 25562-25571), RS 102895 hydrochloride (Seok et al, Nephrol. Dial. Transplant. 2013 Jul;28(7):1700-10. doi: 10.1093/ndt/gfs555. Epub 2013 Jun 22), BMS CCR2 22 (Kredel et al., J Biomol. Screen. 2011 Aug; 16(7):683-93. doi: 10.1177/1087057111406884. Epub 2011 May 3.), INCB 3284 dimesylate (Mcmillin et al, J Neuroinflammation. 2014 Jul 10;11:121. doi: 10.1186/1742-2094-11-121); 3 [(3S,4R)-1-((1R,3S)-3-isopropyl-2-oxo-3-{[6-(trifluoromethyl)- 2H-1,3-benz-oxazin-3(4H)-yl]methyl}cyclopentyl)-3 - methylpiperidin-4-yl]benzoic acid; (3S,48)-N-((1R,3S)-3-isopropyl-3-{[7-(trifluoromethyl)-3,4-dihydroisoquinolin-2(1B)-yl]carbonyl}cyclopentyl)-3-methyltetrahydro-2H-p-yran-4-aminium; 3-[(3S,4R or 3R,4S)-1-((1R,3S)-3-Isopropyl-3-{[6-(trifluoromethyl)-2H-1,3-benzoxazin-3-(4H)-yl]carbonyl} cyclopentyl)-3-methylpiperidin-4-yl]benzoic acid, other chemicals and synthetic compounds as described in Brodmerkel et al, J. Immunol, 2005, 175:5370-7378 and WO2012138880).

[0025] Also, several pharmaceutical groups have developed CCR2 inhibitors: Takeda's diphenylmethane derivative based CCR2 inhibitors (WO97/24325), hexanoic amide derivative based CCR2 inhibitors from Pfizer (WO 98/38167), Teijin's CCR2 antagonists based on piperazine derivatives (WO 97/44329), Merck's 3-arylpiperidine based CCR2 antagonists (WO 98/31364).

[0026] Numerous peptide derivatives based CCR2 antagonists have been also developed. We can cite piperidinyl derivatives (WO2012075115), diazepam derivatives (WO2011048032), cyclohexane derivatives (WO2010121046), carboxamide derivatives (WO2010070032), cyclopentyl/cyclohexyl derivatives (WO2013152269), bicyclic heterocycles (WO2011042399), indole derivatives (WO2012125662), mercapto derivatives (WO2005118578), dipiperidine derivatives (WO2006036527), heteroaryl sulfonamides (US20100056509), fused heteroaryl pyridyl and phenyl benzenesuflonamides (WO2009009740).

[0027] Compositions according to the present invention may comprise peptide based CCR2 antagonists. By way of examples we can cite the heptapeptide LGTFLKC (SEQ ID NO: 1) called "ECL1 (C) inverso" , "ECL1 (C)" having an amino acid sequence CKLFTGL, "ECL2 (N)" having an amino acid sequence LFTKC (SEQ ID NO: 2), "ECL2 (N) inverso" having an amino acid sequence CKTFL(SEQ ID NO: 3), "ECL3 (C)" having an amino acid sequence HTLMRNL (SEQ ID NO: 4) "ECL3 (C) inverso" having an amino acid sequence LNRMLTH (SEQ ID NO: 5), "ECL3 (N)" having an amino acid sequence LNTFQEF (SEQ ID NO: 6), "ECL3 inverso" having an amino acid sequence FEQFTNL (SEQ ID NO: 7), and/or peptides comprising the sequence Thr-Phe-Leu-Lys (SEQ ID NO: 8), as reported in international publication WO2013000922.

[0028] Alternatively, CCR2 antagonists may be anti-CCR2 antibodies and antibody fragments. A number of anti-CCR2 antibodies are known in the art and are available commercially. We can cite in particular monoclonal anti-CCR2 antibody 1D9 (ATCC HB-12549), 8G2 (ATCC HB-12550), LS132 which has described in international publication No. WO 01/57226, human CCR2 blocking antibody such as MLN1202 (Millennium Pharmaceuticals, Cambridge, MA), or a human antibody that neutralizes human CCL2, *e.g.*, carlumab (CNTO 888; Centocor, Inc.) which has been described by Loberg et al., Cancer. Res. 67(19):9417 (2007).

[0029] Also included within the scope of invention are antagonists to CCR2 ligand, for example of MCP-1 (CCL2), CCL7, and/or CCL13.

[0030] Such antagonists may be anti-MCP-1 antibodies which are well known and well described in the literature. As anti-MCP-1 antibodies, we can cite antibodies capable of binding a plurality of beta-chemokines including MCP-1 were disclosed (WO03048083) and an MCP-I binding antibody which also binds eotaxin (US20040047860). Antibodies which selectively bind and neutralize mouse homologs of human MCP-1/CCL2 or human MCP-1/CCL2 like anti-human MCP-1/CCL2 antibody designated C775 which has been described in US 20090297502, as well as human anti MCP-1/CCL2 antibody designated CNTO888 (WO2006125202).

[0031] The compositions of the present invention may also comprise MCP-1/CCL2 truncations, variants, mutant proteins or "muteins" which have the ability to bind CCR2 and have antagonistic activity. Variants of homodimer forming chemokines, such as CCL2, having a single amino acid substitution in the dimerization interface that alters the pattern of hydrogen bonds, so as to result in an obligate monomer that binds to the receptor and has agonistic properties *in vitro* but which can antagonize natural chemokines and have antiinflammatory activity in vivo as taught in international publication WO05037305A1 are among the variants useful in practicing the present invention. A peptide antagonist of MCP-1, is the truncated MCP-1 (9- 76) (Jiang- Hong Gong, et al, J. Exp. Med. 1997, 186: 131).

[0032] Antagonists of ligand CCL7 and CCL13 include small organic or synthetic molecules, natural products, peptides, proteins, peptidomimetics, antibodies, antigen binding fragments, nucleic acid agents and the like. Peptide antagonists of CCL7 and/or of CCL13 may typically be

fragments of CCL7 and/or CC113 that compete with full-length CCL7 and/or with full length of CCL13 for binding to CCR2 and hence antagonise CCL7 and/or CCL13. Using known techniques and based on knowledge of the sequence of CCL7, double- stranded RNA (dsRNA) or single-stranded antisense RNA molecules can be designed to antagonise the target by sequence homology-based targeting of its RNA. Such dsRNAs or ssRNA will typically be small interfering RNAs (siRNAs), usually in a stem-loop ("hairpin") configuration, or micro-RNAs (miRNAs). The sequence of such dsRNAs or ssRND will comprise a portion that corresponds with that of a portion of the mRNA encoding the target. This portion will usually be 100% complementary to the target portion within the target mRNA but lower levels of complementarity (e.g. 90% or more or 95% or more) may also be used.

[0033] As antagonists of CLL7, we may cite anti-CCL7 antibodies of the invention will have CCL7 antagonist (blocking) properties. Preferred antagonists are monoclonal antibodies which specifically recognise an epitope within CCL7 and blocks the activity of CCL7, in particular the interaction between CCR2 and CCL7. Specifically monoclonal antibodies to CCL7 may include CCL7 monoclonal antibody (M03) [see http://www.abnova.com/products/products_detail.asp?catalog_id=H00001491-M03], clone 4B5 (Abnova), CCL7 Antibody h.mcp.3 (Pierce antibodies), Recombinant Human CCL7 / MCP3 protein (Catalog#11926-H08E) (Sinobiological), MA1-21385(Labome) etc...

[0034] As antagonists of ligand CCL13, we may cite anti-CCL13 antibodies, such as antibodies from Novus, Origene, Labome, Sigma Aldrich etc... Monoclonal antibodies against CCL13 include H00006357-M03 (Abnova), MCP-4/CCL13 Antibody 8C12 (Pierce Antibodies), MCP-4/CCL13 Antibody 3G4 (Pierce Antibodies), Human CCL13/MCP-4 Antibody(R and D systems) etc...

[0035] Antagonists of chemokine receptor CCR3 prevent one or more biological functions or bioactivity associated with CCR3. Such antagonist of CCR3 function can inhibit the binding of one or more ligands (*e.g.*, CCL11, CCL26, CCL7, CCL13, CCL15, CCL24, CCL5, CCL28, CCL18) to CCR3 and/or inhibit signal transduction mediated through CCR3. Accordingly, CCR3-mediated processes and cellular responses and functions can be inhibited by antagonists of CCR3. As used herein, "CCR3" refers to naturally occurring CC chemokine receptor 3 (e.g. mammalian CCR3 (e.g., human {Homo sapiens) CCR3) and encompasses naturally occurring variants, such as allelic variants and splice variants.

[0036] Numerous molecules have been described in the art as antagonists of one or more functions of CCR3. Compositions according to the present invention may comprise small molecule based CCR3 antagonists. By way of examples, we can cite the following small molecules like GSK's candidate 776994 (Nature Reviews Drug Discovery 8, 23-33 (January 2009)), benzylpiperidinesubstituted aryl urea derivative DPC-168 (Bioorganic & Medicinal Chemistry Letters 07/2007; 17(11):2992-7), dichloromethylurea based derivative GW766994 (Clinicaltrial.gov- NCT01 160224), naphthalenylcarbonyl derivative SB 328437 (Int Immunol. 2007 Aug;19(8):913-21), *N*-Benzoyl-4-nitroaniline ethyl ester SB 297006 (Int Immunol. 2007 Aug;19(8):913-21), AZD1744 (Current Opinion in Drug Discovery & Development 2010

13(4):414-427), *trans*-1,2-disubstituted cyclohexane derivative BMS 639623 (Bioorganic & Medicinal Chemistry Letters Volume 18, Issue 2, 15 January 2008, Pages 576-585), AZD 3778 (Respir Res. 2010 Feb 9;11:17. doi: 10.1186/1465-9921-11-17.), YM-344031 (Biochem Biophys Res Commun. 2006 Jan 27;339(4):1217-23. Epub 2005 Dec 5.); A-122058(Current Opinion in Drug Discovery & Development 2010 13(4):414-427), (S)-N-((1R,3S,5S)-8-((6-fluoronaphthalen-2-yl)methyl)-8-azabicyclo[3.2.1] octan-3-yl)-N-(2-nitrophenyl)pyrrolidine-1 ,2-dicarboxamide, (R)-1-(1-((6-fluoronaphthalen-2-yl)methyl)pyrrolidin-3-yl)-3-(2-(2-hydroxyethoxy)phenyl)urea; morpholin-acetamide-based compound like 4-[[[[[[(2s)-4-[(3,4-dichlorophenyl)methyl]-2-morpholinyl]methyl]-amino]carbonyl]-amino]methyl]benzamide; and morpholine urea-based compound like N-[[(2S)-4-[(3,4-difluorophenyl)methyl]-2-morpholinyl]-methyl]-3-[(methylsulfonyl)amino]-benzeneacetamide.

[0037] As CCR3 antagonists, we may also cite 2-mercaptobenzothiazole derivatives, aryl or phenyl sulfonamide derivatives (WO2012051090), bridged bicyclic amine derivatives (WO2004076448), diazepam derivatives (WO2011048032), substituted piperidines (WO2010115836), pyrollidinyl alkylamide derivatives (WO2010013078) bicyclic heterocycles (WO2011042399), piperidyl derivatives (WO2008049874), amino alkyl amide derivatives (WO2007034251), imidazole derivatives (WO2007025751), azetidine derivatives (WO03077907), pyran derivatives (WO2010069979), substituted pyrimidine derivatives (WO2004004731), or morpholinyl derivatives (WO03099798).

[0038] Compositions according to the present invention may also comprise antibody based CCR3 antagonist. Some examples of anti-CCR3 antibodies include PE anti-human CD193 (CCR3) antibody available from Biolegend, anti-CCR3 antibodies ab32512, ab36827, ab36829, ab36827, ab1667, ab16231, ab157139 available from Abcam, Y31 from OriGene, eBio5E8-G9-B4 from eBioscience, human CCR3 MAb (Clone 61828) from R and D systems. See also U.S. Pat. Nos. 6,806,061 and 6,207,155, and in U.S. published applications 20050191702, 20050069955, and 20020147312 for exemplary antibodies which specifically bind and inhibit the CCR3 receptor and U.S. Pat. Nos. 6,946,546 and 6,635,251, as well as U.S. published applications 20040191255 and 20040014132 for exemplary antibodies, which specifically bind and inhibit eotaxin-1 and eotaxin-2.

[0039] Additional compounds for inhibiting the CCR3 receptor include RNA, DNA or RNA/DNA aptamers directed against CCR3, eotaxin-1, eotaxin-2 or eotaxin-3. Exemplary methods for making aptamers are described in U.S. Patent Nos. 5,270,163, 5,840,867, 6,180,348 and 6,699,843. Other compounds for inhibiting the CCR3 receptor include anti-sense oligonucleotides or siRNAs directed against CCR3, eotaxin-1, eotaxin-2 or eotaxin-3, including the anti-sense oligonucleotides directed against the CCR3 receptor such as that described in U.S. Patent No. 6,822,087.

[0040] Peptide based CCR3 antagonists may be derived from phage libraries, such as for example peptide CPWYFWPC as described in Eur. J. Immunol. 2001 Dec; 31(12):3535-45 or peptide analogues of CCR3 (WO1999043711).

[0041] Also included within the scope of invention are antagonists to CCR3 ligand, such as for example CCL11 antagonists, which can include small organic or synthetic molecules, natural products, peptides, proteins, peptidomimetics, antibodies, antigen binding fragments, nucleic acid agents and the like. CCL11 truncations, variants, mutant proteins or "muteins" having the ability to bind CCR3 and have antagonistic activity may also be used to practice the method of the invention.

[0042] A particularly preferred CCR3 antagonist is naphthalenylcarbonyl derivative SB 328437.

[0043] Antagonist of chemokine receptor CXCR4 one or more biological functions or bioactivity associated with CXCR4. Such antagonist of CXCR4 function can inhibit the binding of one or more ligands (e.g., CXCL12-α and/or CXCL12-β (SDF-1-α or SDF-1-β)) to CXCR4 and/or inhibit signal transduction mediated through CXCR4. Accordingly, CXCR4-mediated processes and cellular responses (*e.g.*, proliferation, migration, chemotactic responses and differentiation of fibrocytes) can be inhibited by CXCR4 antagonists.

[0044] Several small molecules based CXCR4 antagonists which may be used in the compositions according to the present invention have been identified and chemically well characterized. They have been described in details as including tetrahydroquinolines, N-substituted indoles, 1,4-phenylenebis(methylene) derivatives, and N-containing heterocycles. These small molecules are described *inter alia* in Wilson LJ et al. Drug Development Research. 2011; 72:598-602). Further small molecules have been described as CXCR4 antagonist. We can cite in particular para-xylyl-enediamine-based compounds like Plerixafor or AMD3100 (see Uy et al, Expert Opin Biol Ther. 2008 Nov;8(11):1797-804. doi: 10.1517/14712598.8.11.1797), TG-0054 or Burixafor (ClinicalTrials.gov Identifier: NCT01018979 and Hsu et al, Cell Transplant. 2014 May 12), JM1657 (Mini Rev Med Chem. 2005 Sep;5(9):805-24), AMD3329 (Bridger et al., J. Med. Chem. 1999 Sep 23;42(19):3971-81), AMD3465 (Bodart et al, Biochem Pharmacol. 2009 Oct 15;78(8):993-1000. doi: 10.1016/j.bcp.2009.06.010. Epub 2009 Jun 18), AMD070 (Crawford et al, Org. Process Res. Dev., 2008, 12 (5), pp 823-830), MSX-122 (Liang et al, PLoS One. 2012;7(4):e34038. doi: 10.1371/journal.pone.0034038. Epub 2012 Apr 2), CTCE-9908 (Wong et al, BMC Urology, January 2014, 14:12), WZ811 (http://www.selleckchem.com/products/wz-811.html), N, N'-Di-2-pyridinyl-1,4-benzenedimethanamine, 4F-benzoyl-TN14003 (BKT-140) (Peled et al, Clin. Cancer Res. 2014 Jan 15;20(2):469-79. doi: 10.1158/1078-0432.CCR-13-1302. Epub 2013 Nov 18).

[0045] Several of these small molecules have been approved or are under clinical phases as showed in the following table:

Plerixafor	FDA approved	Hematopoetic stem cell mobilization in patients with non-Hodgkin's lymphoma and multiple myeloma	Genzyme
Plerixafor	Phase I	Glioma, Acute Myeloid Leukemia, Chronic Lymphocytic Leukemia	Genzyme
Plerixafor	Phase I	Myelokathexis (WHIM syndrome)	Genzyme

Plerixafor	FDA approved	Hematopoetic stem cell mobilization in patients with non-Hodgkin's lymphoma and multiple myeloma	Genzyme
TG-0054	Phase II	Hematopoietic stem cell mobilization in patients with multiple myeloma, non-Hodgkin lymphoma or Hodgkin disease	TaiGen Biotechnology Co., Ltd.
AMD070	Phase I/II	HIV Infections	National Institute of Allergy and Infectious Diseases (NIAID)
MSX-122	Phase I	Refractory Metastatic or Locally Advanced Solid Tumors	Metastatix, Inc.
CTCE-9908	Phase I/II	Advanced Solid Tumors	Chemokine Therapeutics Corp.
POL6326	Phase II	Hematopoetic stem cell mobilization in patients with Leukemia, Lymphoma and Multiple Myeloma	Polyphor Ltd.

[0046] CXCR4 antagonists have also been described in numerous publications based on various chemical scaffolds like for example indole-based CXCR4 antagonists *(*Bioorg Med Chem Lett. 2008;18:4124-9), tetrahydroquinoline-based derivatives or bicyclams (US 5,583,131, WO200056729), cyclam mimetics (US20060264451), guanidine-based CXCR4 antagonists (Antimicrob Agents Chemother. 2011;55:255-63).

[0047] A particularly preferred CXCR4 antagonist is Plerixafor (Mozobil) or its derivatives, structurally modified compounds made from Plerixafor. Such derivatives may be aromatic linked polyamine macrocyclic compounds such as tetrafluoro derivatives of Plerixafor which are described *inter alia* in WO 93/12096 and US patent 5583131.

[0048] Other CXCR4 antagonists are cationic molecules able to bind the predominantly anionic extracellular domain of CXCR4. They belong to different chemical classes including cyclic penta- and tetra-peptides, diketopiperazine mimetics, bicyclams, tetrahydroquinolines, thiazolylisothiourea derivatives, benzodiazepines, dipicolylamine-zinc(II) complexes and naturally occurring derivatives.

[0049] Compositions according to the present invention may also comprise peptide based CXCR4 antagonist. To this regard, we can cite peptide based CXCR4 antagonists like LY2510924, GST-NT21MP, T140 a cyclic pentapeptide-based antagonist has been identified as being a highly potent CXCR4 antagonist, and its analogs (TC14012, TE14005, and TN14003), Peptide S, cyclopentapeptide CXCR4 antagonist FC131 (cyclo(-Arg(1)-Arg(2)-2-Nal(3)-Gly(4)-D-Tyr(5)-), 2; 2-Nal = 3-(2-naphthyl)alanine), and the analogue FC122 which

corresponds to the amino acid sequence of FC131 wherein an Arg residue has been replaced by the epimeric N-methyl-D-arginine, or modified peptides like POL6326, cyclic peptides and pentapeptide-based CXCR4 antagonists (WO2008150689).

[0050] According to the present invention, CXCR4 inhibitor may be an antibody-based moiety directed against the CXCR4 receptor, which antibody-based moiety is capable of acting as a CXCL12 antagonist. Specifically anti-CXCR4 antibodies may include anti-CXCR4 ECL3, monoclonal antibody 12G5, monoclonal antibody 708, monoclonal antibody 716 and monoclonal antibody 717 (R&D Systems catalog Nos. MAB170, MAB171, MAB172 and MAB173), monoclonal antibody 2B11, 44717.111, 44716.111, 44708.111 [R&D Systems, Minneapolis, Minn, also see Stalmeijer et al, J Virol. Mar 2004; 78(6): 2722-2728].

[0051] Also included within the scope of invention are antagonists to CXCR4 ligand, *e.g.*,CXCL12-α and/or CXCL12-β (SDF-1-α or SDF-1-β)) antagonists, which can include small organic or synthetic molecules, natural products, peptides, proteins, peptidomimetics, antibodies, antigen binding fragments, nucleic acid agents and the like. SDF-1 truncations, variants, mutant proteins or "muteins" having the ability to bind CXCR4 and have antagonistic activity may also be used to practice the method of the invention.

[0052] Nucleic acid inhibitors of SDF-1 activity have also been described and may be used in the compositions of the present invention. These nucleic acid-based inhibitors may function at either the receptor binding level or the gene expression and translational levels. The nucleic acid inhibitors of CXCR4 activity include, without limitations, nucleic acid enzymes (such as ribozymes), nucleic acid aptamers, antisense nucleic acids, and RNAi, such as siRNA. Nucleic acid CXCR4 inhibitors have been described in the following references: U.S. Patent No. 6,429,308 B1; U.S. Publication No. 2005/0124569 A1; U.S. Patent No. 6,916,653 B2; U.S. Publication No. 2005/0202077 A1. Such nucleic acid inhibitors can include an antisense oligonucleotide which is complementary to some parts of base sequences of chromosomal DNA and/or RNA encoding CXCR4 protein. The antisense oligonucleotide of the present invention may be DNA or RNA.

[0053] Specifically antisense oligonucleotide can be complimentary to the base sequence containing initiation codon region from +61 to +91 when the gene transcription initiation point of mRNA encoding CXCR4 protein is to be +1, and at the same time hybridizes stably with the said sequence specifically and blocks the translation into a protein so as to have a function to inhibit the biosynthesis of the CXCR4 protein. Alternatively it could be siNA that can be unmodified or chemically-modified whereby the use of chemically-modified siNA improves various properties of native siNA molecules through increased resistance to nuclease degradation in vivo and/or through improved cellular uptake as elaborated in '077. Also included within scope are mRNA coding for the CXCR4 proteins that can be cleaved by hammerhead ribozymes so as to effectively block production of these proteins as described in U.S. Patent No. 6,916,653 B2. Further within scope are siNAs that may be effectively employed in compositions to include the siRNA sequences corresponding to the target sequences provided in SEQ ID NO: 101-823 of U.S. Publication No. 2005/0202077.

[0054] The CCR2, CCR3 and or CXCR4 antagonists suitable for use in accordance with the present invention can be administered alone but, in human therapy, will generally be administered in admixture with a suitable pharmaceutically acceptable vehicle, excipient, diluent, or carrier selected with regard to the intended route of administration and standard pharmaceutical practice. Such pharmaceutically acceptable vehicle or excipient may be present in an amount between 0.1% and less than 100% by weight. Optimizing drug-excipient ratios are with the reach of a person with ordinary skill in art for instance the desired weight ratio of drug/excipient in the composition could be less than or equal to the ratio of solubilities of drug/excipient, in a suitable medium.

[0055] Compositions according to the present invention are thus preferably pharmaceutical compositions for use in a method of treating and/or preventing COPD and AECOPD and thus comprise a therapeutically effective amount of at least one antagonist or inhibitor of CCR2/CCL2, CCR2/CCL7, CCR2/CCL13, CXCR4/CXCL12, and/or CCR3/CCL11 receptor/ligand pairs and a pharmaceutically acceptable carrier. Such pharmaceutical compositions are efficient in reducing fibrocytes recruitment and migration associated with COPD and modulated via CCR2 and/or CCR3 and/or CXCR4.

[0056] A therapeutically effective amount is a predetermined amount sufficient to achieve an effective systemic concentration or local concentration in the tissue and desired effect, *i.e.*, inhibiting or blocking/antagonizing one or more of the above receptor/ligand pairs. The specific dose of a compound administered according to this invention to obtain therapeutic and/or prophylactic effects will, of course, be determined by the physician depending on the conditions of the patients, weight, age and sex, compound administered, the route of administration, etc...

[0057] Pharmaceutical compositions of the present invention may be administered orally, buccally, or sublingually, and may be in the form of tablets, capsules (including soft gel capsules), multiparticulate, gels, films, elixirs, solutions or suspensions, which may contain flavoring or coloring agents, for immediate-, delayed-, modified-, sustained-, dual-, controlled-release or pulsatile delivery applications. Such compounds may also be administered via fast dispersing or fast dissolving dosages forms or in the form of high energy dispersion or as coated particles. Suitable pharmaceutical formulations may be in coated or un-coated form as desired.

[0058] Such solid pharmaceutical compositions, for example, tablets may contain excipients such as microcrystalline cellulose, lactose, sodium citrate, calcium carbonate, dibasic calcium phosphate, glycine and starch, disintegrants such as sodium starch glycollate, croscarmellose sodium and certain complex silicates, and granulation binders such as polyvinylpyrrolidone, hydroxypropylmethyl cellulose (HPMC), hydroxypropylcellulose (HPC), hydroxypropyl methylcellulose acetate succinate (HPMCAS), sucrose, gelatin and acacia. Additionally, lubricating agents such as magnesium stearate, stearic acid, glyceryl behenate and talc may be included. Solid compositions of a similar type may also be employed as fillers in gelatin capsules or HPMC capsules. Excipients in this regard include lactose, starch, cellulose, milk

sugar, or high molecular weight polyethylene glycols. For aqueous suspensions and/or elixirs, the CCR2, CCR3 and/or CXCR4 antagonists compounds may be combined with various sweetening or flavoring agents, coloring matter or dyes, with emulsifying and/or suspending agents and with diluents such as water, ethanol, propylene glycol and glycerin, and combinations thereof.

[0059] Modified release and pulsatile release dosage forms may contain excipients such as those detailed for immediate release dosage forms together with additional excipients that act as release rate modifiers, these being coated on and/or included in the body of the device. Release rate modifiers include, but are not exclusively limited to, HPMC, HPMCAS, methyl cellulose, sodium carboxymethylcellulose, ethyl cellulose, cellulose acetate, polyethylene oxide, Xanthan gum, Carbomer, ammonio methacrylate copolymer, hydrogenated castor oil, camauba wax, paraffin wax, cellulose acetate phthalate, hydroxypropylmethyl cellulose phthalate, methacrylic acid copolymer and mixtures thereof. Modified release and pulsatile release dosage forms may contain one or a combination of release rate modifying excipients. Release rate modifying excipients maybe present both within the dosage form, *i.e.,* within the matrix, and/or on the dosage form, *i.e.,* upon the surface or coating.

[0060] Fast dispersing or dissolving dosage formulations (FDDFs) may contain the following ingredients: aspartame, acesulfame potassium, citric acid, croscarmellose sodium, crospovidone, diascorbic acid, ethyl acrylate, ethyl cellulose, gelatin, hydroxypropylmethyl cellulose, magnesium stearate, mannitol, methyl methacrylate, mint flavoring, polyethylene glycol, fumed silica, silicon dioxide, sodium starch glycolate, sodi stearyl fumarate, sorbitol, xylitol. The terms dispersing or dissolving as used herein to describe FDDFs are dependent upon the solubility of the drug substance used, *i.e.,* in cases where the drug substance is insolu fast dispersing dosage form can be prepared, and, in cases where the drug substance is soluble, a fast dissolving dosage form can be prepared.

[0061] The CCR2, CCR3 and/or CXCR4 antagonists suitable for use in accordance with the present invention can also be administered parenterally, for example, intracavemosally, intravenously, intra-arterially, intraperitoneally, intrathecally, intraventricularly, intraurethrally, intrasternally, intracranially, intramuscularly or subcutaneously, or they may be administered by infusion or needle-free techniques. For such parenteral administration they are best used in the form of a sterile aqueous solution, which may contain other substances, for example, enough salts or glucose to make the solution isotonic with blood. The aqueous solutions should be suitably buffered (preferably, to a pH of from about 3 to 9), if necessary. The preparation of suitable parenteral formulations under sterile conditions is readily accomplished by standard pharmaceutical techniques well known to those skilled in the art.

[0062] For oral and parenteral administration to patients may be daily dosage level of the CCR2, CCR3 and/or CXCR4 antagonists as determined by a physician and will vary with the age, weight and response of the particular patient. The dosage may be by a single dose, divided daily dose, or multiple daily doses. Alternatively, continuous dosing, such as for example, via a controlled (*e.g.,* slow) release dosage form can be administered on a daily

basis or for more than one day at a time.

[0063] The CCR2, CCR3 and/or CXCR4 antagonists suitable for use in accordance with the present invention can also be administered intranasally or by inhalation and are conveniently delivered in the form of a dry powder inhaler or an aerosol spray presentation from a pressurized container, pump, spray or nebuliser with the use of a suitable propellant, *e.g.* dichlorodifluoromethane, trichlorofluoromethane, dichlorotetrafluoroethane, a hydrofluoroalkane such as 1 ,1 ,1 ,2-tetrafluoroethane (HFA 134A(TM) or 1 ,1 ,1 ,2,3,3, 3-heptafluoropropane (HFA 227EA(TM)), carbon dioxide or other suitable gas. In the case of a pressurized aerosol, the dosage unit may be determined by providing a valve to deliver a metered amount. The pressurized container, pump, spray or nebuliser may contain a solution or suspension of the active compound, e.g. using a mixture of ethanol and the propellant as the solvent, which may additionally contain a lubricant, *e.g.*, sorbitan trioleate. Capsules and cartridges (gelatine capsule) for use in an inhaler or insufflator may be formulated to contain a powder mix of a compound of the invention and a suitable powder base such as lactose or starch.

[0064] Aerosol or dry powder formulations are preferably arranged so that each metered dose or "puff' contains a therapeutically effective amount of CCR2, CCR3 and/or CXCR4 antagonists antagonist for delivery to the patient to be treated. The overall daily dose with an aerosol will be in the range of from 1 to 50 mg, which may be administered, in a single dose or, more usually, in divided doses throughout the day. CCR2, CCR3 and/or CXCR4 antagonists suitable for use in accordance with the present invention may also be formulated for delivery via an atomiser. Formulations for atomiser devices may contain the following ingredients as solubilisers, emulsifiers or suspending agents: water, ethanol, glycerol, propylene glycol, low molecular weight polyethylene glycols, sodium chloride, fluorocarbons, polyethylene glycol ethers, sorbitan trioleate, and oleic acid.

[0065] The CCR2, CCR3 and/or CXCR4 antagonists suitable for use in accordance with the present invention may also be used in combination with a cyclodextrin. Cyclodextrins are known to form inclusion and non-inclusion complexes with drug molecules. Formation of a drug-cyclodextrin complex may modify the solubility, dissolution rate, and bioavailability and/or stability property of a drug molecule. Drug-cyclodextrin complexes are generally useful for most dosage forms and administration routes. As an alternative to direct complexation with the drug the cyclodextrin may be used as an auxiliary additive, e.g. as a carrier, diluent or solubiliser. Alpha-, beta- and gamma-cyclodextrins are some of the most commonly used and suitable examples are described in PCT Publication Nos. WO 91/11172, WO 94/02518 and WO 98/55148. According to the present invention, the oral administration is the preferred route.

[0066] In circumstances where the recipient suffers from a swallowing disorder or from impairment of drug absorption after oral administration, the drug may be administered parenterally, sublingually, or buccally. In the event that the agent is inactive orally then parenteral administration could be utilized.

[0067] Other possible formulations, such as nanoparticles, liposomes and immunologically based systems may also be used to administer an appropriate dose of the compositions comprising therapeutically effective amount of CCR2, CCR3 and/or CXCR4 antagonists according to the present invention.

[0068] Antagonists of CCR2, CCR3 and/or CXCR4 receptors may be administered singly or in any combination thereof. Further, CCR2, CCR3 and/or CXCR4 antagonists can be administered singly or in any combination thereof in a temporal sense, in that they may be administered simultaneously, before, and/or after each other. According to the disclosure provided herein, CCR2, CCR3 and or CXCR4 antagonists are useful in reducing and/or inhibiting fibrocytes migration and differentiation and are thus useful for treating and/or preventing COPD as well as AECOPD.

[0069] The present invention also provides kits or pharmaceutical packages that include appropriate doses of the above antagonists or compositions for use in the prevention and/or treatment of COPD and AECOPD. In addition to compositions in the form of, for example, tablets, capsules, or lyophilized powders, the kits or pharmaceutical packages can include instructions for using and administering the composition for the prevention and/or treatment of COPD and AECOPD. Such kits or packages may be provided in a bottle or another appropriate form (*e.g.*, a blister pack). Optionally, the kits or pharmaceutical packages can also include other pharmaceutically active agents, and/or materials used in administration of the drug(s), such as diluents, needles, syringes, applicators, and the like.

[0070] In particular, pharmaceutical compositions and kits according to the present invention may be administered in association with other pharmaceutically active agents, such as for example bronchodilatators (LABA, LAMA), corticoids, and/or phosphodiesterase inhibitors either orally or by inhalation.

[0071] The present invention further provides a method of suppressing fibrocytes proliferation, migration and differentiation mediated and/or modulated by CCR2, CCR3 and/or CXCR4 in a subject having COPD or AECOPD or at a risk of developing COPD or AECOPD comprising administering to the subject a therapeutically effective amount of the pharmaceutical composition as described above.

[0072] According to a second embodiment, the present invention is directed to *in vitro* or *in vivo* method of screening or identifying agents that can be used in the treatment methods described herein. These methods can include determination of whether an agent inhibits CCR2, CCR3 and or CXCR4 ligand binding or function followed by confirmation of it as being effective in treating and/or preventing COPD. Alternatively, the screening methods can simply involve testing agents that are known to be CCR2, CCR3 and/or CXCR4 inhibitory therapeutic agents for their efficacy in treating and/or preventing COPD. Testing an agent for its efficacy in altering CCR2, CCR3 and/or CXCR4 activity can be carried out using *in vitro* and/or *in vivo* methods that are well known in the art (Charo et al., (1994) PNAS 91, 2752-2756). Therapeutic efficacy of such active compounds can be determined by standard therapeutic procedures in

cell cultures or in animal models, *e.g.*, for determining the ED50 (the concentration of compound that produces 50% of the maximal effect). Such testing can be carried out in appropriate animal model systems for COPD.

[0073] According to this embodiment, further antagonists of CCR2, CCR3 and CXCR4 functions may be identified, for example, by screening libraries of collections of molecules. Another source of antagonists of CCR2, CCR3 and/or CXCR4 functions may be combinatorial libraries, which can comprise many structurally distinct molecular species. Combinatorial libraries can be used to identify lead compounds or to optimize a previously identified lead. Such libraries can be manufactured by well-known methods of combinatorial chemistry and screened by suitable methods.

[0074] Other selective antagonists can be identified using standard assays known to those skilled in the art. Briefly, one type of screen to identify selective modulators uses cell lines, including primary cells or transfected CCR2, CCR3 and/or CXCR4 cells. Alternatively, animal models could be utilized.

[0075] The method of the present invention is thus particular useful for screening/identifying agents capable of decreasing fibrocytes migration and differentiation in COPD or during AECOPD. Said method may comprise administering to a test animal over-expressing one or more of CCR2, CCR3 and/or CXCR4 and analyzing whether the amount of CCR2, CCR3 and/or CXCR4 is decreased compared to the levels prior to administration of the test agent, wherein if the amount of the CCR2, CCR3 and/or CXCR4 is decreased, the test agent is identified as an agent is capable of decreasing fibrocytes migration and differentiation in COPD.

[0076] According to a third embodiment, the present invention is directed to a method of assessing the risk of COPD or AECOPD in a subject, comprising; a) obtaining a suitable sample from the said subject b) isolating and identifying the circulating fibrocytes in the said sample c) optionally assessing fibrocytes migration in the said sample and d) measuring the expression levels of CCR2, CCR3, and/or CXCR4 chemokine receptors in the said sample. Such method may further comprise a step of administering to the subject diagnosed with risk of developing COPD, AECOPD or diagnosed with COPD or AECOPD, an effective amount of the pharmaceutical composition as described above.

[0077] According to a fourth embodiment, the present invention provides an *in vitro* method of measuring the level of at least one gene selected from the group consisting of CCR2, CCR3 and CXCR4 in the peripheral blood fibrocytes. The present invention also provides a method for monitoring the response to a therapeutic agent in a patient suffering from COPD comprising the step of measuring the level of expression of at least one gene selected from the group consisting of CCR2, CCR3 and CXCR4 in the peripheral blood fibrocytes of the patient.

EXAMPLES

Example 1 - Enrollment of subject

[0078] Subjects aged more than 40 years were eligible for enrollment if they had a clinical diagnostic of COPD exacerbation according to the GOLD guidelines (Gold 1998. Global Initiative for Chronic Obstructive Lung Disease. Global Strategy for the Diagnosis, Management and Prevention for Chronic Obstructive Pulmonary Disease. NIH Publication - updated 2011). COPD patients with exacerbation have been recruited during hospitalization in Intensive care unit or as outpatients in the clinical investigation centre of the CHU de Bordeaux. 48 healthy volunteers without any history of lung disease and with normal lung function testing were recruited. Subjects are separated in 2 sub-groups according to smoking history (never smokers, former or current smokers) and paired to patients according to age and sex.

[0079] Main exclusion criteria for COPD patients and healthy subjects were asthma, lung fibrosis, idiopathic pulmonary hypertension and chronic viral infections (hepatitis, HIV). Exacerbating COPD patients and control subjects were enrolled in the "Firebrob" study. Additionally, COPD patients that have not exacerbated during a minimal period of one year were also recruited as outpatients in the clinical investigation centre of the CHU de Bordeaux ("Cobra" study). They are designed as "non-exacerbating COPD patients" in the following text. All subjects provided written informed consent. The study protocol was approved by the local research ethics committee and the French National Agency for Medicines and Health Products Safety.

Example 2 - Design of the "Firebrob" study

[0080] The study was conducted in centers group clinical trial during 3 years. A summary of the study is provided Figure 1. The study has been registered under the N° NCT01 196832 at ClinicalTrials.gov (*i.e.* "Firebrob" study).

[0081] There were two visits for exacerbating COPD patients: a visit during the exacerbation (inclusion, VI), a visit two months ± 7 days after the exacerbation (stable state, V2). The inclusion visit (VI) consisted of the information and signature of the inform consent, taking blood sample (50 ml) for fibrocyte analysis. The second visit (V2) consisted of a clinical and functional evaluation (plethysmography, TLCO, arterial gaz) and taking blood sample for fibrocyte analysis. There was one visit for control subjects and "non-exacerbating COPD patients", during which the inform consent was signed, a clinical and functional evaluation was performed (plethysmography, TLCO, arterial gaz), and blood sample was taken for fibrocyte analysis.

Example 3 - Design of the "Cobra" study

[0082] There was one visit "non-exacerbating COPD patients", during which the inform consent was signed, a clinical and functional evaluation was performed (plethysmography, TLCO, arterial gaz), and blood sample was taken for fibrocyte analysis.

[0083] The study have been registered under the N°CPP 0811738 (*i.e.* "Cobra" study)

Example 4 - Circulating fibrocytes

[0084] Purification of nonadherent non-T (NANT) cells was performed. Briefly, peripheral blood mononuclear cells (PBMC) were separated from whole blood by Ficoll-Hypaque density gradient centrifugation. After the first centrifugation at 150g for 15 min, the top plasma layer was harvested and kept at -80°C for further analysis. Mononuclear cells at the interface were harvested, washed once with IX PBS. Erythrocyte lysis was performed by adding 20 ml of hypotonic 0.2% NaCl solution during 30s, followed by adding 20 ml of 1.6% NaCl to end with an isotonic solution. Mononuclear cells were again washed with IX PBS, resuspended in Dulbecco's modified Eagle medium (DMEM), 4.5 g/l glucose, L-glutamine, supplemented with 20% fetal bovine serum (FBS), penicillin/streptomycin and MEM non essential amino acid and incubated 1h at 37°C. The non-adherent mononuclear cell fraction was taken and washed in cold IX PBS 0.5% BSA, 2 mM EDTA. T-cells were further depleted with anti-CD3 monoclonal antibody (Miltenyi Biotech). At least $0.2x10^6$ nonadherent non-T (NANT) cells were distributed in each FACS tube and fixed overnight with Cytofix/Cytoperm (eBioscience).

Example 5 - Identification and characterization of circulating fibrocytes

[0085] Fibrocytes were identified by flow cytometry as double positive for the surface marker CD45 and the intracellular marker collagen I. Fixed blood NANT cells were washed in permeabilization buffer (eBioscience) and incubated either with mouse anti-human collagen I antibodies (Millipore Cat# MAB3391, RRID:AB_94839) or with matched IgGI isotype control (Santa Cruz Biotechnology Cat# sc-3877, RRID:AB_737222), followed by fluorescein isothiocyanate (FITC)-conjugated anti-mouse antibodies (Beckman Coulter Cat# IM0819). Next, the cell pellet was incubated either with allophycocyanin (APC)-conjugated anti-CD45 antibodies (BD Biosciences Cat# 555485, RRID:AB_398600) or with matched APC-conjugated IgGI isotype control (BD Biosciences Cat# 555751, RRID:AB_398613). The cell suspension was analyzed with a BD FACSCanto II flow cytometer (BD Biosciences, San Jose, CA). Offline analysis was performed with FACSDiva software. The negative threshold for CD45 was set using a matched APC-conjugated IgG1 isotype control, and all subsequent samples were gated for the CD45 positive region. Cells gated for CD45 were analyzed for collagen-1 expression, with negative control thresholds set using FITC-stained cells. Specific staining for collagen-1 was determined as an increase in positive events over this threshold. Fibrocyte numbers were expressed as a percentage of total PBMC counts.

Example 6 - Fibrocyte migration

[0086] Fibrocyte migration was assessed using a modified Boyden chamber assay. The transwell inserts (pore size 8 µm) and the wells were coated for 1h at room temperature with poly-lysine-ethylene glycol (PEG-PLL, Susos) to prevent cell adhesion. The inserts and the wells were rinsed with PBS. $0,3.10^6$ nonadherent non-T (NANT) cells resuspended in 0.2 ml resuspended in 0.2 ml DMEM, 4.5 g/l glucose, L-glutamine, supp DMEM, 4.5 g/l glucose, L-glutamine, supplemented with ITS, penicillin/streptomycin and MEM non essential amino acid were added to the upper compartment of each well. When indicated, NANT cells were pretreated for 1h at 37° by 25 µg/ml plerixafor (Sigma-Aldrich) or 10 µM SB 328437 (R&D Systems) before being added to the upper compartment. Recombinant human CXCL12 (25 ng/ml to 200 ng/ml; R&D Systems), recombinant human CCL11 (25 ng/ml to 200 ng/ml; R&D Systems) or plasma (50% dilution) extracted from blood coming from COPD VI patient or control subject was added to the bottom compartment of each well. After about 12h, the content of bottom compartment was removed to assess fibrocyte migration by flow cytometry using double labeling CD45-collagen I. To obtain absolute values of migratory cells, flow cytometric counts for each condition were obtained during a constant predetermined time period (1 min). The fraction of migratory fibrocytes was defined by the ratio between the number CD45+coll I+ cells counted in the bottom chamber divided by the number of CD45+coll I+ cells added in the upper compartment. These values were normalized to the fraction of migratory fibrocytes obtained in the basal condition (medium only).

Example 7 - Measurement of plasma CXCL12 and CCL11

[0087] Plasma CXCL12 and CCL11 were measured by ELISA according the manufacturer's instructions (R&D Systems).

Example 8 - Results

Enrollment and Baseline Characteristics

[0088] 58 exacerbating COPD patients and 48 control subjects were enrolled (Figure 1). Level of fibrocytes in 48 exacerbating COPD patients (VI), in 9 non exacerbating COPD patients and in 38 control subjects were then quantified. Level of fibrocytes in 27 COPD patients at stable state (V2) was then quantified.

Circulating blood fibrocytes

[0089] The percentage of blood fibrocytes (CD45+ ColI+ cells) was higher in patients with COPD during exacerbation ("VI", median=9.6 (95% confidence interval [CI], 9.5 to 15.7) of PBMC, n=48) compared with "non-exacerbating COPD patients" ("Nex", median=2.4 (95% CI, 0.3 to 6.8) of PBMC, n=9, $p<0.05$) and in control subjects (median=3.0 (95% CI, 3.1 to 5.3) of PBMC, n=38, $p<0.001$) (Figure 2A). Similar results were obtained in the fibrocyte level when expressed as absolute counts per milliliter of blood (Figure 2B). Both the percentage (Figure 2C) and the absolute number (Figure 2D) of circulating CD34-positive fibrocytes were increased in exacerbating COPD patients as compared to those in control subjects. However, when separating subgroups of exacerbating COPD patients, based on their treatment for the exacerbation of COPD (antibiotic, oral corticoids), ventilation mode (spontaneous ventilation, non-invasive ventilation or intubation), presence or absence of hospitalization, no significant differences in fibrocytes between the different subgroups were observed (data not shown).

[0090] Two months after exacerbation ("V2"), both the percentage (Figure 2E) and the absolute number (Figure 2F) of fibrocytes were significantly reduced as compared to those assessed at VI ($p<0.01$). Moreover, there was a significant increase in the percentage of fibrocytes at V2 in a subgroup of patients with 2 or more unscheduled visit for COPD the year before VI and that without any unscheduled visit (Figure E1).

Relationships between fibrocytes, survival and both functional and clinical parameters

[0091] Survival data were collected in COPD patients for a median period of 1.4 year and up to 3 years after VI. Kaplan-Meier survival analysis was performed in 2 subgroups of patients based on the percentage of fibrocytes assessed at VI. Patients with more than 28% fibrocytes had a significant reduced life expectancy compared with patients with less than 28% fibrocytes (Figure 3A). There was no statistical difference between the 2 subgroups in terms of sex ratio, age, FEV1, FVC, PaO2 (data not shown). The subgroup of patients with more than 28% fibrocytes consisted of 6 patients with acute exacerbation all requiring hospitalization, whereas the subgroup of patients with less than 28% fibrocytes consisted of 36 patients with acute exacerbation (20 requiring hospitalization and 16 without hospitalization).

[0092] Correlations coefficients between the percentages of fibrocytes assessed at the second visit (*i.e.*, V2 two months after the exacerbation at a stable state) and various functional parameters were also determined. The percentage of fibrocytes was negatively and significantly correlated to FEV1 (% predicted, Figure 3B), FVC (% predicted, Figure 3C), the FEV1/FVC ratio (%, Figure 3D), TLCO (% predicted, Figure 3E) and PaO_2 (mmHg, Figure 3F). Similar negative correlations were obtained between the percentage of circulating fibrocytes at the second visit and FEV1 (L), FVC (L) or FEF25-75 (L/s and % predicted) (Figure E2). By contrast, there was no significant correlation between the percentages of circulating fibrocytes of exacerbating patients with age (data not shown).

Fibrocyte expression of chemokine receptors

[0093] The expression of chemokine receptors was further evaluated in fibrocytes by flow cytometry. CXCR4, CCR2 and CCR3 were expressed by a high proportion of fibrocytes (Figures 4A, C, E), whereas CCR5 and CCR7 were only found on a small proportion of CD45+CoII+ cells (Figures 4G and H). There was a higher level of CXCR4+ and CCR3+ fibrocytes in COPD patients than in control subjects (Figures 4B, D and F).

Role of the CXCL12/CXCR4 and CCL11/CCR3 axes in fibrocyte migration

[0094] Since more CXCR4+ and CCR3+ fibrocytes were found in the blood of exacerbating COPD patients, role of both CXCR4 and CCR3 in plasma-induced fibrocytes migration was investigated in an *in vitro* assay. Plerixafor, an antagonist of CXCR4 (De Clercq, E. 2003. The bicyclam AMD3100 story. Nat Rev Drug Discov 2(7):581-7) induced a significant reduction in the plasma-induced recruitment of fibrocytes obtained from exacerbating COPD patients but no significant reduction in the migration of fibrocytes obtained from normal subjects (Figure 5A). By contrast, plasma-induced migration of fibrocytes from exacerbating COPD patients or from control subjects was not affected by SB 328437, an antagonist of CCR3 (White, J. R., et al. 2000. J Biol Chem 275(47):36626-31) (Figure E3A). Plasma concentrations of some of ligands of CXCR4 and CCR3 were also compared. Plasma concentrations of CXCL12 alpha (ligand of CXCR4) and CCL11 and CCL13 (ligands of CCR3) did not differ significantly between groups (Figure 5B, Figure E3B). Therefore, the migratory response of fibrocytes to increasing concentrations of CXCL12 alpha and CCL11 was examined. CXCL12 alpha (Figure 5C) but not CCL11 (Figure E3C) induced a significant fibrocytes migration in a dose-dependent manner. Interestingly, 100 ng/ml of CXCL12 alpha triggered a significantly higher migration of fibrocytes from exacerbating COPD patient compared to fibrocytes from control subjects (Figure 5C), suggesting that fibrocytes from exacerbating COPD patient had an enhanced chemosensitivity to CXCL12 compared to fibrocytes from controls. This response was completely abolished by a treatment with plerixafor, showing that this answer was completely mediated by CXCR4 (Figure 5D).

SEQUENCE LISTING

[0095]

<110> UNIVERSITE DE BORDEAUX
INSTITUT NATIONAL DE LA SANTE ET DE LA RECHERCHE MEDICALE - INSERM
CENTRE HOSPITALIER DE BORDEAUX

<120> NEW COMPOSITIONS AND METHODS OF TREATING AND/OR PREVENTING CHRONIC OBSTRUCTIVE PULMONARY DISEASE

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REFERENCES CITED IN THE DESCRIPTION

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Anvendelse af plerixafor til behandling og/eller forebyggelse af akutte forværringer af kronisk obstruktiv lungesygdom

PATENTKRAV

1. En sammensætning til anvendelse i en fremgangsmåde til forebyggelse og/eller behandling af AECOPD omfattende en terapeutisk effektiv mængde plerixafor som antagonist eller inhibitor af kemokinreceptor CXCR4.

2. En farmaceutisk sammensætning til anvendelse i en fremgangsmåde til behandling og/eller forebyggelse af AECOPD omfattende sammensætningen som defineret i patentkrav 1 og en farmaceutisk acceptabel bærer.

3. En farmaceutisk sammensætning til anvendelse i en fremgangsmåde ifølge patentkrav 2, yderligere omfattende bronkodilatatorer, corticoider og/eller phosphodiesteraseinhibitorer.

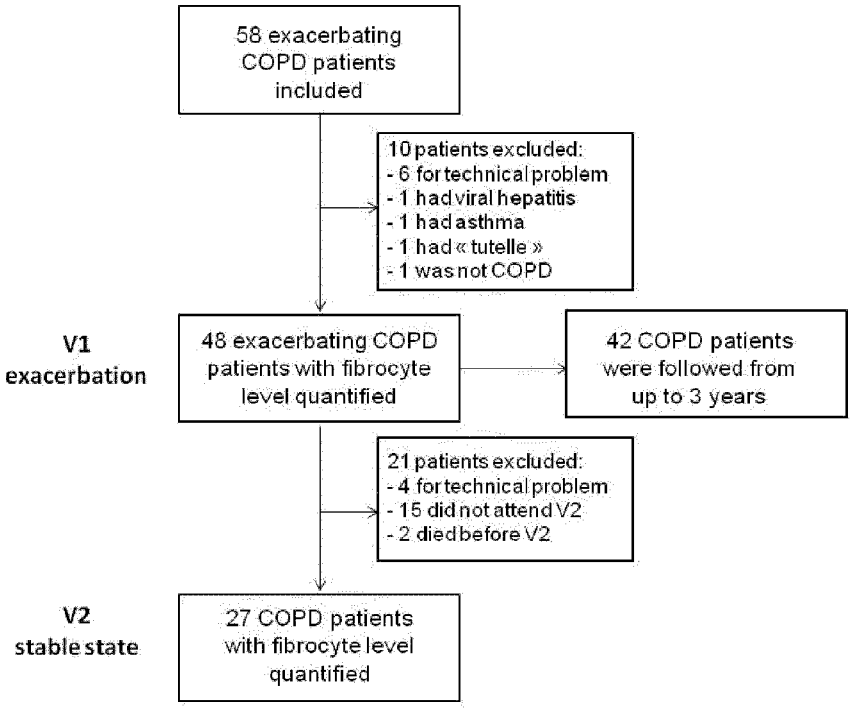
4. Farmaceutisk sammensætning til anvendelse ifølge patentkrav 2 eller 3, hvor sammensætningen administreres oralt, bukkalt eller sublingualt og er i form af tabletter, kapsler (inklusive bløde gelkapsler), multipartikulater, geler, film, eliksirer, opløsninger eller suspensioner, som kan indeholde aromastoffer eller farvestoffer til øjeblikkelig, forsinket, modificeret, vedvarende, dobbelt, kontrolleret frigivelse eller pulserende afgivelsesapplikationer.

5. Farmaceutisk sammensætning til anvendelse ifølge patentkrav 4, hvor nævnte sammensætning administreres ved inhalation og er i form af en tørpulverinhalator eller en aerosolspraypræsentation fra en trykbeholder, pumpe, spray eller forstøver.

6. Sæt eller farmaceutisk pakke til anvendelse i en fremgangsmåde til behandling og/eller forebyggelse af AECOPD omfattende en eller flere doser af den farmaceutiske sammensætning ifølge et hvilket som helst af patentkravene 2-5.

DRAWINGS

FIGURE 1



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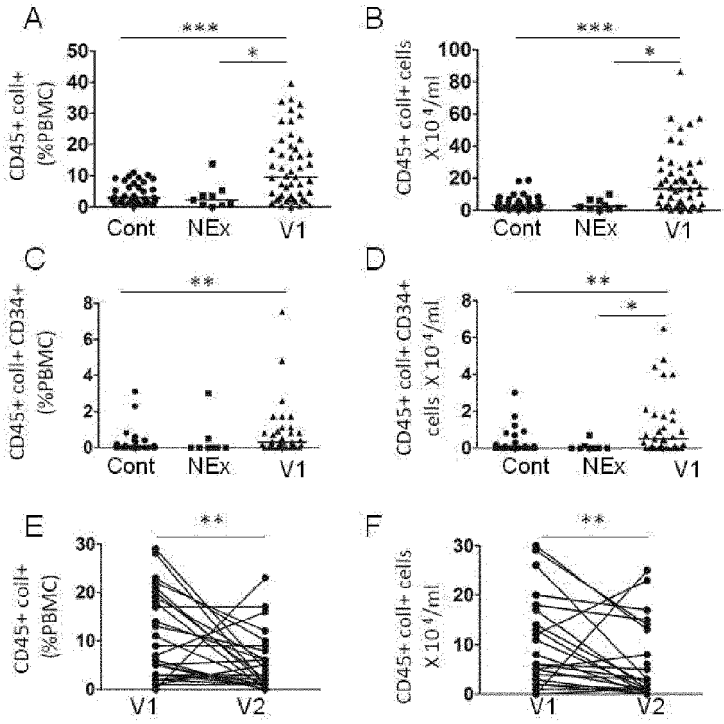
A
***
*
CD45+ coll+ (%PBMC)
50
40
30
20
10
0
Cont
NEx
V1
B
***
*
CD45+ coll+ cells X 10⁴/ml
100
80
60
40
20
0
Cont
NEx
V1
C
**
CD45+ coll+ CD34+ (%PBMC)
8
6
4
2
0
Cont
NEx
V1
D
**
*
CD45+ coll+ CD34+ cells X 10⁴/ml
8
6
4
2
0
Cont
NEx
V1
E
**
CD45+ coll+ (%PBMC)
30
20
10
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V1
V2
F
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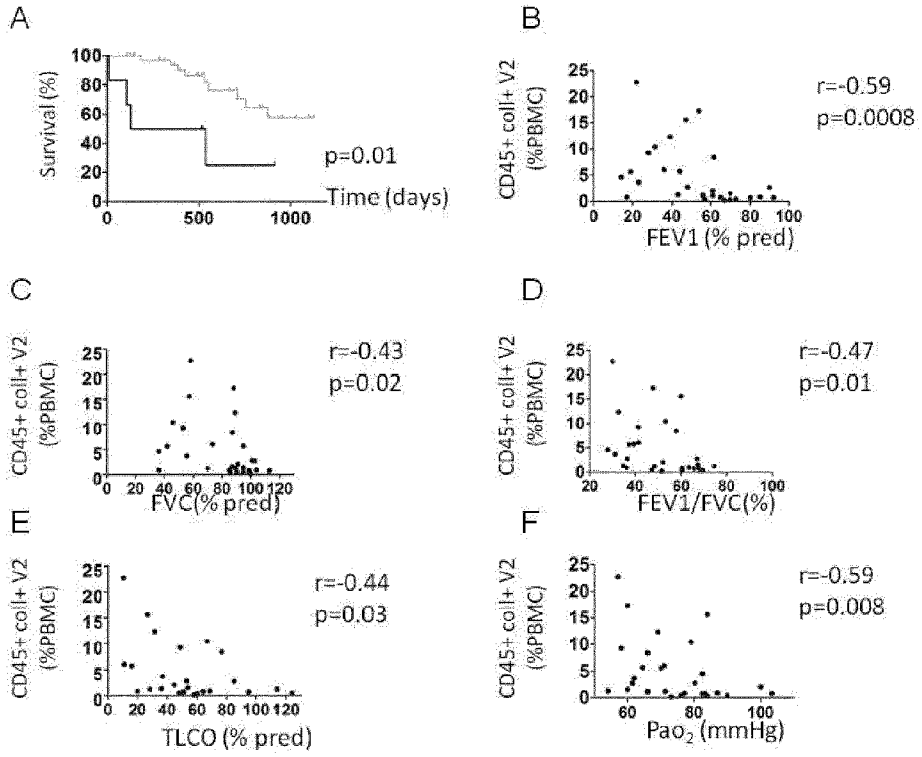
CD45+ coll+ cells X 10⁴/ml
30
20
10
0
V1
V2

FIGURE 3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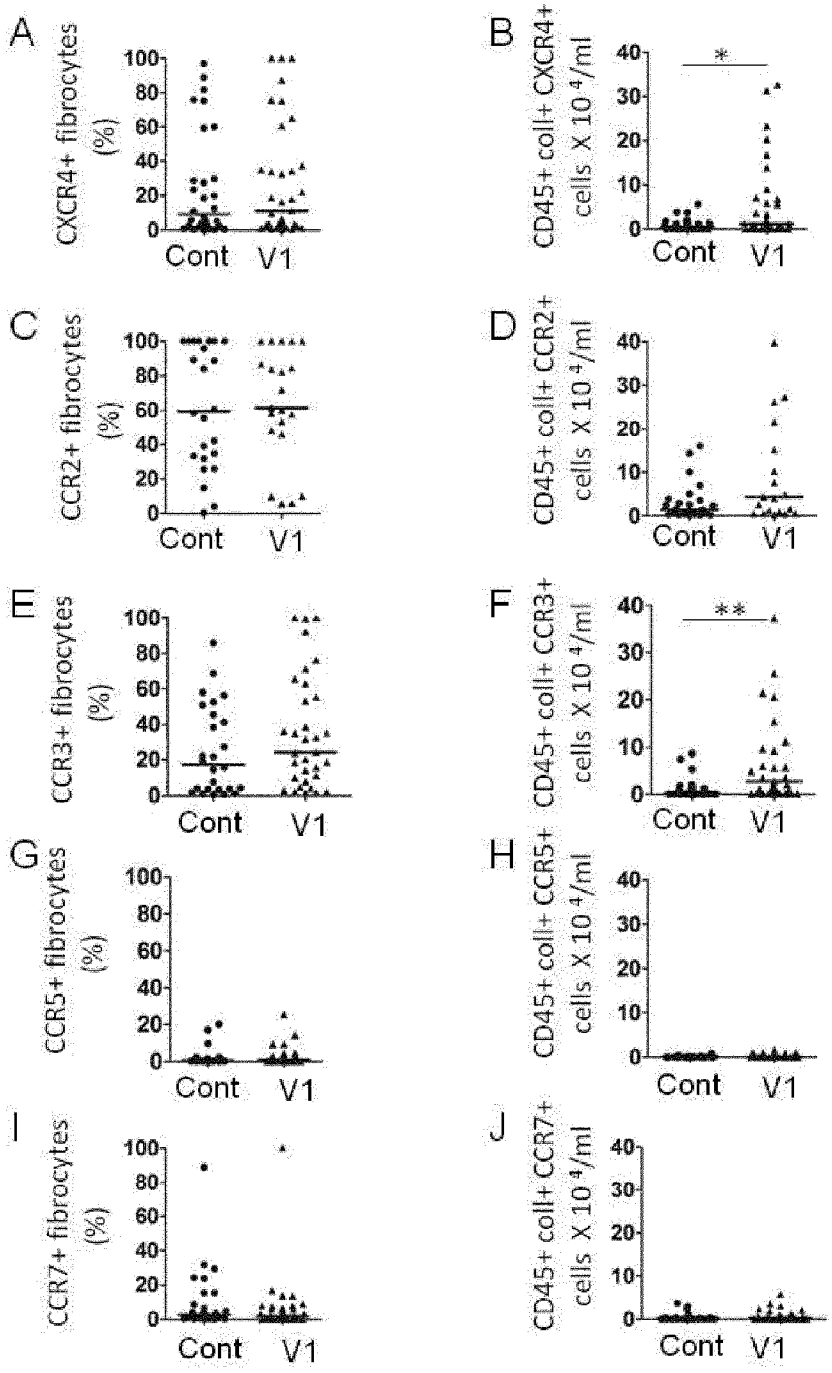
Survival (%)
p=0.01
Time (days)
B
CD45+ coll+ V2 (%PBMC)
r=-0.59
p=0.0008
FEV1 (% pred)
C
CD45+ coll+ V2 (%PBMC)
r=-0.43
p=0.02
FVC(% pred)
D
CD45+ coll+ V2 (%PBMC)
r=-0.47
p=0.01
FEV1/FVC(%)
E
CD45+ coll+ V2 (%PBMC)
r=-0.44
p=0.03
TLCO (% pred)
F
CD45+ coll+ V2 (%PBMC)
r=-0.59
p=0.008
Pao2 (mmHg)

FIGURE 4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CXCR4+ fibrocytes (%)
100
80
60
40
20
0
Cont
V1
B
CD45+ coll+ CXCR4+ cells X 10 4/ml
40
30
20
10
0
*
Cont
V1
C
CCR2+ fibrocytes (%)
D
CD45+ coll+ CCR2+ cells X 10 4/ml
E
CCR3+ fibrocytes (%)
F
CD45+ coll+ CCR3+ cells X 10 4/ml
**
G
CCR5+ fibrocytes (%)
H
CD45+ coll+ CCR5+ cells X 10 4/ml
I
CCR7+ fibrocytes (%)
J
CD45+ coll+ CCR7+ cells X 10 4/ml

FIGURE 5

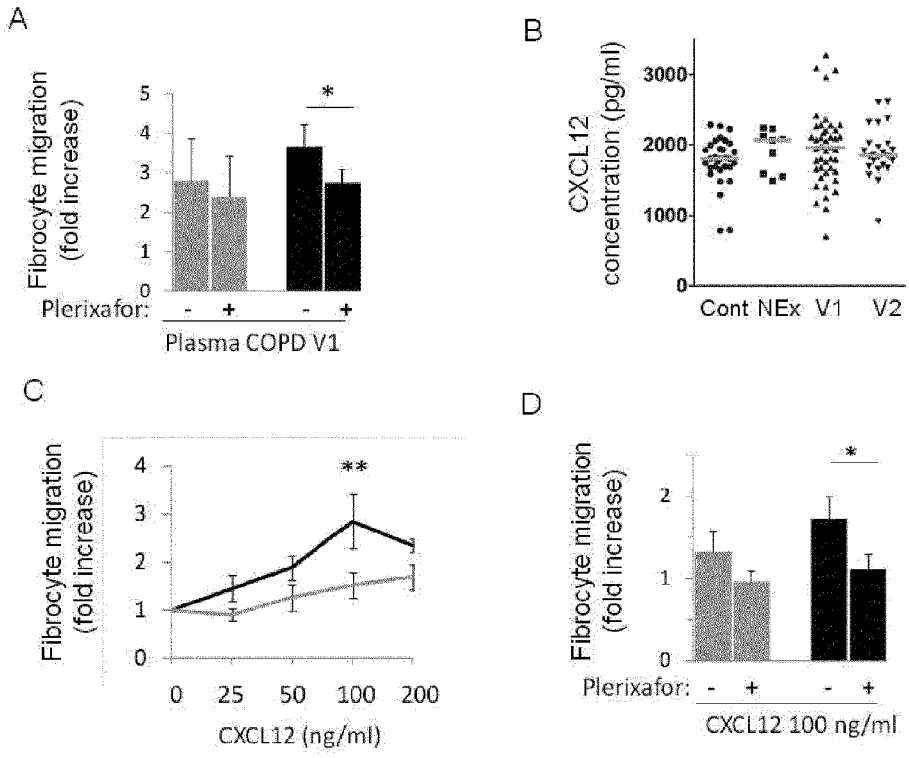
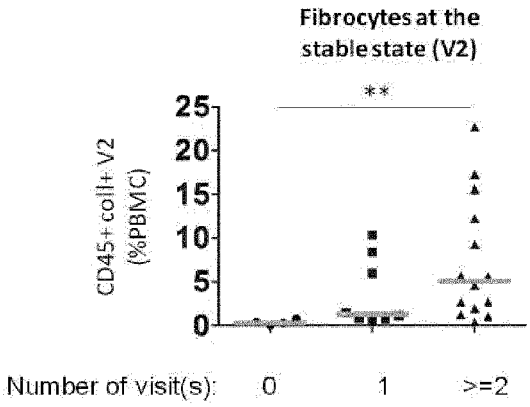

A
Fibrocyte migration (fold increase)
5
4
3
2
1
0
*
Plerixafor: - + - +
Plasma COPD V1
B
CXCL12 concentration (pg/ml)
3000
2000
1000
0
Cont NEx V1 V2
C
Fibrocyte migration (fold increase)
4
3
2
1
0
**
0 25 50 100 200
CXCL12 (ng/ml)
D
Fibrocyte migration (fold increase)
2
1
0
*
Plerixafor: - + - +
CXCL12 100 ng/ml

FIGURE 6


Fibrocytes at the stable state (V2)
**
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20
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10
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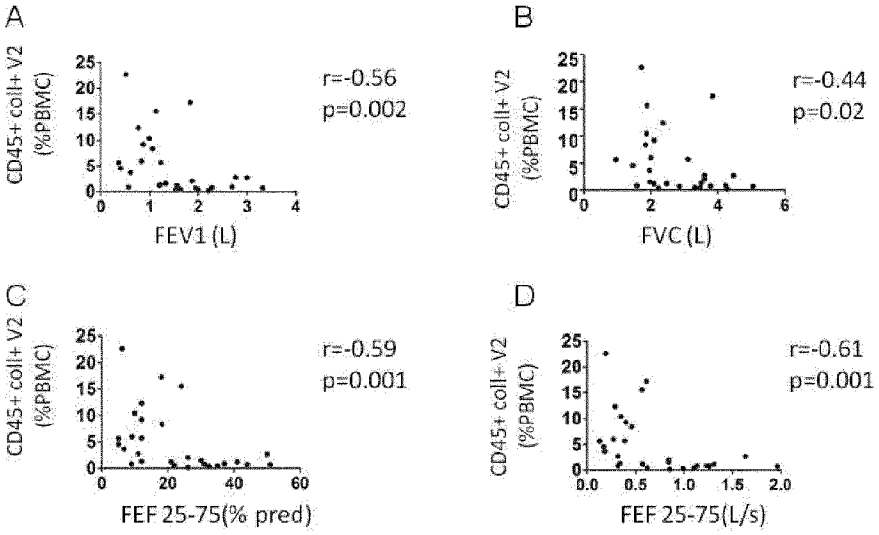
0
Number of visit(s):
0
1
>=2

FIGURE 7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FEV1 (L)
r=-0.56
p=0.002
B
CD45+ coll+ V2 (%PBMC)
FVC (L)
r=-0.44
p=0.02
C
CD45+ coll+ V2 (%PBMC)
FEF 25-75(% pred)
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CD45+ coll+ V2 (%PBMC)
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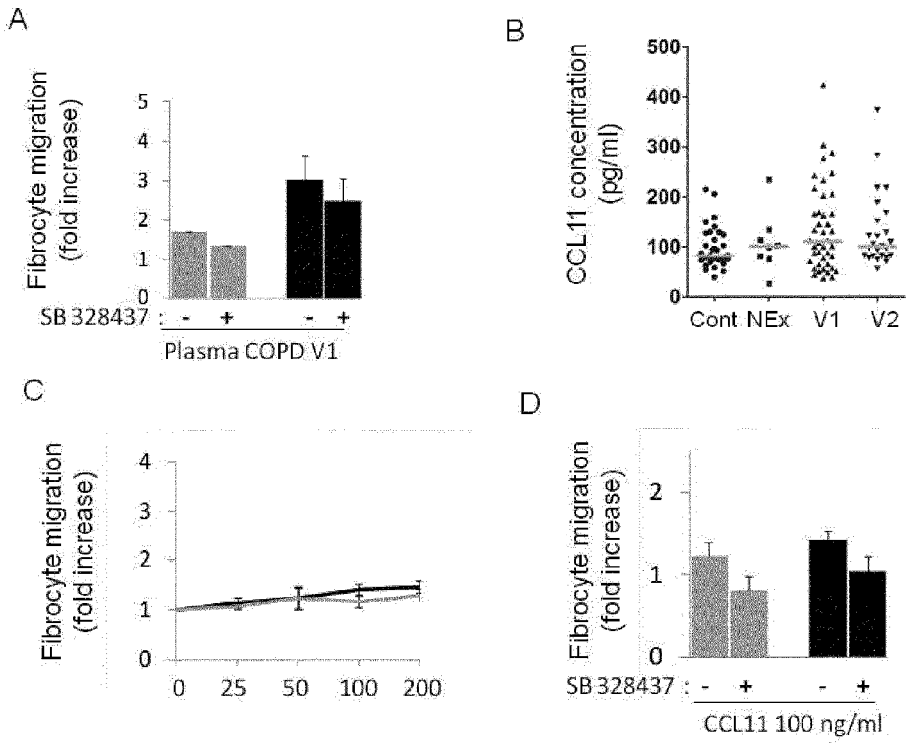
FIGURE 8


A
Fibrocyte migration (fold increase)
5
4
3
2
1
0
SB 328437 : - + - +
Plasma COPD V1
B
CCL11 concentration (pg/ml)
500
400
300
200
100
0
Cont NEx V1 V2
C
Fibrocyte migration (fold increase)
4
3
2
1
0
0 25 50 100 200
D
Fibrocyte migration (fold increase)
2
1
0
SB 328437 : - + - +
CCL11 100 ng/ml