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(54) **DIAGNOSIS OF CARDIOVASCULAR DISEASE**

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(57) **ABSTRACT**

This invention relates to methods for the detection of cardio-vascular disease, e.g., acute coronary syndrome, heart failure and/or pulmonary embolism, in high body mass index (BMI) individuals, e.g., with a BMI of 25-29, or 30 or above, and those with impaired renal function.
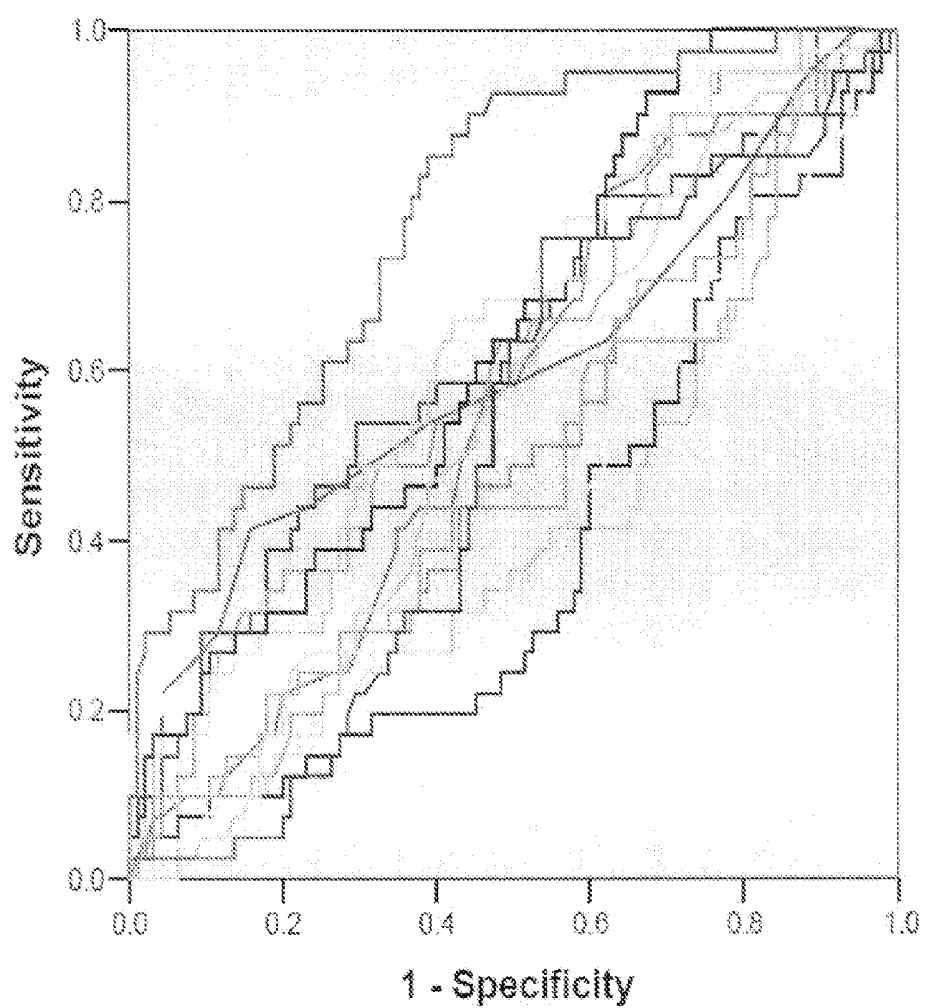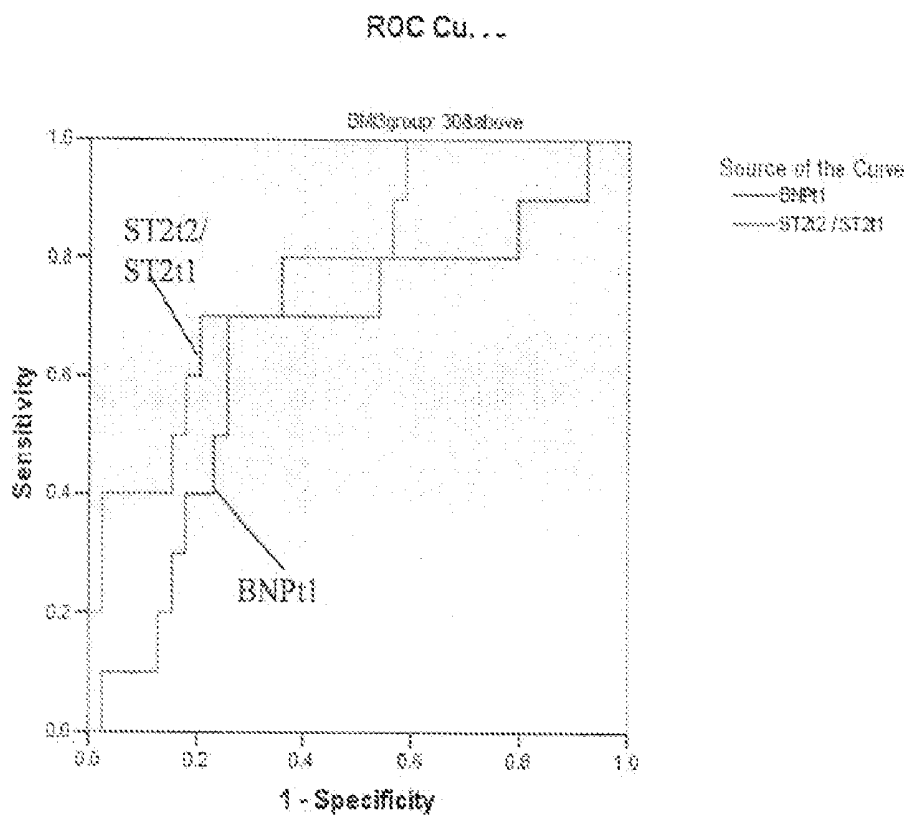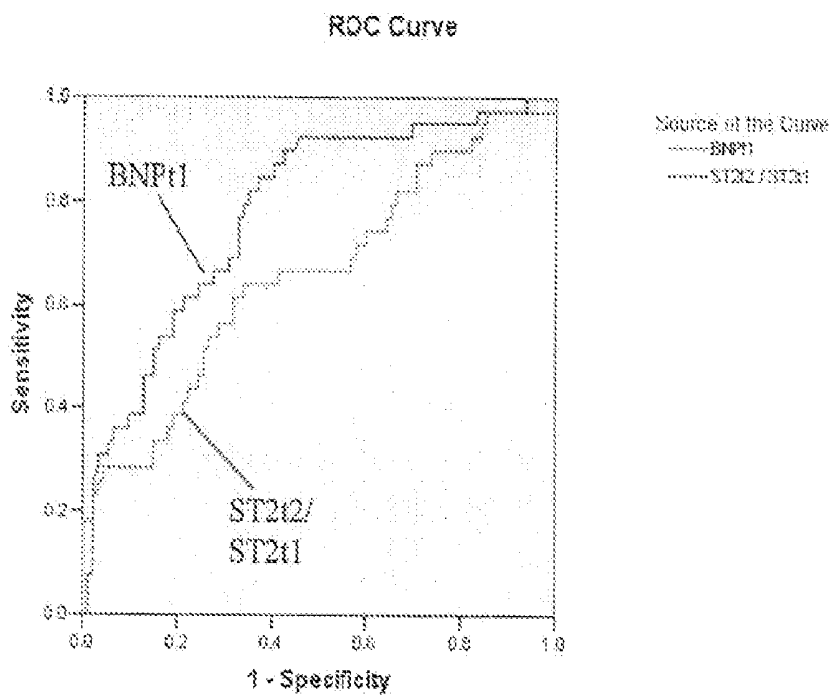
Figure 1

ROC Curve

Figure 2

ROC Cu...

Figure 3
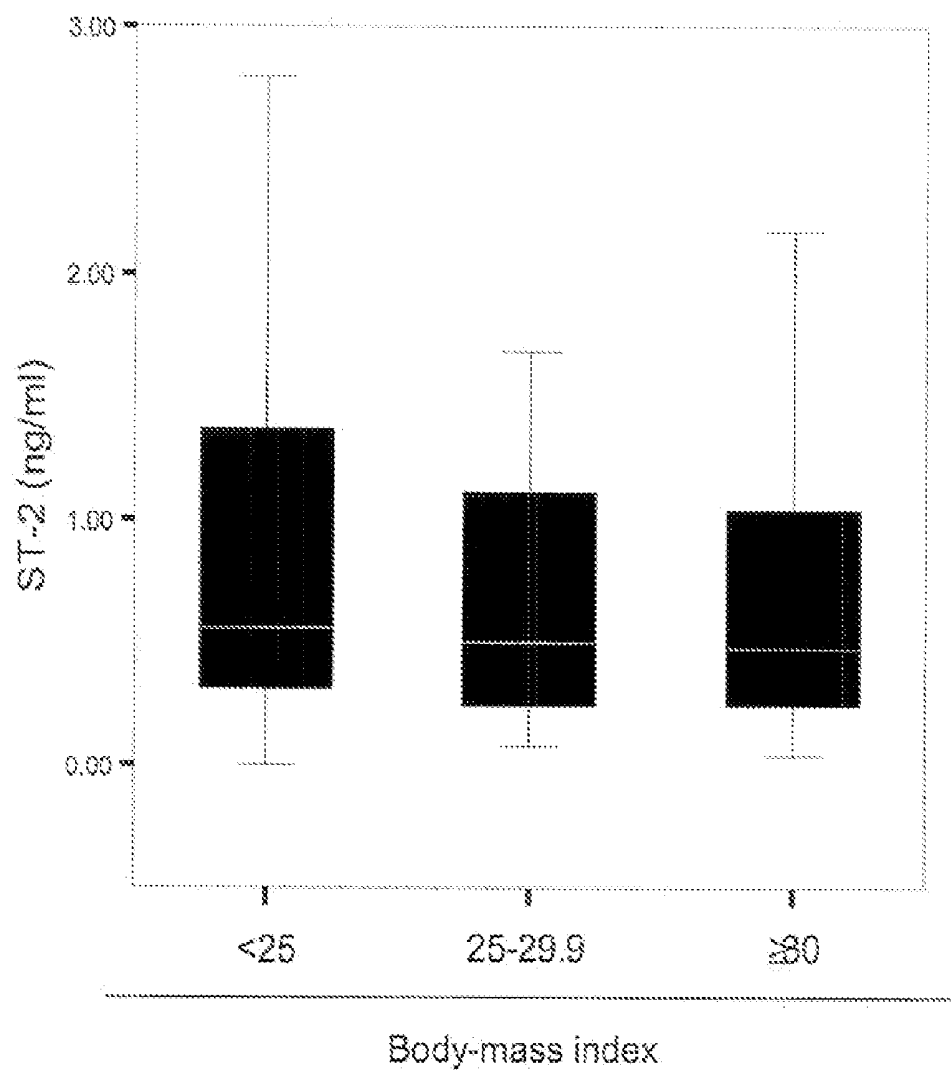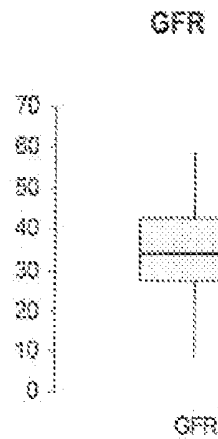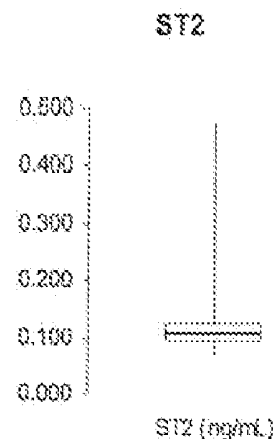
ROC Curve

Figure 4

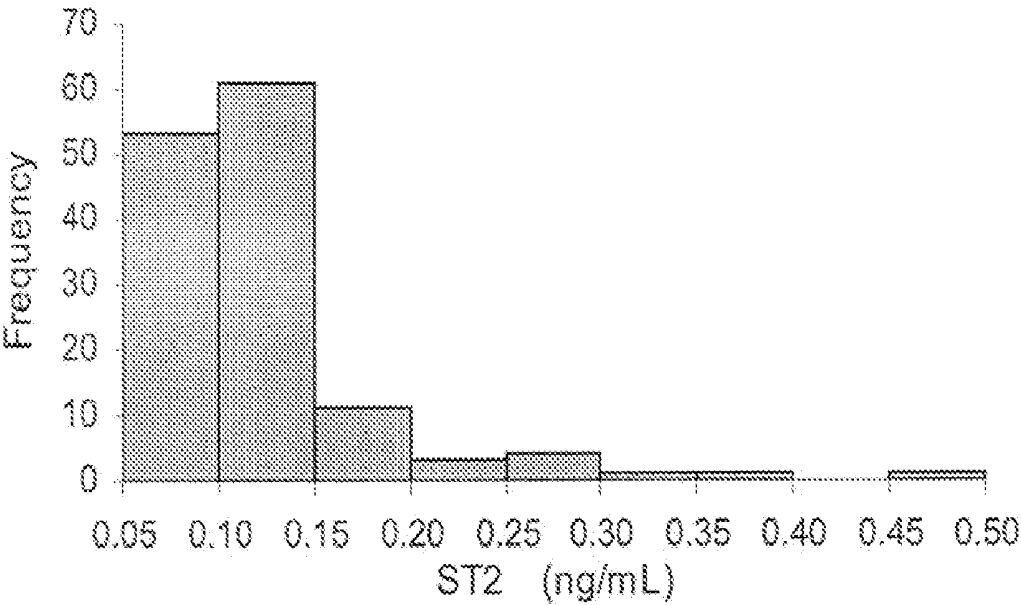FIGURE 5A   FIGURE 5B

FIGURE 6

DIAGNOSIS OF CARDIOVASCULAR DISEASE

TECHNICAL FIELD

[0001] This invention relates to methods for the detection of heart failure and pulmonary embolism in high body mass index (BMI) individuals and those with unpaired renal, function.

BACKGROUND

[0002] Levels of natriuretic peptides such as B-type natriuretic peptide (BNP) and N terminal-pro BNP (NT-proBNP) have been shown to be diagnostic of cardiovascular disease (Clerieo and Emdin, Clin. Chem. 50:33-50 (2004)). However, it is known and accepted in the field that certain subjects have levels of natriuretic peptide that are lower than expected relative to a "normal" subject for the mm level of disease. The exact mechanism for this phenomenon is not knows. These subjects include people with unpaired renal function (Anwaruddin et al., J. Am. Coll. Cardiol. 47(1):91-7 (2006); McCullough et al., Am. J. Kidney Dis. 41(3):571-9 (2003)), and those who are overweight (Body Mass Index (BMI) of 25-29) or obese (BMI ≧30) (Krauser et al. Am. Bean J. 149(4):744-50 (2005); McCord et al., Arch. Intern. Med. 164(20):2247-52 (2004)).

SUMMARY

[0003] The present invention is based, at least in part, on the surprising discovery that, unlike the natriuretic peptides (NPs), the biomarker ST2 (also known as Interleukin 1 Receptor Like-1 (IL1RL1)) is not affected by high body mass index (BMI) or by impaired renal function, and therefore provides better prognostic and diagnostic information than NPs in subjects with, high (BMI) or impaired renal function. Thus, the methods described herein include determining whether a subject has a high BMI and/or has renal failure, and if the subject has one or both conditions, selecting the subject, and determining levels of IL1LR1, and, optionally BNP and/ or D-dimer in the subject. These methods can be used to diagnose cardiovascular disease (CVD), e.g., acute coronary syndrome (ACS), heart failure (BF), and pulmonary embolism (PE) in the subject, e.g., in subjects with dyspnea.

[0004] In some embodiments, the methods include determining levels of IL-33 is addition to or as an alternative to determining levels of ST2.

[0005] In one aspect, the invention provides methods for diagnosing cardiovascular disease (CVD), e.g., acute coronary syndrome (ACS), heart failure (HF), or pulmonary embolism (PE) in a subject who has a body mass index (BMI) of greater than or equal to 25. The methods include determining the subject's BMI, and if the subject's BMI is equal to or greater than 25, selecting the subject; and determining levels of ST2, and optionally one or both of BNP level and D-dimer level, in the subject's blood, plasma, or serum. The relationship of the ST2 level to a reference level of ST2, e.g., a reference level that represents a level of ST2 in a subject who does not have CVD, indicates whether the subject has CVD. In some embodiments, if the subject's BNP level is less man 500 pg/mL, e.g., 100-500 pg/mL, and the D-dimer level, is less than 500 µg/L, then the relationship of the ST2 level to a reference level of ST2, e.g., a reference level that represents a level of ST2 in a subject who does not have HF, indicates whether the subject has HF. In some embodiments, if the

subject's BNP level is less than 100 pg/mL, and the D-dimer level is 500-4000 µg/L, then the relationship of the ST2 level to a reference level of ST2, e.g., a reference level that represents a level of ST2 is a subject who does not have FE, indicates whether the subject has PE.

[0006] In another aspect, the invention provides methods for diagnosing cardiovascular disease (CVD), e.g., acute coronary syndrome (ACS), heart failure (HF), or pulmonary embolism (PE) in a subject who has impaired renal function. The methods include evaluating the subject's renal function, and if the subject has impaired renal function, selecting the subject; and determining an ST2 level, and optionally BNP level and/or D-dimer level, in the subject's blood, plasma or serum. The relationship of the ST2 level to a reference level of ST2, e.g. a reference level that represents a level of ST2 in a subject who does not have CVD, indicates whether the subject has CVD. In some embodiments, if the subject's BNP level is less than 500 pg/mL, e.g., 100-500 pg/mL, and die D-dimer level is less than 500 µg/L, then the relationship of the ST2 level to a reference level of ST2, e.g., a reference level that represents a level of ST2 in a subject who does not have HF, indicates whether the subject has HF. In some embodiments, if the subject's BNP level is less than 100 pg/mL, and the D-dimer level is 500-4000 µg/L, then the relationship of the ST2 level to a reference level of ST2, e.g., a reference level, that represents a level of ST2 in a subject woo does not have PE, indicates whether the subject has PE.

[0007] In some embodiments, the reference level represents a level in a subject who does not have CVD, e.g., does not have ACS, HF, and/or PE, in some embodiments, e.g., wherein the biomarker level of ST2 is measured using an immunoassay, e.g., an enzyme-linked immunosorbent assay (ELISA), e.g., as described in Example 1, the reference level is about 0.2 to 0.3 ng/ml, e.g., the level can be 0.20, 0.23, 0.25, 0.27, or 0.29 ng/ml of serum, and values above that level indicate the presence of CVD, e.g., ACS, HF and/or PE. If an analytical technique other than the ELISA described in Example 1 is employed, the reference ST2 level may be different than described herein. However, die specific numbers recited herein should be construed to be equivalent to corresponding numbers generated using other analytical techniques.

[0008] In general, determining a level of ST2, BNP, and/or D-dimer in a subject includes obtaining a biological sample from the subject, contacting binding compositions to the sample, wherein the binding compositions specifically, bind to ST2, BNP and D-dimer, and measuring or determining the specific binding of the binding composition to the sample. The binding compositions can be, e.g., antibodies that bind specifically to ST2, BNP, and D-dimer polypeptides (e.g., an anti-ST2 Ab, an anti-BNP Ab, and an anti-D-dimer Ab), or oligonucleotide probes that bind specifically to ST2, BNP and D-dimer polynucleotides (e.g., an ST2-specific probe, a BNP-specific probe, and a D-dimer-specific probe).

[0009] The methods can also include determining levels of one or more additional biomarkers, e.g., NT-proANP, proANP, ANP, troponin, CRP, creatinine, Blood Urea Nitrogen (BUN), liver function enzymes, albumin, and bacterial endotoxin.

[0010] In some embodiments, determining whether a subject has impaired renal function includes determining a glomerular filtration rate (GFR) and/or serum creatinine level. The

subject has mildly, moderately or severely impaired renal function if they have a GFR or serum creatinine level shown in Table 1:

TABLE 1

Grade	GFR (ml/minute)	Serum Creatinine (μmol/litre)
mild	20-50	150-300
moderate	10-20	300-700
severe	<10	>700

[0011]   Also provided herein, are kits for diagnosing cardiovascular disease (CVD), that include three different antibodies that specifically bind to ST2, BNP, and D-dimer polypeptides, respectively, or three different nucleic acid probes that specifically bind to nucleic acids encoding ST2. BNP, and D-dimer, respectively, and instructions for use in a method described herein.

[0012]   "Upregulated," as used herein, refers to increased expression of a gene and/or its encoded polypeptide. "Increased expression" refers to increasing (i.e., to a detectable extent) replication, transcription, and/or translation of IL-33, since upregulation of any of these processes results in an increase in concentration/amount of the polypeptide encoded by the gene. Conversely, "downregulation." or "decreased expression" as used herein, refers to reduced replication, transcription, and/or translation of the IL-33 gene and/or its encoded polypeptide. The upregulation or downregulation of gene expression can be directly determined by detecting an increase or decrease, respectively, in the level of mRNA for the gene, or the level of protein expression of the gene-encoded polypeptide, using any suitable means known to the art, such as nucleic acid hybridization or antibody detection methods, respectively, and in comparison to controls. "Expression," as used herein, refers to nucleic acid and/or polypeptide expression.

[0013]   As used herein, a "subject" is a mammal, e.g., a human. In all embodiments, human nucleic acids, polypeptides, and human subjects can be used.

[0014]   As used herein, a "biological sample" includes one or more of blood, serum, plasma, urine, and body tissue, in some embodiments, a sample is a serum or blood sample.

[0015]   Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Methods and materials are described herein for use in the present invention; other, suitable methods and materials known in the art can also be used. The materials, methods, and examples are illustrative only and not intended to be limiting. All publications, patent applications, patents, sequences, database entries, and other references mentioned herein are incorporated by reference in their entirety. In case of conflict, the present specification, including definitions, will control.

[0016]   Other features and advantages of the invention will be apparent from the following detailed description and figures, and from the claims.

DESCRIPTION OF DRAWINGS

[0017]   FIG. 1 is a Receiver Operating Characteristics (ROC) curve of the Second Prospective Randomized Amlodipine Survival Evaluation (PRAISE-2) study, illustrating the characteristics of the study population for age, weight, height, BMI, left ventricular ejection fraction (LVEF), creatinine, ST2t1, norepinephrine (NEt1), epinephrine (Et1), dopamine (DAt1), angiotensin (ANGt1), malondialdehyde (MDAt1), adrenolutin (ADRt1), ANPt1, and BNPt1, "t1" refers to a level taken at a list time.

[0018]   FIG. 2 is a ROC curve for BNP and ST2 Ratio in the PRAISE-2 study; the two measures have similar AUC, with BNP somewhat higher.

[0019]   FIG. 3 is a ROC curve for prognostic utility of BNP and ST2 ratio in high BMI individuals; in this case, ST2 ratio has a greater AUC.

[0020]   FIG. 4 is a box graph of ST2 levels in subjects with various BMIs (<25, 25-29, and ≧30), allowing no significant difference in ST2 levels between the BMIs.

[0021]   FIGS. 5A-B are box graphs illustrating mean Glomerular Filtration Rate (GFR, 5A) and ST2 levels (5B) in a population of 133 subjects with moderate to severe renal insufficiency.

[0022]   FIG. 6 is a bar graph illustrating the distribution of ST2 levels in the population described in Example 3, showing that the vast majority of subjects in the population have levels of ST2 that are below 0.2 ng/ml.

DETAILED DESCRIPTION

[0023]   Clinical evaluation of cardiovascular disease (CVD) using natriuretic peptides (NPs) in subjects with high body mass index (BMI) or impaired renal function is complicated by the fact that these subjects have levels of natriuretic peptide that are lower than expected relative to a "normal" subject for the same level of disease. The exact mechanism for this phenomenon is not known. However, one theory, not meant to be limiting, is that lower NP levels in obese and overweight subjects and those with impaired renal function may be related to the clearance mechanisms for NPs, which may have both a renal and epithelial component. ST2, although possibly produced in a similar manner as NPs, does not suffer from these limitations. Therefore, the methods described herein include the use of ST2 (and/or IL-33, the ligand for ST2) in these special subjects, for whom NPs may provide misleading information.

[0024]   General Methodology

[0025]   General methods for using levels of ST2 for diagnosis are described in, e.g., U.S. Pat. App. No. 2004/0048286 to Lee et al., the entire contents of which are incorporated herein by reference. The methods described herein are particularly useful in populations of subjects for whom NPs are less useful in the diagnosis and prognosis of CVD. These subjects include those with high BMI, e.g., overweight subjects (BMI of 25-29) or obese subjects (BMI ≧30). Thus, in some embodiments, the methods include determining a subject's BMI, and if the subject is overweight or obese, selecting the patient (e.g., selecting the subjects on the basis of their BMI). These subjects also include those with renal impairment. Thus, in some embodiments, the methods include determining whether a subject has impaired renal function, and if the subject has impaired renal function, selecting the patient.

[0026]   In general, the methods described herein include evaluating levels of ST2 is a biological sample (e.g., a blood, serum, plasma, urine, or body tissue sample), and optionally BNP and/or D-dimer in a subject e.g., a mammal, e.g., a human. These levels provide information regarding the presence of CVD, e.g., HF and/or PE in a subject. For example, a

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diagnosis of CVD, e.g., HP in a subject with an ambiguous level of BNP can be confirmed by the presence of elevated ST2 and low D-dimer levels. A diagnosis of CVD, e.g. PE in a subject with ambiguous levels of D-dimer can be confirmed by the presence of high ST2 and low BNP.

[0027] Evaluating circulating levels of ST2, BNP, or D-dimer in a subject typically includes obtaining a biological sample, e.g., serum or blood, from the subject. Levels of ST2, BNP, and D-dimer in the sample can be determined by measuring levels of polypeptide in the sample, using methods known in the art and/or described herein, e.g. immunoassays such as enzyme-linked immunosorbent assays (ELISA). Alternatively, levels of ST2, BNP, and D-dimer mRNA can be measured, again using methods known in die art and/or described herein, e.g., by quantitative PCR or Northern blotting analysis.

[0028] An antibody that "binds specifically to" an antigen, binds preferentially to the antigen in a sample containing other proteins. The term "antibody" as used herein refers to an immunoglobulin molecule or immunologically active portion thereof, i.e., so antigen-binding portion. Examples of immunologically active portions of immunoglobulin molecules include F(ab) and F(ab')$_2$ fragments which can be generated by treating the antibody with an enzyme such as pepsin. The antibody can be polyclonal, monoclonal, recombinant, e.g., a chimeric or humanized, fully human, non-human, e.g., murine, monospecific, or single chain antibody. In some embodiments it has effector function and can fix complement.

[0029] A "probe" is a nucleic acid that is at least 10, and less than 200 (typically less than about 100 or 50) base pairs in length. A probe that "binds specifically to" a target nucleic acid hybridizes to the target under high stringency conditions. As used herein, the term "hybridizes under high stringency conditions" describes conditions for hybridization and washing. As used herein, high stringency conditions are 0.5M sodium phosphate, 7% SDS at 65° C., followed by one or more washes at 0.2×SSC, 1% SDS at 65° C. Methods for performing nucleic acid hybridization assays are known to those skilled in the art and can be found in Ausubel et al., Eds., *Current Protocols in Molecular Biology*, John Wiley & Sons, N.Y. (1989), 6.3.1-6.3.6.

[0030] Detection can be facilitated by coupling (e.g., physically linking) the antibody or probe to a detectable substance (e.g., antibody labeling). Examples of detectable substances include various enzymes, prosthetic groups, fluorescent materials, luminescent materials, bioluminescent materials, and radioactive materials. Examples of suitable enzymes include horseradish peroxidase, alkaline phosphatase, β-galactosidase, or acetylcholinesterase; examples of suitable prosthetic group complexes include streptavidin/biotin and avidin/biotin; examples of suitable fluorescent materials include umbelliferone, fluorescein, fluorescein isothiocynate, rhodamine, dichlorotriazinylamine fluorescein, dansyl chloride, quantum dots, or phycoerythrin; an example of a luminescent material includes luminol; examples of bioluminescent materials include luciferase, luciferin, and acquorin, and examples of suitable radioactive materials include ^{125}I, ^{131}I, ^{35}S or [3]H.

[0031] Diagnostic assays can be used with biological matrices such as live cells, cell extracts, cell lysates, fixed cells, cell cultures, bodily fluids, or forensic samples. Conjugated antibodies useful for diagnostic or kit purposes, include antibodies coupled to dyes, isotopes, enzymes, and metals, see, e.g., Le Doussal et al. New Engl. J. Med. 146:169-175 (1991);

Gibellini et al., J. Immunol. 160:3891-3898 (1998); Hsing and Bishop, New Engl J. Med. 162:2804-2811 (1999); Everts et al., New Engl. J. Med. 168:883-889 (2002). Various assay formats exist, such as radioimmunoassays (RIA). ELISA, and lab on a chip (U.S. Pat. Nos. 6,176,962 and 6,517,234).

[0032] Known techniques in biochemistry and molecular biology can be used in the methods described herein (see, e.g., Maniatis et al., *Molecular Cloning, A Laboratory Manual*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y. (1982); Sam brook and Russell, *Molecular Cloning*, 3rd ed., Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y. (2001); Wu, *Recombinant DNA*, Vol. 217, Academic Press, San Diego, Calif. (1993); and Ausbel et al., *Current Protocols in Molecular Biology*, Vols. 1-4, John Wiley and Sons, Inc. New York, N.Y. (2001)).

[0033] Once a level of ST2 has been determined, the level can be compared to a reference level, or directly correlated with a value known to correspond to the presence or absence of CVD. In some embodiments, the reference level will represent a threshold level, above which the subject has CVD, e.g., ACS, PE, or HF, and/or has a given severity of CVD, e.g., ACS, HF, or PE, e.g., severe disease. The reference level chosen may depend on the methodology used to measure the levels of ST2. For example, in some embodiments, where circulating levels of soluble ST2 are determined using an immunoassay, e.g., as described herein, the reference level is about 0.2 to 0.3 ng/ml, e.g., 0.20, 0.23, or 0.29 ng/ml of serum, and a level of ST2 above that reference level indicates that the subject has CVD, e.g., ACS, PE, or HF, and/or has severe CVD, e.g., severe ACS, PE, or HF; these reference levels apply when the levels are determined using the method describe in Example 1 herein. In some embodiments, the reference level is a range of levels.

[0034] In some embodiments, the methods described herein include determining levels of IL-33 in addition to, or as an alternative to, ST2. In some embodiments, both levels of ST2 and IL-33 are determined, and the information from the comparison of both biomarkers with their respective, reference levels provides cumulative information regarding the presence of CVD, and/or presence of severe CVD in the subject in some embodiments, the ratio of ST2 to IL-33 may be determined, and the ratio compared to a reference ratio that represents a threshold ratio above which the subject has CVD, and/or has severe CVD. Alternatively or in addition, the presence and/or levels of IL-33/ST2 complexes can be determined and compared with a reference level to provide information regarding the presence of CVD, e.g., ACS, PE, or HF, in a subject; for example, levels of the complex above a selected threshold would indicate that the subject has CVD, e.g., ACS, PE, or HF.

[0035] In some embodiments, the methods include the use of additional diagnostic methods. Any diagnostic methods known in the art can be used, and one of skill in the art will be able to select diagnostic methods that are appropriate for the subject's symptoms. In some embodiments, the methods described herein include other diagnostic methods in addition to or as an alternative to the measurement of other biomarkers, e.g., physical measurements of lung function or cardiac function as are known in the art.

[0036] Thus, the methods described herein can also include measuring levels of ST2, optionally BNP and/or D-dimer, and one or more additional biomarkers, e.g., biomarkers that aid in the subject's diagnosis. As one example, for a subject who has chest pain or dyspnea, biomarkers indicative of

cardiac or cardiovascular disease can be measured, e.g., cardiac troponin (cTn), e.g., cTnI or cTnT, NT-proBNP, proBNP, NT-proANP, proANP, and/or ANP; alternatively or in addition, additional biomarkers of pulmonary disease can be measured. Thus, in subject's presenting with symptoms that include MI in their differential diagnoses, the methods can Include measuring levels of cTnI, to determine whether the subject is having an MI. One of skill in the art will appreciate that there are a number of additional diagnostic methods that can be used, depending on the situation and the subject's condition.

[0037] Also included herein are kits that include a reagent for the detection of ST2, BNP, and D-dimer polypeptide or nucleic acid, e.g., antibodies (i.e., antibodies that bind specifically to one of ST2, BNP, and D-dimer polypeptides), or nucleic acid probes (i.e., probes that are complementary to all or part of one of ST2, BNP, and D-dimer nucleic acids) and instructions for use in a method described herein.

[0038] The methods described herein are useful in the diagnosis of subjects with CVD, e.g., ACS, PE, or HF. In the methods described herein, if an overweight or obese subject (e.g., a subject with a BMI of 25-29, or 30 or above) has ambiguous, e.g., low or moderate, BNP (i.e., <500 pg/ml of serum), D-dimer levels of less than 500 μg/L of plasma, and elevated ST2 (e.g., levels above a reference, e.g., 0.2 ng/ml of serum), then die subject can be diagnosed with CVD, e.g., HF and treated accordingly, e.g., with surgical or pharmaceutical intervention, and/or lifestyle change, in spite of the low or moderate BNP levels.

[0039] In the methods described herein, if a subject (e.g., a subject with a BMI of 25-29, or 30 or above) has low BNP (i.e., <100 pg/ml of serum), ambiguous D-dimer levels, e.g., 300-4000 μg/L of plasma, and elevated ST2 (e.g., levels above a reference, e.g., 0.2 ng/ml of serum), then die subject can be diagnosed with CVD, e.g., PE, and treated accordingly, e.g., with anticoagulant therapy, in spite of their ambiguous D-dimer levels.

[0040] ST2/Interleukin 1 Receptor-Like 1 (IL1RL1)

[0041] The ST2 gene is a member of the interleukin-1 receptor family, whose, protein product exists both as a transmembrane form, as well as a soluble receptor that is detectable in serum (Kieser et al., FEBS Lett. 372(2-3): 189-93 (1995); Kumar et al., J. Biol. Chem. 270(46):27905-13 (1995); Yanagisawa et al. FEBS Lett. 302(1):51-3 (1992); Kuroiwa et al, Hybridoma 19(2): 151-9 (2000)). ST2 was recently described to be markedly up-regulated in an experimental model of heart failure (Weinberg et al., Circulation 106(23):2961-6 (2002)), and preliminary results suggest that ST2 concentrations may be elevated in those with chronic severe HF (Weinberg et al. Circulation 107(5):721-6(2003)) as well as in those with acute myocardial infarction (MI) (Shimpo et al. Circulation 109(18):2186-90 (2004)).

[0042] The transmembrane form of ST2 is thought to play a role in modulating responses off helper type 2 cells (Lohning et al., Proc. Natl. Acad. Sci. U. S. A. 95(12):6930-5 (1998); Schmitz et al. Immunity 23(5):479-90 (2005)), and may play a role in development of tolerance in states of severe or chronic inflammation (Brint et al., Nat. Immunol. 5(4): 373-9 (2004)), while the soluble form of ST2 is up-regulated in growth stimulated fibroblasts (Yanagisawa et ah, 1992, supra). Experimental data suggest that the ST2 gene is markedly up-regulated in states of myocyte stretch (Weinberg et

al., 2002, supra) in a manner analogous to the induction of the BNP gene (Bruneau et al. Cardiovasc. Res. 28(10); 1519-25 (1994)).

[0043] Tominaga, FEBS Lett. 258:301-304 (1989), isolated murine genes that were specifically expressed by growth stimulation in BALB/c-3T3 cells; they termed one of these genes St2 (for Growth Stimulation-Expressed Gene 2). The St2 gene encodes two protein products: ST2 (IL1RL1), which is a soluble secreted form; and ST2L, a transmembrane receptor form that is very similar to the interleukin-1 receptors. The HUGO Nomenclature Committee designated the human homolog of ST2, the cloning of which was described in Tominaga et al., Biochim. Biophys, Acta. 1171:215-218 (1992), as interleukin 1 Receptor-Like 1 (IL1RL1). The two terms are used interchangeably herein.

[0044] The mRNA sequence of the shorter, soluble isoform of human ST2 can be found at GenBank Ace. No. NM_003850.2, and the polypeptide sequence is at GenBank Ace. No. NP_093847.2; the mRNA sequence for the longer form of human ST2 is at GenBank Ace. No. NM_016232.4; the polypeptide sequence is at GenBank Acc. No. NP_057316.3. Additional information is available in the public databases at GeneID: 9173, MIM ID # 601203, and UniGene No. Hs.66. In general, in the methods described herein, the soluble form of ST2 polypeptide is measured.

[0045] Methods for detecting and measuring ST2 are known in the art, e.g., as described in U.S. Pat. Pub. Nos. 2003/0124624, 2004/0048286 and 2005/0130136, the entire contents of which am incorporated herein by reference. Kits for measuring ST2 polypeptide are also commercially available, e.g., the ST2 ELISA Kit manufactured by Medical & Biological Laboratories Co., Ltd. (MBL International Corp., Woburn, Mass.), no. 7638. In addition, devices for measuring ST2 and other biomarkers are described in U.S. Pat. Pub. No. 2005/0250156.

[0046] In some embodiments, the level of ST2 is determined once, e.g., at presentation. In some embodiments, the level of S2 is determined at one or more of 2, 4, 6, 8, 12, 18, and/or 24 hours, and/or 1-7 days after the onset of symptoms.

[0047] In some embodiments, the level of ST2 is determined more that once; in that ease, the higher measurement can be used. In embodiments where the level of ST2 is determined mom that once, die highest level can be used, or the change in levels can be determined and used. Levels of ST2 can also be determined multiple times to evaluate a subject's response to a treatment. For example, a level of ST2 taken after administration of a treatment, e.g., one or more doses or rounds of a treatment, can be compared to levels of ST2 before the treatment was initiated, e.g., a baseline level. The change in ST2 levels would indicate whether the treatment was effective; e.g., a reduction in ST2 levels would indicate that the treatment was effective.

[0048] In some embodiments, the methods include determining the identity of the nucleotide sequence at RefSNP ID; rs1041973.

[0049] Interleukin-33 (IL-33)

[0050] in the methods described herein, IL-33 can be measured instead of or in addition to ST2.

[0051] IL-33 was recently identified as the ligand for ST2, and the presence of increased levels of IL-33 in various inflammatory disorders has been described (see Schmitz et al., Immunity 23(5):479-90 (2005); U.S. Pat. Pub. No. 2005/0203046). The ratio of ST2 to IL-33 can also be determined.

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[0052] IL-33 protein is expressed as an inactive molecule, pre-IL-33, that is activated after cleavage by Caspase I resulting in the active IL-33 peptide as well as the cleavage peptide product, pro-IL-33. Therefore, the methods described herein can include measuring one, two, or all three of mature IL-33, pre-IL-33, and/or pro-IL-33, all of which are included in the term "IL-33."

[0053] The nucleic acid sequence of IL-33 can be found at GenBank. Acc. No. NM_033439.2, and the polypeptide sequence is at GenBank Acc. No. NP_254274.1. Additional information is available in the public databases at GeneID: 90865, MIM ID # *6086κ, and UniGene No. Hs.348390. IL-33 is also known as Chromosome 9 Open Reading Frame 26 (C9ORF26); Nuclear Factor from High Endothelial Venules (NFHEV); and interleukin 33. See also Baekkevold et al., Am. J. Path. 163: 69-79 (2003).

[0054] Methods for measuring levels of IL-33 polypeptide and nucleic acid are known in the art, see, e.g., Schmitz et al, Immunity 23(5):479-90 (2005); U.S. Pat. Pub. No. 2005/0203046.

[0055] Body Mass Index (BMI)

[0056] Obesity influences the expression of BNP in chronic HF. It is known that there is a significant inverse relationship between body mass index (BMI) and BNP levels.

[0057] BMI is determined by weight relative to height, and equals a person's weight in kilograms divided by height in meters squared ($BMI=kg/m^2$). Accepted interpretations are given in Table 2.

TABLE 2

Category	BMI
Underweight	≤ 18.5
Normal weight	18.5-24.9
Overweight	25-29.9
Obese	≥ 30

[0058] Thus, the methods described herein can include determining a subject's height, determining a subject's weight, and calculating BMI from the values determined thereby. Alternatively, the methods described herein can include reviewing a subject's medical history to determine their BMI.

[0059] In some embodiments, the methods described herein include selecting subjects who have a BMI of 30 or above (i.e., obese subjects).

[0060] Renal Function

[0061] Measures of renal function can include serum creatinine results as well as estimated glomerular filtration rate (GFR) (see, e.g., Levey et al., Ann. Intern. Med. 130(6):461-70 (1999)). Renal impairment is usually divided into three grades, shown in Table 3.

TABLE 3

Grade	GFR (ml/minute)	Serum Creatinine (μmol/litre)
mild	20-50	150-300
moderate	10-20	300-700
severe	<10	>700

[0062] Thus, the methods described herein can include determining a subject's serum creatinine levels and/or GFR.

Alternatively, the methods described herein can include reviewing a subject's medical history to determine their serum creatinine levels and/or GFR.

[0063] BNP

[0064] B-type natriuretic peptide (BNP), is a marker of heart failure. Levels of BNP pan be determined, e.g., in whole blood or serum, using standard methodology. For example, a number of assay kits are commercially available, e.g., the Triage BNP Test (Biosite, Inc., San Diego, Calif.), a point-of-care assay that whole blood or plasma and produces results in about 15 minutes; a chemiluminescent sandwich immunoassay (Bayer HealthCare Diagnostics, Tarrytown, N.Y.) for BNP that is run on the ADVIA Centaur and ACS; 180 platforms; a microparticle-based immunoassay (Abbott Laboratories, Abbott Park, Ill.) for BNP that is run on the AxSYM platform; and a chemiluminescent immuno-enzymatic assay (Biosite, Inc., San Diego, Calif.) for BNP that is run on the following Beckman Coulter platforms: Access, Access 2, Synchron LXI and the UniCel DXI. An electrochemiluminescent assay (Roche Diagnostics, Indianapolis, Ind.) available for measuring NT-proBNP.

[0065] The reference ranges for BNP and NTproBNP vary depending on a number of factors. The following ranges are for use where BNP levels are measured using an ELISA-type method, and one of skid in die art will be able to determine what levels obtained using other methods are equivalent. If the BNP level is >500 pg/mL, then HF is highly likely. Levels of BNP of 100-500 pg/mL are often described as a "grey zone," in which diagnosis is less certain. In lean subjects, if the BNP is <100 pg/mL, then HF is unlikely, however, obesity Influences the expression of BNP in chronic HF (Mehra et al., J Am Coll Cardiol. 43(9):1590-1595 (2004)), so levels of <100 pg/mL do not rule oat heart failure in obese subjects (Silver et ah, Cong. Heart Fail. 10(5 suppl. 3):1-30 (2004)).

[0066] D-Dimers

[0067] A D-dimer is a stable end-product of fibrin degradation, increased levels of D-dimers in the blood are associated with enhanced fibrin formation and fibrinolysis, and thus are diagnostic of conditions associated with these processes.

[0068] Methods for assaying D-dimer levels in the blood axe known in the art. Commercially available assay kits include the VIDAS D-Dimer Exclusion (bioMerieux, Durham, N.C.) a rapid, automated ELISA; Minutex® D-dimer, Biopool Auto-Dimer™ (an automated, immunoturbidimetric assay for analyzers reading at wavelengths of 540-880 nm), MiniQuant™ AMAX Auto D-Dimer™ (Automated D-dimer assay for AMAX instruments), and Accuclot D-Dimer™ assays (a semi-quantitative assay) (Trinity Biotech, Bray, Co. Wicklow, Ireland); and the HemosIL™ D-Dimer assay (instrumentation Laboratory, distributed by Beckman Coulter), a fully automated immunoturbidimetric assay.

[0069] Plasma D-Dimer levels above 4000 μg/L, are highly correlated with the presence of acute PE, and levels below 500 can be used to rule out PE (see, e.g., Perrier et ah, Am. J. Respir. Crit. Care Med., 156(2):492-496 (1997)). Plasma D-dimer level of 500-4000 μg/L are more ambiguous, due to the number of conditions that activate the coagulation and fibrinolytic processes.

[0070] Other Biomarkers

[0071] The methods described herein can also include measuring levels of other biomarkers in addition to ST2 and/or IL-33. Suitable biomarkers include NT-pro BNP, proBNP, BNP, NT-proANP, proANP, ANP, troponin, CRP creatinine,

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D-dimers (degradation products of cross-linked fibrin, whose level becomes elevated following clot formation), BUN (blood-urea-nitrogen), liver function enzymes, albumin, IL-6 and/or bacterial endotoxin. Methods for measuring these biomarkers are known in the art, see, e.g., U.S. Pat. Pub. Nos. 2004/0048286 and 2005/0130136 to Lee et al.; Dhalla et al., Mol. Cell Biochem. 87:85-92 (1989); Moe et al., Am. Heart J. 139:587-95 (2000), the entire contents of which are incorporated herein by reference. Liver function enzymes include Alanine transaminase (ALT); Aspartate transaminase (AST) Alkaline phosphatase (ALP) and Total bilirubin (TBIL).

[0072] In these embodiments, levels of ST2 and one or more additional biomarkers are determined, and the information from the comparison of die biomarkers with their respective reference levels provides additional information regarding the presence of CVD in the subject, and/or the level of severity of CVD in the subject.

EXAMPLES

[0073] The invention is further described in the following examples, which do not limit dm scope of the invention described in the claims.

Example 1

Sandwich ELISA Assay

[0074] This example uses the ST2 ELISA Kit manufactured by Medical & Biological Laboratories Co., Ltd. (MBL International Corp., Woburn, Mass.), no. 7638. This kit is a sandwich ELISA assay utilising monoclonal antibodies for both capture and detection. This procedure is intended to analyze a full plate of samples assayed in replicates at a 1:3 dilution factor and closely follows the manufacturers' protocol. Kits should be stored at 4° C. until use. The procedure described in this example is optimized for human serum or plasma collected in citrate or BDTA anticoagulant tubes. Plasma collected in heparin anticoagulant tubes should not be used in this assay as heparin binds ST2 and inhibits measurement by this ELISA protocol. Plasma or serum samples may be used fresh or stored frozen. This assay is not adversely affected by up to 3 freeze and thaw cycles of plasma samples.

[0075] Reagents should be prepared fresh from a new kit immediately before performing the assays. Allow the kit to equilibrate to room temperature prior to use. Reagents not explicitly discussed below are provided by the manufacturer ready to use.

[0076] 1, Wash solution—wash solution is provided by the manufacturer as a 10× concentrate solution. To make 1 liter of wash solution dilute 100 ml of the 10× concentrate provided with 900 ml of distilled water.

[0077] 2, Detector solution—the detector solution is prepared by diluting the detector concentrate 1:101 with the detector diluent. For a full 96 well plate of samples 10 ml of detector solution is required. To prepare 10 ml of detector solution use a pipette to transfer 10 ml of the blue colored detector diluent to a 15 ml orange top polypropylene tube. Ad 100 μl of the detector concentrate to this volume of detector diluent.

[0078] a. NOTE: this reagent should be prepared during the first assay incubation step.

[0079] 3. Calibrator stock—reconstitute the calibrator protein by dissolving the lyophilized protein in the amount of distilled water defined by the manufacturer

for this manufacturing lot to yield a stock solution of 8 ng/ml. This volume specification is included in the product insert.

[0080] Preparation of Standards and Samples:

[0081] All of the following should be prepared in labeled 1.5 ml polypropylene tubes to be transferred to the assay plate with the P200 pipetter.

[0082] Standards:

[0083] The standard curve is prepared by making 2 fold serial dilutions of the 8 ng/ml stock solution.

[0084] 1. Using a P1000 pipette transfer 250 μl of Assay Diluent to 8 1.5 ml polypropylene tubes labeled S1-S8

[0085] 2. Using the same P1000 pipette transfer 250 μl of the 8 ng/ml Calibrator stock solution to tube S1. This tube know 4 ng/ml calibrator protein.

[0086] a. Mix thoroughly by gently pipetting 3 times being careful not to create bubbles.

[0087] 3. Using the same P1000 pipette and a fresh tip for each of the following transfer 250 μl of the reagent in tube S1 to tube S2, repeat the mixing.

[0088] 4, Repeat step 3 for S2 to S3, S3 to S4, S4 to S5, S5 to S6 and S6 to S7. S8 will be the reagent blank so do not transfer tin; calibrant protein to this well.

[0089] a. Tubes S1-S6 and S8 will now have 250 μl of reagent and tube S7 will have 450 μl

[0090] Samples:

[0091] The plate is set up so that each sample is analyzed as a 1:3 dilution in duplicate. An exemplary set up is shown below in Table 4.

[0092] 1, Label a 1.5 ml polypropylene tube for each sample,

[0093] 3. Using the P200 pipette transfer 160 μl of Assay Diluent to each tube.

[0094] 3. Using a P200 pipette transfer 80 μl of serum or plasma from sample 1 to tube 1. Mix carefully by pipetting 3 times without making bubbles.

[0095] 4. Continue transferring samples to the sample tubes by repeating step 2 for each sample.

[0096] Procedure:

[0097] 1. Use the P200 pipette transfer the standards and diluted serum samples quickly to the 96 well assay plate.

[0098] a. Set the P200 pipette for 100 μl

[0099] b. Transfer 100 μl of the standard curve dilutions to each of columns 1 & 2 in the assay plate

[0100] c. Transfer 100 μl of each of the serum samples to the assay plate in exactly the same positions as shown in the plate map below.

[0101] 2. Cover the assay plate with the provided shield and incubate at room temperature for 60 minutes.

[0102] 3. Using the plate autowasher wash the plate 4 times.

[0103] 4. Detector: using the 8 channel multichannel pipette transfer 100 μl of the detector solution to each well and incubate at room temperature for 60 minutes.

[0104] a. NOTE: this reagent was to be prepared during the first incubation step.

[0105] b. NOTE: use a disposable reagent vessel for this reagent addition. ALWAYS use a fresh disposable reagent vessel for each reagent. It is not necessary to change pipette tips dining this step.

[0106] 5. Wash the plate as in step 3

[0107] 6. Substrate: using the 8 channel multichannel pipette transfer 100 μl of the Substrate to each well and incubate at room temperature for 30 minutes.

[0108] a. The Substrate reagent is provided ready to use by the manufacturer.

[0109] 7. Stop: at the completion of the Substrate incubation using the 8 channel multichannel pipette transfer 100 µl of the Stop solution to each well.

[0110] a. The Stop Solution reagent is provided ready to use by the manufacturer.

[0111] 8. Read the plate at 450 nm with background correction at 620 nm.

[0112] a. The plate should be read within 30 minutes after stopping the reaction.

[0113] 9. Enter the absorbance readings in the provided spreadsheet for analysis.

TABLE 4

Map of Exemplary 96 Well Assay Plate

	1	2	3	4	5	6	7	8	9	10	11	12
A	4.0		1	1	9	9	17	17	25	25	33	33
B	2.0		2	2	10	10	18	18	26	26	34	34
C	1.0		3	3	11	11	19	19	27	27	35	35
D	0.5		4	4	12	12	20	20	28	28	36	36
E	0.25		5	5	13	13	21	21	29	29	37	37
F	0.125		6	6	14	14	22	22	30	30	38	38
G	0.0625		7	7	15	15	23	23	31	31	39	39
H	0.0		8	8	16	16	24	24	32	32	40	40

Example 2

PRAISE-2

[0114] The Second Prospective Randomised Amlodipine Survival Evaluation (PRAISE-2) study was a double-blind, randomized trial prospectively designed to identify echocardiographic predictors of survival among patients with non-ischemic cardiomyopathy and heart failure and to determine if components of the echocardiographic examination add prognostic information to baseline demographic and clinical information (Cabell et al., Am. Heart J. 147(1):151-7 (2004)). One hundred patients participated in the PRAISE-2 echocardiographic study; of these, 93 had full and interpretable echocardiographic examinations. Serum samples were drawn at baseline and 2 weeks, and IL1LR1 levels were determined as described in Example 1.

[0115] Receiver operating characteristic (ROC) curve analysis using Analyse-It software (Analyse-It, Ltd, Leeds, UK). The ROC curve is shown in FIG. 1, and AUC (area under the curve) information for the same parameters shown in FIG. 1 is given below in Table 5. The ROC analysis provides a summary of all of the markers that were evaluated for prognostic value at baseline (t1). An AUC would indicate a neutral result; any result above 0.5 indicates an increase in accuracy of prediction based on that measurement, whereas a result below 0.5 indicates a loss of accuracy (i.e., the variability is high for that marker), and no correlation with the measured parameter.

TABLE 5

PRAISE ROC Results

Variable	AUC	p
Age	0.620	0.027
Height	0.562	0.250

TABLE 5-continued

PRAISE ROC Results

Variable	AUC	p
Weight	0.425	0.168
BMI	0.391	0.043
LVEF	0.421	0.146
Creatinine	0.599	0.066
ST2t1	0.611	0.040
NEt1	0.632	0.015
Bt1	0.496	0.941
DAt1	0.637	0.012
ANGt1	0.471	0.587
MDAt1	0.541	0.451
ADRt1	0.504	0.934
ANPt1	0.811	0.000
BNPt1	0.779	0.000

[0116] The value of ST2 for endpoint prediction was compared to other markers in three BMI groups. The results, shown in Table 6, below, indicate that for patients with a high BMI, ST2 (e.g., the ratio of ST2) is a stronger predictor than BNP. The negative numbers in the middle weight group for ST2 may be due to the presence of anomalous levels in some subjects.

TABLE 6

PRAISE Endpoint Prediction in 3 BMI Groups

BMI Group	Predictor	R	S.E.	Sig.
Under 25	Log BNP time 0	2.472	1.301	0.058
	Age	0.032	0.032	0.319
	Sex	0.274	0.986	0.781
	ST2 Ratio	3.094	1.997	0.121
25 to 30	Log BNP time 0	4.031	1.467	0.006
	Age	0.042	0.037	0.258
	Sex	−0.516	0.960	0.591
	ST2 Ratio	−0.764	1.643	0.642
30 and over	Log BNP time 0	1.283	0.966	0.184
	Age	0.008	0.039	0.844
	Sex	−2.128	1.056	0.044
	ST2 Ratio	6.581	2.539	0.010

[0117] The PRAISE ROC for BNP and ST2 Ratio was also calculated. The results, shown in FIG. 2 and Table 7, indicate drat ST2 ratio is comparable to BNP across the entire PRAISE population, which included both non-overweight, non-obese subjects, as well as subjects in whom HF was stabilised; ST2 levels tend to return to baseline when HF is stabilised.

TABLE 7

ROC for BNP and ST2 Ratio

Predictor	AUC	SE	P	Lower	Upper
BNPt1	0.783	0.043	0.000	0.698	0.868
ST2-Ratio	0.660	0.054	0.004	0.555	0.766

[0118] Prognostic utility of BNP and ST2 Ratio was calculated for those individuals with high BNP the results, shown in Table 8 and FIG. 3, demonstrate that ST2 ratio is a better predictor than BNP in the high BMI group, as it has a higher AUC and a better correlation,

TABLE 8

Prognostic Utility for BNP and ST2 Ratio in High BMI

BMI Group	Predictor	AUC	SE	P	Lower	Upper
Under 25	BNP Baseline	0.788	0.077	0.002	0.637	0.939
	ST2 Ratio	0.717	0.082	0.022	0.555	0.878
25-29	BNP Baseline	0.864	0.055	0.000	0.756	0.972
	ST2 Ratio	0.521	0.097	0.829	0.330	0.711
30 and Above	BNP Baseline	0.669	0.100	0.102	0.473	0.865
	ST2 Ratio	0.772	0.083	0.009	0.609	0.934

[0119] These results indicate that ST2 is predictive of outcome in the compensated heart failure patient when used as a change ever time, and provides additional prognostic resolution in high BMI patients.

Example 2

ST2 is not Affected by BMI

[0120] 600 breathless subjects were enrolled in the PRIDE study to analyze the utility of NT-proBNP for diagnosis and prognosis of acute heart failure (HF). At enrollment, a blinded sample of blood was obtained, processed and frozen at −80° C. For the purposes of ST2 analysis, an aliquot of citrated blood was thawed (second freeze-thaw cycle) and analysed for concentration of ST2 protein. The effect of BMI on ST2 levels was analyzed.

[0121] The results are shown in FIG. 4 and Table 9. ST2 median values were die same across all three BMI groups, and the IQR was nearly identical as well.

TABLE 9

BMI and ST2 levels

BMI	ST2 (median, ng/ml)	Interquartile range (ng/ml)
<25 (n = 77)	0.56	0.31-1.39
25-29.9 (n = 65)	0.49	0.23-1.13
≧30 (n = 66)	0.48	0.23-1.04

[0122] These results demonstrate drat, unlike BNP, ST2 levels are net affected by BMI.

Example 3

ST2 Concentrations are not Affected by Renal Insufficiency

[0123] The effect of renal impairment on ST2 concentrations was evaluated in a population of 135 patients with, moderate to severe renal insufficiency None of the patients were on dialysis, and none were previously diagnosed with CVD. All of the patients were evaluated using glomerular filtration rate (GFR in mls/min) as determined by the Modification of Diet in Renal Disease (MDRD) method as a measure of renal function. Echocardiography and coronary artery calcium (CAC) measurements were also performed on each subject to detect latent CVD. Multiple biomarkers were also evaluated.

[0124] The descriptive statistics for ibis cohort are shown in Table 10; the mean GFR and ST2 are illustrated graphically in FIGS. 5A-8.

TABLE 10

Glomerular Filtration Rate (GFR) and ST2 Levels

	GFR	ST2 levels (ng/ml)
Mean	34.5	0.122
Median	34	0.107
Std Error	0.989	0.005
Std Dev.	11.4	0.059
Coeff. Var.	33.3	48.346
Lower 95% CL	32.5	0.112
Upper 95% CL	36.4	0.132
25th Percentile	27	0.090
75th Percentile	43	0.127
Minimum	9	0.068
Maximum	59	0.476
Count	135	135

[0125] In this cohort of patients with stable, chronic disease, only ten (8%) bad ST2 levels above 0.2, dm highest of which was 0.476 ng/ml. This distribution of ST2 values is shown in FIG. 6. This was as expected is this population of subjects with chronic, managed renal insufficiency; one would not expect to see very high ST2 levels.

[0126] Pearson Correlation analysis was performed in this population to determine whether there was a correlation between ST2 levels and renal function, as measured by either GFR or creatinine clearance. The results are shown in Tables 11 and 12.

TABLE 11

Pearson Correlation Results - GFR and ST2

Variable	Mean	Std Dev.	Std Err	N
	Descriptive Statistics			
GFR	34.5	11.5	0.989	135
ST2 (ng/mL)	0.122	0.059	0.005	135

	GFR	ST2 (ng/mL)
	Correlation Matrix (R)	
GFR	1.000	0.028
ST2 (ng/mL)	0.028	1.000
	Correlation Significance (P)	
GFR	—	0.748
ST2 (ng/mL)	0.748	—

TABLE 12

Pearson Correlation Results - Creatinine Clearance and ST2

Variable	Mean	Std Dev.	Std Err	N
	Descriptive Statistics			
Screening Cr	2.175	0.859	0.081	113
ST2 (ng/mL)	0.122	0.058	0.006	113

TABLE 12-continued

Pearson Correlation Results - Creatinine Clearance and ST2

	Screening Cr	ST2 (ng/mL)
Correlation Matrix (R)		
Screening Cr	1.000	−0.018
ST2 (ng/mL)	−0.018	1.000
Correlation Significance (P)		
Screening Cr	—	0.851
ST2 (ng/mL)	0.851	—

[0127] These results demonstrate that, as was expected in this population of subjects with chronic, managed renal insufficiency, there is no correlation between ST2 levels and either GFR (p=0.75) or creatinine clearance (p=0.851) in this population. This indicates that renal insufficiency, by itself does not cause an elevation of ST2 levels.

[0128] The same analyses were carried out in a population of 139 subjects at the San Diego Veteran's Administration Hospital. All of the subjects bad previously beers diagnosed with acme decompensated heart failure (ADHF), and the mean ST2 level was about twice that seen in the population, of patients with chronic renal insufficiency but no HF (see Tables 11-12). There is an almost ubiquitous correlation between, renal insufficiency and heart failure, with an almost 80% confluence of patients with stage III/IV HF also having impaired renal function (Fonarow and Heywood, Am. J. Med. (2006) 119(12A):S17-S25. Thus, because ADHF is correlated with ST2 levels, one would expect to see a correlation between, renal. insufficiency (as measured by GFR) and ST2 levels. This was exactly what was seen, as shown in Tables 13 and 14,

TABLE 13

Pearson Correlation Results - GFR and ST2 in ADHF

Descriptive Statistics

Variable	Mean	Std Dev.	Std Err	N
GFR	59.1	25.3	2.143	139
ST2 (ng/mL)	0.283	0.332	0.028	139

	GFR	ST2 (ng/mL)
Correlation Matrix (R)		
GFR	1.000	−0.062
ST2 (ng/mL)	−0.062	1.000
Correlation Significance (P)		
GFR	—	0.470
ST2 (ng/mL)	0.470	—

TABLE 14

Pearson Correlation Results - GFR and ST2 Ratios in ADHF

Descriptive Statistics

Variable	Mean	Std Dev.	Std Err	N
GFR	59.1	25.3	2.143	139
ST2 ratio	1.038	3.038	0.258	139

	GFR	ST2 ratio
Correlation Matrix (R)		
GFR	1.000	−0.161
ST2 ratio	−0.161	1.000
Correlation Significance (P)		
GFR	—	0.058
ST2 ratio	0.058	—

[0129] These results demonstrate mat, in subjects with ADHF, ST2 values, whether represented as a single level or a ratio, are correlated with, measures of renal insufficiency, bat are independent of die renal insufficiency; thus, mere is no causative relationship between the two. Rather, both variables are related to and independently interact with a third parameter (in this case, heart failure).

Other Embodiments

[0130] It is to be understood that white the invention has been described in conjunction with the detailed description thereof, the foregoing description is intended to illustrate and not limit the scope of the invention, which is defined by the scope of the appended claims. Other aspects, advantages, and modifications are within the scope of the folio wing claims.

1. A kit for diagnosing cardiovascular disease (CVD), the kit comprising antibodies that specifically bind to ST2, BNP, and D-dimer, or nucleic acid probes that specifically bind to nucleic acids encoding ST2, BNP, and D-dimer, and instructions for use in a method of diagnosing heart failure (HF) or a pulmonary embolism (PE) in a subject who has one or both of (i) a body mass index (BMI) of greater than or equal to 25, or (ii) impaired renal function.

2. A method of diagnosing cardiovascular disease (CVD) in a subject who has one or both of (i) a body mass index (BMI) of greater than or equal to 25, or (ii) impaired renal function, the method comprising:
    one or both of:
        (A) determining the subject's BMI, and if the subject's BMI is equal to or greater than 25, selecting the subject; or
        (B) evaluating the subject's renal function, and if the subject has impaired renal function, selecting the subject; and
    determining levels of BNP, D-dimers, and ST2 in a biological sample from the subject;
    wherein the subject's BNP level, D-dimer level, and ST2 level indicates whether the subject has CVD.

3. The method of claim 2, wherein the CVD is heart failure (HF) or pulmonary embolism (PE).

4. The method of claim 2, wherein the BNP level, D-dimer level, and ST2 level are detected in a biological sample comprising blood, plasma, or serum.

5. The method of claim **2**, wherein if the subject's BNP level is less than 500 pg/mL, and the D-dimer level is less than 500 µg/L, then the relationship of the ST2 level to a reference level of ST2 indicates whether the subject has HF.

6. The method of claim **2**, wherein if the subject's BNP level is less than 100 pg/mL, and the D-dimer level is 500-4000 µg/L, then the relationship of the ST2 level to a reference level of ST2 indicates whether the subject has PE.

7. The method of claim **5**, wherein the reference level of ST2 represents a level in a subject who does not have HF.

8. The method of claim **5**, wherein the reference level of ST2 is about 0.2 to 0.3 ng/ml of serum, and values above that level indicate the presence of HF.

9. The method of claim **6**, wherein the reference level of ST2 represents a level in a subject who does not have PE.

10. The method of claim **6**, wherein the reference level of ST2 is about 0.2 to 0.3 ng/ml of serum, and values above that level indicate the presence of PE.

11. The method of claim **2**, wherein the subject's BNP level is 100-500 pg/mL.

12. The method of claim **2**, further comprising determining a level in the subject of one or more other biomarkers.

13. The method of claim **12**, wherein the other biomarkers are selected from the group consisting of NT-pro ANP, ANP, troponin, CRP, creatinine, Blood Urea Nitrogen (BUN), liver function enzymes, albumin, and bacterial endotoxin.

14. The method of claim **2**, wherein determining whether the subject has impaired renal function comprises determining glomerular filtration rate (GFR) and/or serum creatinine level, and the subject has impaired renal function if they have a GFR or serum creatinine level shown in the following table:

Grade	GFR (ml/minute)	Serum Creatinine (µmol/litre)
mild	20-50	150-300
moderate	10-20	300-700
severe	<10	>700

15. The kit of claim **1**, wherein a subject has impaired renal function if they have a GFR or less than 50 ml/minute.

16. The method of claim **2**, wherein the subject has a BMI of greater than or equal to 30.

17. The method of claim **2**, wherein the subject has a BMI of 25 to 29.

18. A method of diagnosing cardiovascular disease (CVD) in a subject who has impaired renal function, the method comprising:

evaluating the subject's renal function, and if the subject has impaired renal function, selecting the subject; and

determining an ST2 level in a biological sample from the subject;

wherein the relationship of the ST2 level to a reference level of ST2 indicates whether the subject has CVD.

19. The method of claim **18**, wherein the reference level of ST2 represents a level in a subject who does not have CVD.

20. The method of claim **18**, wherein the reference level of ST2 is about 0.2 to 03 ng/ml of serum, and values above that level indicate the presence of CVD.

21. The method of claim **18**, wherein the reference level of ST2 represents a level in a subject who does not have CVD.

22. The method of claim **18**, wherein the CVD is heart failure (HF) or pulmonary embolism (PE).

23. The method of claim **18**, wherein the biological sample comprises blood, plasma, or serum.

24. The method of claim **18**, further comprising determining a level in the subject of one or more other biomarkers.

25. The method of claim **24**, wherein the other biomarkers are selected from the group consisting of BNP, D-Dimer, NT-proANP, and ANP troponin, CRP, creatinine, Blood Urea Nitrogen (BUN), liver function enzymes, albumin, and bacterial endotoxin.

26. The method of claim **18**, wherein determining whether the subject has impaired renal function comprises determining glomerular filtration rate (GFR) and/or serum creatinine level, and the subject has impaired renal function if they have a GFR or serum creatinine level shown in the following table:

Grade	GFR (ml/minute)	Serum Creatinine (µmol/litre)
mild	20-50	150-300
moderate	10-20	300-700
severe	<10	>700

27. The kit of claim **1**, wherein the CVD is heart failure (HF) or pulmonary embolism (PE).

28. The kit of claim **1**, wherein the BNP level, D-dimer level, and ST2 level are detected in a biological sample comprising blood, plasma, or serum.

29. The kit of claim **1**, wherein the subject has a BMI of greater than or equal to 30.

30. The kit of claim **1**, wherein the subject has a BMI of 25 to 29.

* * * * *

专利名称(译)	诊断心血管疾病		
公开(公告)号	US20100009356A1	公开(公告)日	2010-01-14
申请号	US12/299177	申请日	2007-05-01
[标]申请(专利权)人(译)	重症监护诊断股份有限公司		
申请(专利权)人(译)	急救诊断，INC.		
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摘要(译)

本发明涉及在高体重指数（BMI）个体中检测心血管疾病，例如急性冠状动脉综合征，心力衰竭和/或肺栓塞的方法，例如，BMI为25-29，或30或更高，以及那些肾功能受损的人。

Figure 1

ROC Curve