CLAIMS

1. A method for treating Pulmonary Hypertension Heart Failure with preserved ejection fraction (PH-HFpEF) in a human subject afflicted with PH-HFpEF comprising administering to the human subject an amount of levosimendan, its metabolites OR-1896 or OR-1855, or a combination thereof, that is effective to treat the PH-HFpEF in the human subject.

2. The method of claim 1, wherein the treating comprises

    a) a reduction in the human subject's pulmonary capillary wedge pressure at rest, preferably by 1 to 30 mmHg;
    b) a stabilization of the human subject's pulmonary capillary wedge pressure at rest at 5 to 35 mmHg or 10 to 35 mmHg;
    c) a reduction in the human subject's pulmonary capillary wedge pressure during exercise by the human subject, preferably by subject by 1 to 40 mmHg;
    d) stabilization of the human subject's pulmonary capillary wedge pressure during exercise by the human subject, preferably at 10 to 50 mmHg;
    e) the treating does not comprise a significant change in pulmonary capillary wedge pressure during exercise by the human subject;
    f) a reduction in the human subject's pulmonary capillary wedge pressure when the human subject's legs are elevated, preferably the reduction is 1 to 30 mmHg;
    g) stabilization of the human subject's pulmonary capillary wedge pressure when the human subject's legs are elevated, preferably the stabilization is at 10 to 50 mmHg;
    h) a reduction in the human subject's right atrial pressure at rest, preferably by 1 to 30 mmHg;
    i) stabilization of the human subject's right atrial pressure at rest at 1 to 30 mmHg or at 5 to 30 mmHg;
    j) a reduction in the human subject's right atrial pressure during exercise by the human subject, preferably by 1 to 30 mmHg;
    k) stabilization of the human subject's right atrial pressure during exercise by the human subject at 5 to 40 mmHg;
    l) a reduction in the human subject's right atrial pressure when the human subject's legs are elevated;
    m) a reduction in the human subject's mean pulmonary artery pressure at rest, preferably by 1 to 30 mmHg;
    n) stabilization of the human subject's mean pulmonary artery pressure at rest at 15 to 65 mmHg;
    o) a reduction in the human subject's mean pulmonary artery pressure during exercise by the human subject, preferably by 1 to 30 mmHg;
    p) stabilization of the human subject's mean pulmonary artery pressure during exercise by the human subject at 25 to 85 mmHg or 25 to 80 mmHg;
    q) a reduction in the human subject's mean pulmonary artery pressure when the human subject's legs are elevated;
    r) an increase in the human subject's cardiac output at rest, preferably by 0.01 to 3 liters/min;
    s) stabilization of the human subject's cardiac output at rest at 2 to 10 liters/min;
    t) an increase in the human subject's cardiac output during exercise by the human subject;
    u) an increase in the human subject's cardiac output during exercise by the human subject by 0.01 to 5 liters/min or by 0.01 to 4 liters/min or by at 3.0 to 15.0 liters/min;

v) does not comprise a significant increase in the human subject's heart rate or does not comprise an increase in the human subject's heart rate of more than 10 beats/min;
w) an improvement in the human subject's quality of life;
x) an improvement in the human subject's six (6) minute walk distance, preferably of 5 to 150 meters;
y) an improvement in the physician's assessment of the human subject's functional class;
z) a reduction in the incidence of hospitalization for heart failure;
aa) a reduction in all-cause mortality; or
bb) an improvement in right heart failure and/or right ventricular dysfunction, preferably as evidenced by a reduction in right atrial pressure at rest and during 25 watts of exercise.

3. The method of claim 2, wherein in (w) the improvement in the human subject's quality of life is measured by a patient reported outcome assessment tool.

4. The method of claim 3,wherein the treating comprises an improvement in the human subject's quality of life according to a change in the human subject's patient reported outcome assessment tool score of at least 1, more preferably at least 2.

5. The method of any one of claims 1-4, wherein the human subject is a responder to levosimendan therapy.

6. The method of claim 5, wherein

a) a responder to levosimendan therapy is a human subject whose pulmonary capillary wedge pressure decreases by at least 4mmHG during bicycle exercise at 25 watts following the initial infusion;
b) a responder to levosimendan therapy is a human subject whose cardiac index decreases by no more than 10% between the baseline measurements and repeated measurements following the initial infusion;
c) the human subject is a responder to levosimendan therapy if the human subject has cardiac reserve;
d) the human subject is a responder to levosimendan therapy if the human subject's stroke volume increases during exercise by the human subject;
e) the human subject is a responder to levosimendan therapy if the human subject's stroke volume increases during exercise by the human subject when determined with a catheter in the human subject's heart measuring the blood moving out of the left ventricle with every beat;
f) the human subject is a responder to levosimendan therapy if the human subject's stroke volume increases during exercise by the human subject when estimated with an electrocardiogram and/or echocardiogram;
g) the human subject is a responder to levosimendan therapy if the human subject's stroke volume increases during exercise by the human subject when determined with a dobutamine stress test;
h) the human subject is a responder to levosimendan therapy if the human subject's stroke volume increases during exercise by the human subject by at least 0.005 liters;
i) the human subject is a responder to levosimendan therapy if the human subject's stroke volume increases during exercise by the human subject by 1 to 50 mL when determined

with a catheter in the human subject's heart measuring the blood moving out of the left ventricle with every beat;

j) the human subject is a responder to levosimendan therapy if the human subject's stroke volume increases during exercise by the human subject by 1 to 50 mL when estimated with an echocardiogram, right heart catheterization, or other means; or

k) the human subject is a responder to levosimendan therapy if the human subject's stroke volume increases during exercise by the human subject by 1 to 50 mL when determined with a dobutamine stress test.

7. The method of any one of claims 1-6, wherein the human subject afflicted with PH-HFpEF

a) has a left ventricular ejection fraction of at least 40%;
b) has a baseline pulmonary arterial pressure of at least 35;
c) has a baseline pulmonary capillary wedge pressure of at least 20;
d) is classified as classification IIb or classification III by the physician's assessment of New York Heart Association Classification;
e) has the ability to walk at least 50 meters in a six-minute walk test, does not have the ability to walk more than 550 meters in a six-minute walk test, or has the ability to walk at least 50 meters, but not more than 550 meters, in a six-minute walk test;
f) is not afflicted with heart failure with reduced ejection fraction;
g) is not afflicted with heart failure with preserved ejection fraction without pulmonary hypertension;
h) has a primary diagnosis of Group 2 PH-HFpEF;
i) is not afflicted with coronary artery disease;
j) has not had previous percutaneous coronary intervention;
k) has not had previous percutaneous coronary intervention, unless the human subject has had a negative stress test within the last year;
l) has not had previous cardiac surgery;
m) has not had previous cardiac surgery, unless the human subject has had a negative stress test within the last year;
n) is not afflicted with congenital heart disease;
o) is not afflicted with a clinically significant lung disease;
p) does not have a planned heart or lung surgery;
q) does not have a cardiac index greater than 4.0 L/min/m2;
r) does not concomitantly receive pulmonary vasodilator therapy;
s) has not received pulmonary vasodilator therapy within the last 14 days;
t) does not receive dialysis treatment;
u) does not have a Glomerular Filtration Rate less than 30 mL/min/1.73m2;
v) does not have liver dysfunction with Child Pugh Class B or C;
w) does not have evidence of systemic infection;
x) does not weigh more than 150 kg;
y) can manage their symptomatic systolic blood pressure to ensure it is greater than 100 mmHg;
z) does not have a heart rate greater than or equal to 100 beats per minute with the drug;
aa) does not have a heart rate greater than or equal to 100 beats per minute with the drug that is symptomatic and persistent for at least 10 minutes;
bb) does not have hemoglobin less than 80 g/L;

cc) does not have serum potassium less than 3.0 mmol/L at baseline;
dd) does not have serum potassium greater than 5.5 mmol/L at baseline;
ee) does not have serum potassium less than 3.0 mmol or greater than 5.5 mmol/L at baseline;
ff) does not have severely compromised immune function;
gg) is not pregnant, is not suspected to be pregnant, or is not breast-feeding; or
hh) is a patient with Biventricular Failure.

8. The method of any one of claims 1-7, wherein the administering is via IV administration.

9. The method of any one of claims 1-8, wherein the administering takes place intermittently, weekly, or chronically.

10. The method of any one of claims 1-9, wherein the administering is given via a 24-hour infusion.

11. The method of any one of claims 1-9, wherein the administering is chronic administration given via a less than 24-hour infusion.

12. The method of any one of claims 1-11, wherein the administering is an administration of a dose of

a) levosimendan 2.5 mg/mL infusion concentrate that includes levosimendan, povidone, citric acid, and ethanol;
b) levosimendan 2.5 mg/mL infusion concentrate that includes levosimendan, povidone, citric acid, and ethanol and is supplied in 5 mL of total volume;
c) levosimendan 2.5 mg/mL infusion concentrate that includes levosimendan, povidone, citric acid, and ethanol and is supplied in 5 mL of total volume that is added to one 250 mL infusion bag of 5% Dextrose;
d) levosimendan 2.5 mg/mL infusion concentrate that includes levosimendan, povidone, citric acid, and ethanol and is supplied in 5 mL of total volume that is added to one 250 mL infusion bag of 0.9 Normal Saline;
e) levosimendan 2.5 mg/mL infusion concentrate that includes levosimendan, povidone, citric acid, and ethanol and is supplied in 5 mL of total volume that is added to one 250 mL infusion bag of 5% Dextrose or 0.9 Normal Saline where the human subject weights less than 85 kg;
f) levosimendan 2.5 mg/mL infusion concentrate that includes levosimendan, povidone, citric acid, and ethanol and is supplied in 10 mL of total volume;
g) levosimendan 2.5 mg/mL infusion concentrate that includes levosimendan, povidone, citric acid, and ethanol and is supplied in 10 mL of total volume that is added to one 500 mL infusion bag of 5% Dextrose;
h) levosimendan 2.5 mg/mL infusion concentrate that includes levosimendan, povidone, citric acid, and ethanol and is supplied in 10 mL of total volume that is added to one 500 mL infusion bag of 0.9 Normal Saline;
i) levosimendan 2.5 mg/mL infusion concentrate that includes levosimendan, povidone, citric acid, and ethanol and is supplied in 10 mL of total volume that is added to one 500 mL infusion bag of 5% Dextrose or 0.9 Normal Saline where the human subject weights at least 85 kg.

13. The method of any one of claims 1-12, wherein an administration infusion rate is reduced to 0.05 μg/kg/min when a dose is not well-tolerated by the human subject.

14. The method of any one of claims 1-7, wherein the administration is via oral dosing.

15. The method of claim 14, wherein the oral dosing comprises an immediate release formulation or an extended-release formulation.

16. The method of any one of claims 1-8, wherein the administration is subcutaneous administration of a subcutaneous formulation.

17. The method of claim 16, wherein the subcutaneous formulation is an intravenous formulation with additives.

18. The method of claim 16, wherein the subcutaneous formulation comprises

a) 12.5 mg of levosimendan in a non-aqueous formulation that is added to 150 mL of 5% Dextrose, 0.9 Normal Saline, or other pharmaceutically acceptable diluent or carrier to create a levosimendan concentration of 0.0833 mg/mL in the subcutaneous formulation;

b) 12.5 mg of levosimendan in a non-aqueous formulation that is added to 250 mL of 5% Dextrose, 0.9 Normal Saline, or other pharmaceutically acceptable diluent or carrier to create a levosimendan concentration of 0.05 mg/mL in the subcutaneous formulation;

c) 12.5 mg of levosimendan in a non-aqueous formulation that is added to 500 mL of 5% Dextrose, 0.9 Normal Saline, or other pharmaceutically acceptable diluent or carrier to create a levosimendan concentration of 0.025 mg/mL in the subcutaneous formulation;

d) 12.5 mg of levosimendan in a non-aqueous formulation that is added to 1000 mL of 5% Dextrose, 0.9 Normal Saline, or other pharmaceutically acceptable diluent or carrier to create a levosimendan concentration of 0.0125 mg/mL in the subcutaneous formulation; or

e) 12.5 mg of levosimendan in a non-aqueous formulation that is added to 1500 mL of 5% Dextrose, 0.9 Normal Saline, or other pharmaceutically acceptable diluent or carrier to create a levosimendan concentration of 0.008333 mg/mL in the subcutaneous formulation.

19. The method of any one of claims 16-18, wherein the subcutaneous administration of the subcutaneous formulation comprises water in an amount effective to reduce pain caused by the subcutaneous administration.

20. The method of any one of claims 16-19, wherein the subcutaneous administration of the subcutaneous formulation comprises buffers to raise the pH higher than 3.5.

21. The method of any one of claims 16-20, wherein the subcutaneous administration of the subcutaneous formulation

a) has reduced side effects relative to intravenous administration of levosimendan in the human subject; or
b) reduces peak plasma concentrations of levosimendan relative to intravenous administration in the human subject, preferably by at least 1% to 25%.

22. The method of any of claims 1-21 wherein the amount of levosimendan its metabolites OR-1896 or OR-1855, or a combination thereof, is administered in combination with a cardiovascular drug.

23. The method of claim 22, wherein the amount of levosimendan its metabolites OR-1896 or OR-1855, or a combination thereof, and the amount of the cardiovascular drug when taken together is effective to reduce the symptoms of PH-HFpEF.

24. The method of any one of claims 22-23, wherein the cardiovascular drug is a drug used to treat pulmonary arterial hypertension (PAH), World Health Organization (WHO) Groups 1-5 pulmonary hypertension patients, coronary artery disease (CAD), or heart failure with reduced ejection fraction (HFrEF).

25. The method of any one of claims 22-23, wherein the cardiovascular drug is a PDE inhibitor, a phosphodiesterase-5 (PDE5) inhibitor, an endothelin receptor antagonist (ERA), a prostanoid, a soluble guanylate cyclase stimulator, a nitrate, a nitrite, an NO donor, a calcium channel blocker (CCB), a fatty acid oxidation inhibitor, a beta-blocker (BB), an angiotensin-converting enzyme (ACE) inhibitor, a neprilysin inhibitor, a neprilysin and angiotensin receptor blocker (ANRI), an angiotensin II receptor blocker (ARB), a diuretic, an aldosterone antagonist, digoxin, ivabradine, hydralazine, seralaxin, a natriuretic peptide, an atrial natriueretic peptide (ANP), a natriuretic peptide, a K-ATP channel activator, a NEP inhibitor, or a prostacyclin.

26. The method of any one of claims 22-23, wherein the cardiovascular drug is a pulmonary vasodilator drug.

27. The method of claim 26, wherein the pulmonary vasodilator is a phosphodiesterase-5 (PDE5) inhibitor, an endothelin receptor antagonist (ERA), or a prostacyclin.

28. The method of any one of claims 26-27, wherein the amount of levosimendan, its metabolites OR-1896 or OR-1855, or a combination thereof, administered in combination with the pulmonary vasodilator drug is administered to a human subject afflicted with pre and post capillary pulmonary hypertension and heart failure with preserved ejection fraction (Cpc-PH-HFpEF).

29. The method of any of claims 1-28 wherein no arrythmias, atrial or ventricular, are observed when comparing baseline electrocardiographic monitoring with 72-hour monitoring after 5 weeks of treatment.

30. The method of any one of claims 1-29 wherein treating presents no more statistically significant adverse events than the matching placebo.

31. The method of any one of claims 1-30, wherein a weekly 24-hour dosing of levosimendan results in steady state blood levels of OR1896 in the range of 0.20 ng/mL to 25.00 ng/mL.

32. An article of manufacture comprising:

a) a 5mL vial dose of levosimendan 2.5 mg/mL infusion concentrate that includes levosimendan, povidone, citric acid, and ethanol;

b) 250 mL of 5% Dextrose or 0.9 Normal Saline; and

c) a buffer for increasing pH.

33. Use of an amount of levosimendan, its metabolites OR-1896 or OR-1855, or a combination thereof, to effectively treat Pulmonary Hypertension Heart Failure with preserved ejection fraction (PH-HFpEF) in a human subject.

34. Use of an amount of levosimendan, its metabolites OR-1896 or OR-1855, or a combination thereof, for preparing medicament for administering to a human subject afflicted with Pulmonary Hypertension Heart Failure with preserved ejection fraction (PH-HFpEF to effectively treat PH-HFpEF in the human subject.

35. A medicament comprising an amount of levosimendan, its metabolites OR-1896 or OR-1855, or a combination thereof, for use in effectively treating Pulmonary Hypertension Heart Failure with preserved ejection fraction (PH-HFpEF) in a human subject.

36. Use of an amount of levosimendan, its metabolites OR-1896 or OR-1855, or a combination thereof, in combination with a cardiovascular drug to effectively treat Pulmonary Hypertension Heart Failure with preserved ejection fraction (PH-HFpEF) in a human subject.

37. Use of an amount of levosimendan, its metabolites OR-1896 or OR-1855, or a combination thereof, for preparing a medicament in combination with a cardiovascular drug for administering to a human subject afflicted with Pulmonary Hypertension Heart Failure with preserved ejection fraction (PH-HFpEF) to effectively treat PH-HFpEF in the human subject.

38. A medicament comprising an amount of levosimendan, its metabolites OR-1896 or OR-1855, or a combination thereof, for use in combination with a cardiovascular drug to effectively treat Pulmonary Hypertension Heart Failure with preserved ejection fraction (PH-HFpEF) in a human subject.

39. A subcutaneous formulation of levosimendan for use in treating PH-HFpEF in a human subject afflicted with PH-HFpEF, wherein the subcutaneous formulation is obtained from a dried powder, wherein the dried powder is obtained from a pharmaceutical composition comprising: (a) levosimendan; (b) sulfo-butyl-ether beta-cyclodextrin; (c) sodium hydroxide or acetic acid; and water for injection.

40. The composition of claim 39, wherein the amount of levosimendan is 2.5mg / ml water for injection.

41. The composition of any one of claims 39-40, wherein the amount of sulfo-butyl-ether beta-cyclodextrin is 0.175mg / ml water for injection.

42. The composition of any one of claims 39-41, wherein the sodium hydroxide or acetic acid is in a suitable amount to adjust the pH to a range of 7.2 to 7.8.

43. The composition of any one of claims 39-42, wherein the pharmaceutical composition is lyophilized.

44. The composition of any one of claims 39-43, wherein subcutaneous formulation of levosimendan is obtained from the dried powder by reconstitution of the dried powder in an amount of aqueous solution suitable for subcutaneous administration.

45. The composition of claim 44, wherein the reconstituted subcutaneous formulation is pH adjusted to 7.2 to 7.8 with sodium hydroxide or acetic acid.

46. A method for treating Pulmonary Hypertension Heart Failure with preserved ejection fraction (PH-HFpEF) in a human subject afflicted with PH-HFpEF comprising administering to the human subject an amount of a cardiovascular drug that is effective to treat the PH-HFpEF in the human subject, wherein the cardiovascular drug is selected from the group consisting of a PDE inhibitor, a phosphodiesterase-5 (PDE5) inhibitor, an endothelin receptor antagonist (ERA), a prostanoid, a soluble guanylate cyclase stimulator, a nitrate, a nitrite, an NO donor, a calcium channel blocker (CCB), a fatty acid oxidation inhibitor, a beta-blocker (BB), an angiotensin-converting enzyme (ACE) inhibitor, a neprilysin inhibitor, a neprilysin and angiotensin receptor blocker (ANRI), an angiotensin II receptor blocker (ARB), a diuretic, an aldosterone antagonist, digoxin, ivabradine, hydralazine, seralaxin, a natriuretic peptide, an atrial natriueretic peptide (ANP), a natriuretic peptide, a K-ATP channel activator, a NEP inhibitor, and a prostacyclin.

47. A method for treating Pulmonary Hypertension Heart Failure with preserved ejection fraction (PH-HFpEF) in a human subject afflicted with PH-HFpEF comprising administering to the human subject an amount of a pulmonary vasodilator drug that is effective to treat the PH-HFpEF in the human subject, wherein the pulmonary vasodilator drug is selected from the group consisting of a phosphodiesterase-5 (PDE5) inhibitor, an endothelin receptor antagonist (ERA), and a prostacyclin.

48. The method of claim 47, wherein the amount of the pulmonary vasodilator drug is administered to a human subject afflicted with pre and post capillary pulmonary hypertension and heart failure with preserved ejection fraction (Cpc-PH-HFpEF).

49. A cardiovascular drug for use in treating Pulmonary Hypertension Heart Failure with preserved ejection fraction (PH-HFpEF) in a subject, wherein the cardiovascular drug is selected from the group consisting of a PDE inhibitor, a phosphodiesterase-5 (PDE5) inhibitor, an endothelin receptor antagonist (ERA), a prostanoid, a soluble guanylate cyclase stimulator, a nitrate, a nitrite, an NO donor, a calcium channel blocker (CCB), a fatty acid oxidation inhibitor, a beta-blocker (BB), an angiotensin-converting enzyme (ACE) inhibitor, a neprilysin inhibitor, a neprilysin and angiotensin receptor blocker (ANRI), an angiotensin II receptor blocker (ARB), a diuretic, an aldosterone antagonist, digoxin, ivabradine, hydralazine, seralaxin, a natriuretic peptide, an atrial natriueretic peptide (ANP), a natriuretic peptide, a K-ATP channel activator, a NEP inhibitor, and a prostacyclin.

50. A pulmonary vasodilator drug for use in treating Pulmonary Hypertension Heart Failure with preserved ejection fraction (PH-HFpEF) in a subject, wherein the pulmonary vasodilator drug is selected from the group consisting of a phosphodiesterase-5 (PDE5) inhibitor, an endothelin receptor antagonist (ERA), and a prostacyclin.

51. The method of claim 50, wherein the Pulmonary Hypertension Heart Failure with preserved ejection fraction (PH-HFpEF) is pre and post capillary pulmonary hypertension and heart failure with preserved ejection fraction (Cpc-PH-HFpEF).

52. The method of claim 1, wherein the subject is orally administered a capsule comprising up to 0.1mg, 0.25mg, 0.5mg, 0.75mg, 1mg, 2mg, 3mg, or 4mg, more preferably 1-3mg, of levosimendan, its metabolites OR-1896 or OR-1855, or a combination thereof.

53. The method of claim 52, wherein the subject is administered a capsule once a day for a time period of 1-60 days, preferably 14 days.

54. The method of any one of claims 52-53, wherein the subject increases the number of capsules taken per day after every time period if the treatment is tolerated by the subject.

55. The method of any one of claims 52-54, wherein the subject is orally administered between 0.1-10mg of levosimendan, its metabolites OR-1896 or OR-1855, or a combination thereof, per day, preferably between 1-4mg of levosimendan, its metabolites OR-1896 or OR-1855, or a combination thereof per day.

56. The method of any one of claims 52-55, wherein the subject received a final intravenous injection of levosimendan, its metabolites OR-1896 or OR-1855, or a combination thereof at least one day, more preferably at least one week, before beginning oral administration of levosimendan, its metabolites OR-1896 or OR-1855, or a combination thereof.