Abstract: In one embodiment a precordial device comprises a sternal notch alignment portion and at least one measurement device connected to the precordial device wherein when the sternal notch alignment portion is aligned with a sternal notch of a patient, the precordial device is in alignment with the patients chest such that consistent result can be obtained by the at least one measurement device. In another embodiment a precordial device comprises a sternal notch alignment portion for alignment with a sternal notch of a patient; an ECG measurement device; an ICG measurement device.
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A PRECORDIAL DEVICE

TECHNICAL FIELD

The invention relates to a precordial device. In particular, the invention relates to a precordial device comprising one or multiples of measurements and treatment devices such as an electrocardiograph (ECG), Impedance Cardiograph (ICG), electronic stethoscopes, ultrasound stethoscopes, ultrasound probes, defibrillator/external pacemaker, drug administration devices, non-invasive blood pressure device, saturation meter, precordial impulse meters, apical impulse meter, sternal heave meter, percussion sound generator, chest circumference indicator, patient positioning indicator and breathing rate devices which work in synchronised real time environment and is complimented alongside a neural network and or software analysis package of which some of multiples of these devices are included into a single embodiment that ensures correct positioning of these devices on the precordium of a person so as to record these device results in a compliant and consistent manner when comparing different tests on the same person or tests of different persons with each other.

BACKGROUND

A precordial device is a device which can be arranged to overlay the anterior chest wall and extend to the lateral chest walls and to the abdomen of a patient and comprises at least one measurement device used to determine, for example, the cardiovascular and respiratory status of the patient. The measurement device may contain amongst others an ECG device.

An ECG device is used to measure the electrical impulses (electrical potential differences) of the heart, the rate and regularity of the heartbeats. The measurements can be used to determine the size and position of the chambers of the heart, the presence of any damage to the heart and the effects of drugs or devices used to regulate the heart, such as a pacemaker.
A known ECG device comprises a plurality of ECG sensors (electrodes) which are attached using adhesive, by a skilled user such as a nurse or a doctor, directly to precise locations on a patient's chest. This type of ECG device produces accurate results if the ECG sensors are positioned correctly. However, if the ECG sensors are placed in even a slightly incorrect position, the result can be inaccurate especially in the situation where prior recordings are compared with a new recording. To overcome the potential for inaccuracies, the ECG device must always be positioned by a skilled user in a consistent manner, typically according to a protocol, although protocols differ from institution to institution.

Another disadvantage associated with known ECG devices is that each ECG sensor must be connected to an ECG lead wire, and the ECG lead wires can get swapped (i.e. the wrong terminal to the wrong position), when the separate ECG sensors are affixed to the patient. These wires also tend to pull the sensor from the attached skin with resulting recording disturbances. The wires are also in the way and get entangled and it takes a lot of time to perform this procedure.

Other types of ECG devices are disclosed in European Patent Publication No. 061 791 5, entitled ECG diagnostic pad, by Y Sekine and US Patent Publication No. 200504951 5, entitled electrode belt for acquisition, processing and transmission of cardiac (ECG) signals, by D. J. Misczynski et al.

European Patent Publication No. 061 791 5 describes an ECG diagnostic pad, illustrated in Figure 16, having upper fit portions 12 with upper limb lead electrodes 22a, 22b, central fit portions 14 with unipolar precordial lead electrodes 32a-32f and lower fit portions 16 with flank lead electrodes 42a, 42b is fitted onto the chest wall of a patient.

US Patent Publication No. 200504951 5, describes an electrode chest belt as illustrated in figure 17. The chest belt comprises a flexible belt 100, which adjusts to accommodate individuals of varying sizes, two or more electrodes 110, 120, and an electronic processing unit 140. The electrodes 110, 120 are connected to the electronic processing unit 140.
Both the ECG diagnostic pad and ECG electrode belt must be strapped to the patient such that the electrodes are arranged in the correct position. This must be done by a skilled user so that accurate measurements can be obtained. However, it is sometimes not possible for a skilled user to perform this procedure. In remote locations a skilled user may not be available, such as in the telemedicine environment, or in a remote clinic in a poorly developed country where the person applying the ECG has had no medical training or in the case of a user assisting a patient on an aeroplane in flight without any help from a skilled person. An unskilled user would not know where to place the ECG sensors (electrodes) correctly and which ECG lead to attach to which ECG sensor.

Furthermore, since all the known devices must be strapped onto the patient, or must be attached to the patient with adhesive both skilled and unskilled users are unable to do a quick spot check of the current state of a patient's cardiovascular status. The described invention in this document can be held by pushing it slightly or holding it to the precordium of the chest of the patient by either another person or by the patient himself.

None of these inventions also describes that Impedance Cardiography (ICG), electronic stethoscopes, ultrasound stethoscopes, ultrasound probes, defibrillator/external pacemaker, drug administration devices, saturation meter, precordial impulse meters, apical impulse meter, sternal heave meter, percussion sound generator, chest circumference indicator, patient positioning indicator and breathing rate devices must be placed at constant positions without swapping for instance the different stethoscope recordings by accident.

Furthermore none of the prior art describes how these different devices can, within the same time domain, be synchronised or "communicate with each other" and thus the sum total of analytical capacity of the biometric results being far greater than the individual sum of the diagnostic parameters in time with each other to extract more biometric data of the person tested. An example of this is to synchronise ECG features with features extracted from the apical impulse meter with resultant extra features i.e. time delay between the QRS ECG component and the apical impulse beat.
Embodiments of the invention seek to provide a superior device both in user functionality ease of use and diagnostic/therapeutic capacity, and particularly, a handheld precordial device that does not need to be strapped to the patient or glued onto the patient, which can be used by a non-skilled user (for example, the patient himself by just holding the device to his chest with his left arm while the device records his essential cardiac features for instance Congestive Cardiac Failure parameter).

SUMMARY

The invention provides a precordial device comprising:

- a sternal notch alignment portion; and
- at least one measurement device connected to the precordial device,

wherein when the sternal notch alignment portion is aligned with a sternal notch of a patient, the precordial device is in alignment with the patient’s chest such that consistent result can be obtained by the at least one measurement device.

At least one measurement device may comprise an electrocardiogram (ECG) device.

The ECG device may comprise an ECG Lead V1; an ECG Lead V2; an ECG Lead V3; an ECG Lead V4; an ECG Lead V5; an ECG Lead V6; an ECG Lead V7; an ECG Lead V8; an ECG Lead V9; an ECG Lead rV1; an ECG Lead rV2; an ECG Lead rV3; an ECG Lead rV4; an ECG Lead rV5; an ECG Lead rV6; an ECG Lead rV7; an ECG Lead rV8; an ECG Lead rV9; an ECG Lead Right Arm; an ECG Lead Left Arm; an ECG Lead Left Foot; and an ECG Lead Right Foot.

The ECG Lead Right Arm and the ECG Lead Left Arm can be placed on the exterior surface of the device where the patient can touch the leads with his upper limbs.

The ECG Lead Right Arm, ECG Lead Left Arm, ECG Lead Right Leg and ECG Lead Right Leg may be attached to the precordial device with wires.
The ECG device may be capable of connection, via a single connection means to a computer. The ECG device may be capable of wireless connection to a computer. The precordial device may further comprise a computer with a human interface device built into the precordial device in communication with the ECG.

At least one ECG measuring device may also function as an impedance cardiograph (ICG) measuring device.

At least one measurement device may comprise a stethoscope chest piece device. The stethoscope chest piece device may comprise an Aortic valve stethoscope sensor; a Pulmonary valve stethoscope sensor; a Tricuspid valve stethoscope sensor; and Mitral valve stethoscope sensor. The chest piece device may further comprise a tracheal sound stethoscope sensor; an other heart sound stethoscope sensor; a basal respiratory sound stethoscope sensor; an abdominal sound stethoscope sensor; a left side Carotid artery stethoscope sensor; and a right side Carotid artery stethoscope sensor. A diaphragm of any one of the stethoscope sensors may comprise an electrode connection portion.

The precordial device may include an ECG or ICG sensor electrically connected to the electrode connection portion.

The stethoscope sensors may comprise a pressure sensor.

A diaphragm of any one of the stethoscope sensors may comprise an impedance cardiograph (ICG) sensor or an electro cardiograph (ECG) sensor.

The at least one measurement device may comprise an ultrasound probe or an ultrasound stethoscope. The ultrasound probe or stethoscope may cover a full surface area of the precordium, in use.

The precordial device may further comprise: foam, gel or fluid filled bags provided on an exterior surface thereof.
The foam or gel may be able to absorb noise mainly having a frequency below 50 Hz.

The precordial device may further comprise:

- a handle connected to an exterior surface of the precordial device.

The handle may have elastic properties. The handle may have shock absorbing properties.

At least one measurement device may comprise a sensor capable of monitoring any movement of a user holding the device and/or any movement of a patient. The sensor may be an accelerometer. This sensor might be fitted into the handle or into the area where a person is holding the device to the patient.

The at least one measurement device may comprise an accelerometer or inclinometer device. The accelerometer device may comprise a one-, two-, or three-axis accelerometer sensor. The accelerometer device may comprise a superior sternal accelerometer sensor; an inferior sternal accelerometer sensor; a lateral chest accelerometer sensor; and an abdominal accelerometer sensor.

The at least one measurement device may comprise at least one defibrillation and external cardiac pacing electrode pad. The precordial device may comprise a right Clavicle defibrillation and external cardiac pacing electrode pad and an Apical defibrillation and external cardiac pacing electrode pad.

The at least one measurement device may comprise at least one oxygen saturation device. The oxygen saturation device may comprise at least one light emitting device, and at least one light receiving device. The oxygen saturation device may be positioned below the sternal notch alignment portion. The oxygen saturation device may be positioned to the lower left hand side of the precordial device. The oxygen saturation device may be positioned any position on the Precordial Device touching the skin of the precordium. The oxygen saturation device may be connected to the precordial device with wires. The oxygen saturation device may be placed on the device in such a manner that the patient can put his finger into or on the oxygen
saturation sensing area while the device is positioned on the patient's chest. The at least one ECG electrode may be positioned to make contact with the finger of the patient.

The at least one light emitting device may be capable of emitting light having a wavelength of substantially 910nm +/- 30nm. The at least one light emitting device may be capable of emitting light having a wavelength of substantially 670nm +/- 30nm.

The precordial device may comprise a plurality of light emitting devices arranged to form a circle around the at least one light receiving device. The plurality of light emitting devices may form a circle having a radius greater than or equal to substantially 20mm +/- 15mm.

The precordial device may further comprise a finger probe on the anterior side of the precordial device.

The at least one measurement device may comprise an apical impulse device. An apical impulse device may be provided to the lower left hand side of the precordial device over the apex of the heart. The sternal heave impulse device may be provided over the sternum of the precordium. The precordial impulse device may comprise measuring impulses at any location on the precordium. The apical impulse device may comprise a semi-curved base that follows the contour of the precordium, and a grid of pressure sensors provided on the precordial side of the semi-curved base.

The impulse device may comprise a grid of one, two or three dimensional accelerometer sensors.

The at least one measurement device may comprise a temperature sensing device. The temperature sensing device may comprise an infrared sensor. The temperature sensing device may comprise a contact sensor. The temperature sensing device may comprise at least one temperature sensor capable of measuring local skin temperature of a patient. The temperature sensing device may comprise at least one temperature sensor capable of measuring ambient temperature. The temperature sensing device may comprise at least one temperature sending device.
connected to the Precordial Device by means of wires. At least one temperature sensor may be provided on an exterior surface of the precordial device to measure ambient temperature.

The at least one measurement device may comprise at least one percussion hammer.

The at least one percussion hammer may comprise:
- a rubber portion capable of contacting a patient's skin; and
- a solenoid connected to the precordial device, wherein when in use a moving portion of the solenoid contacts the rubber portion.

The at least one percussion hammer may comprise a plurality of percussion hammers placed in a row. The rubber portion of the percussion hammer may be a high density rubber.

The percussion hammer may further comprise:
- a pressure sensor operable to measure the pressure exerted by the rubber part on the skin; and
- an accelerometer operable to measure an acceleration of the hammer and of the rubber part.

The percussion hammer may include a bone vibrator and can measure a bone vibrator pressure against the precordium. The at least one bone vibrator may press against the sternum or to any area of the precordium.

The at least one measurement device may comprise at least one pressure sensor.

The precordial device may further comprise a hub to which peripherals devices are capable of connection. The hub may comprise a USB hub; a Serial connectivity hub; a FireWire hub; a wireless hub; or a ZigBee hub.
The precordial device may further comprise a conductive substance dispenser. The conductive substance dispenser may comprise an electrode comprising a hole and a tube from which the conductive substance is dispensed. The conductive substance may comprise an electrode gel or saline water or any other conductive liquid substance.

The precordial device according may further comprise a disposable cover that act as a barrier between the precordial device and the precordium. An area of the disposable cover may be conductive and another area of the disposable cover may be non-conductive. An area of the disposable cover may be provided with adhesive glue. An area of the disposable cover may be provided with a conductive substance. The cover may have varying thickness.

The at least one measurement device may comprise an impedance cardiograph (ICG) measuring device. The precordial device may further comprise two neck portions. The ICG measuring device may comprise a left neck top ICG sensor; a left neck bottom ICG sensor; a right neck top ICG sensor; a right neck bottom ICG sensor; a left thorax top ICG sensor; a left thorax bottom ICG sensor; a right thorax top ICG sensor; and a right thorax bottom ICG sensor. The distance between a centre of the left neck top ICG sensors and the left neck bottom ICG sensor may be the same as the distance between a centre of the right neck top ICG sensor and the right neck bottom ICG sensor, which may be the same as the distance between a centre of the left thorax top ICG sensor and the left thorax bottom ICG sensor, and which may be the same as the distance between a centre of the right thorax top ICG sensor and the right thorax bottom ICG sensor, for symmetrical placement either side of the neck. The distance may be constant for all paired points. The distance may be in a range of substantially 0mm (zero) to 60mm. The bottom and top sensors may also be parallel semi-circular bands touching the precordium and neck.

The at least one measurement device may comprise a non-invasive blood pressure monitor cuff attached to the exterior portion of the precordial device into which the test subject can place his/her forearm or upper arm. The cuff may comprise of at least one incorporated ECG electrode.
The impedance cardiograph (ICG) measuring device may be capable of dispensing a conductive substance.

The precordial device may further comprise hooks for an elastic belt to enable the precordial device to be affixed to a patient.

The precordial device may further comprise strapping to enable the precordial device to be affixed to a patient.

The precordial device may further comprise an adhesive to enable the precordial device to be affixed to a patient.

The precordial device may further comprise of at least one suction area that will enable the precordial device to be affixed to a patient though negative pressure.

The at least one sensor may be placed inside a negative pressure area to be pressed against the precordium when negative pressure is applied to the suction area.

The at least one measurement device may be connected to an interior surface of the precordial device.

The precordial device may further comprise:
foam, gel or fluid filled bags or air filled bags provided on a surface between the device and the precordium.

The at least one measurement device may be connected to the precordial side of the foam, gel or fluid filled bags or air filled bags.

The at least one measurement device may be connected to the device side of the foam, gel or fluid filled bags or air filled bags.

The invention extends to a precordial device comprising:
an electrocardiogram (ECG) device connected to the precordial device; and
at least one other measurement device connected to the precordial device.
The ECG device may comprise an ECG Lead V1; an ECG Lead V2; an
ECG Lead V3; an ECG Lead V4; an ECG Lead V5; an ECG Lead V6; an ECG Lead V7;
an ECG Lead V8; an ECG Lead V9; an ECG Lead rV1; an ECG Lead rV2; an ECG
Lead rV3; an ECG Lead rV4; an ECG Lead rV5; an ECG Lead rV6; an ECG Lead rV7;
an ECG Lead rV8; an ECG Lead rV9; an ECG Lead Right Arm; an ECG Lead Left Arm;
an ECG Lead Left Foot; and an ECG Lead Right Foot.

The ECG Lead Right Arm and the ECG Lead Left Arm can be placed on
the exterior surface of the device where the patient can touch the leads with his upper
limbs.

The ECG Lead Right Arm, ECG Lead Left Arm, ECG Lead Right Leg and
ECG Lead Right Leg may be attached to the precordial device with wires.

At least one other measurement device may comprise a stethoscope
chest piece device. The stethoscope chest piece device may comprise an Aortic valve
stethoscope sensor; a Pulmonary valve stethoscope sensor; a Tricuspid valve
stethoscope sensor; and Mitral valve stethoscope sensor. The chest piece device may
further comprise a tracheal sound stethoscope sensor; an other heart sound
stethoscope sensor; a basal respiratory sound stethoscope sensor; an abdominal sound
stethoscope sensor; a left side Carotid artery stethoscope sensor; and a right side
Carotid artery stethoscope sensor.

The at least one measurement device may comprise a sensor capable of
monitoring any movement of a user holding the device and/or any movement of a
patient.

The at least one measurement device may comprise an accelerometer
device. The accelerometer device may comprise a three-axis accelerometer sensor.
The accelerometer device may comprise a superior sternal accelerometer sensor; an
inferior sternal accelerometer sensor; a lateral chest accelerometer sensor; and an
abdominal accelerometer sensor.
The at least one measurement device may comprise at least one defibrillation and external cardiac pacing electrode pad. The precordial device may comprise a right Clavicle defibrillation and external cardiac pacing electrode pad and an Apical defibrillation and external cardiac pacing electrode pad.

The at least one measurement device may comprise at least one oxygen saturation device. The oxygen saturation device may comprise at least one light emitting device, and at least one light receiving device.

The precordial device may comprise a plurality of light emitting devices arranged to form a circle around the at least one light receiving device. The plurality of light emitting devices may form a circle having a radius greater than or equal to substantially 20mm +/- 15mm.

The at least one measurement device may comprise an apical impulse device. An apical impulse device may be provided to the lower left hand side of the precordial device over the apex of the heart. The sternal heave impulse device may be provided over the sternum of the precordium. The precordial impulse device may comprise measuring impulses at any location on the precordium. The apical impulse device may comprise a semi-curved base that follows the contour of the precordium, and a grid of pressure sensors provided on the precordial side of the semi-curved base. The impulse device may comprise a grid of one, two or three dimensional accelerometer sensors.

The at least one measurement device may comprise a temperature sensing device.

The at least one measurement device may comprise at least one percussion hammer. The at least one percussion hammer may comprise a rubber portion capable of contacting a patients skin, and a solenoid connected to the precordial device, wherein when in use a moving portion of the solenoid contacts the rubber portion.
The at least one measurement device may comprise at least one pressure sensor.

The precordial device may further comprise a hub to which peripherals devices are capable of connection. The hub may comprise an USB hub; a Serial connectivity hub, a FireWire hub or a wireless hub.

The precordial device may further comprise a conductive substance dispenser. The conductive substance dispenser may comprise an enlarged electrode comprising a hole and a tube from which the conductive substance is dispensed.

The precordial device may further comprise a disposable cover.

The at least one measurement device may comprise an impedance cardiograph (ICG) measuring device. The precordial device in such case may further comprise two neck potions.

The ICG measuring device may comprise a left neck top ICG sensor; a left neck bottom ICG sensor; a right neck top ICG sensor; a right neck bottom ICG sensor; a left thorax top ICG sensor; a left thorax bottom ICG sensor; a right thorax top ICG sensor; and a right thorax bottom ICG sensor.

The precordial device may further comprise foam provided on an exterior surface thereof.

The precordial device may further comprise a handle connected to an exterior surface of the precordial device.

The precordial device may be sized and configured to match a particular patient.

The invention extends further to a disposable cover for a precordial device, the disposable cover comprising a conductive surface and a non-conductive surface. The disposable cover may further comprising an area provided with adhesive
glue properties. The disposable cover may further comprising an area provided with a conductive substance. The disposable cover may have varying thickness.

In another embodiment of the invention a precordial device is provided comprising: a sternal notch alignment portion for alignment with the sternal notch of a patient such positioning alongside the predetermined Anthropometric length is utilised in the device via determination of the sternal length for adults and or growing patients.

In another embodiment of the invention the device design has been specifically tailored to accommodate the position and variable size of the mammary glands of patients to ensure adequate contact and optimum positioning of the precordial device.

The design and layout dimensions and contours and in particular anthropometric lengths and widths adopted have been calculated to offer optimum patient positioning.

**BRIEF DESCRIPTION OF THE DRAWINGS**

For a better understanding of the invention and as to how the same may be carried into effect reference will now be made, by way of example only, to the accompanying drawings, in which:

- Figure 1A illustrates one embodiment of a precordial device of the invention;
- Figure 1B illustrates an inner surface of the precordial device of figure 1A;
- Figure 2 illustrates the positions at which a stethoscope chest piece sensor must be arranged in order to detect valve sounds;
- Figure 3 illustrates one embodiment of a precordial device of the invention having a layer of noise absorbing foam;
- Figure 4A illustrates one embodiment of a precordial device of the invention having a handle;
- Figure 4B illustrates one embodiment of a precordial device of the invention comprising a handle;
- Figure 5 illustrates the internal surface of one embodiment of a precordial device of the invention comprising a stethoscope chest piece device;
Figure 6 illustrates one embodiment of a precordial device of the invention comprising an accelerometer device;

Figure 7 illustrates one embodiment of a precordial device of the invention comprising an ECG device, a stethoscope chest piece device and defibrillation and external cardiac massage pads;

Figure 8 illustrates one embodiment of a precordial device of the invention comprising an oxygen saturation device;

Figure 9 illustrates one embodiment of a precordial device of the invention comprising an apical heartbeat device;

Figure 10 illustrates one embodiment of a precordial device of the invention comprising a temperature sensor;

Figure 11 illustrates one embodiment of a precordial device of the invention comprising a percussion hammer;

Figure 12 illustrates one embodiment of a precordial device of the invention comprising a conductive substance dispenser;

Figure 13 illustrates one embodiment of a precordial device of the invention comprising a sub clavicular pad;

Figure 14 illustrates one embodiment of a precordial device of the invention comprising an ICG (impedance cardiograph) measuring device;

Figure 15 illustrates one embodiment of a precordial device of the invention comprising an ICG (impedance cardiograph) measuring device;

Figure 16 illustrates an ECG diagnostic pad of the prior art;

Figure 17 illustrates an ECG belt of the prior art;

Figure 18 illustrates a sternum (breastbone) of an adult;

Figure 19 illustrates a suprasternal notch of an adult;

Figure 20 illustrates one embodiment of a precordial device of the invention;

Figure 21 illustrates one embodiment of a precordial device of the invention;

Figure 22 illustrates one embodiment of a precordial device of the invention;

Figure 23 illustrates one embodiment of a precordial device of the invention; and

Figure 24 illustrates a cross section of one example of the precordial device.
DETAILED DESCRIPTION

Additional advantages and novel features of the invention will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art upon examination of the following and accompanying drawings or may be learned by practice of the invention.

A precordial device is configured so that it can be accurately placed onto a patient's chest by an unskilled user, such that the precordial device is placed at a constant position on the patient's chest every time.

Figure 18 illustrates a sternum (breastbone) of an adult. It is known that the length of the sternum in all adults is approximately the same (±10mm longer or shorter), since the length of the sternum is not affected much by the height of the adult.

Children and babies sternums are not the same size. Therefore, it is possible to provide a precordial device where the x, y, and z axis can be altered in a "dynamic one change mechanism". In addition, the device needed for newborn babies only has 3 lead ECG (not 12 leads) and 4 stethoscopes, it is a much smaller version and is typically used to monitor heart speed and rhythm, to screen heart sounds and ECG rhythm and to synchronise the latter two with each other. For older children there is typically no need to do 12 lead ECG tests except once they reach adulthood. For these children a larger version than the version for newborns or a smaller version than the version for adults with different sizes depending on the length and age of the patient can be manufactured.

Figure 19 illustrates the suprasternal notch, also known as the jugular notch, which is the large visible dip where the neck joins the sternum, located at the top of the sternum in all humans. A precordial device 16 of the invention is configured to comprise a sternal notch alignment point or portion 11, as illustrated in figures 1A and 18. The sternal notch alignment point 11 is a part of the precordial device which is shaped so that it can be aligned easily with the suprasternal notch of an adult. This shape is variable and can be made to accommodate the users own preference.
A precordial device 16 of the invention also comprises at least one measurement device. This measurement device is attached to the interior or exterior surface of the precordial device 16, such that the at least one measurement device may be in contact with the patients skin, when the precordial device 16 is in use.

Figures 1B illustrates an interior surface of the precordial device 16 illustrated in figure 1A. As illustrated in figure 1B, the measurement device comprises an ECG device and stethoscope chest piece devices. The ECG device comprises ten ECG sensors, ECG Lead V1 1; ECG Lead V2 2; ECG Lead V3 3; ECG Lead V4 4; ECG Lead V5 5; ECG Lead V6 6; ECG Lead Right Arm 7; ECG Lead Left Arm 8; ECG Lead Left Foot 9; and ECG Lead Right Foot 10. The stethoscope chest piece device comprises four stethoscope chest piece sensors, an Aortic area sensor 12; a Pulmonary area sensor 13; a Tricuspid area sensor 14; and a Mitral area sensor 15. Although figure 1B illustrates the measurement device comprising an ECG device 25 and a stethoscope chest piece device, the measurement device may be any measurement device, such as, only an ECG device; only a stethoscope chest piece device; only a temperature sensing device; only an accelerometer device; only a oxygen saturation device; only an ICG device etc; or any combination thereof.

As stated above, the sternal notch alignment point 11 can be aligned easily with the suprasternal notch of an adult. When the sternal notch alignment point 11 of the precordial device 16 is aligned with the suprasternal notch of a patient the precordial device 16 is correctly positioned on the patients chest and repeatability can be ensured, as illustrated in figure 1A. Since it is known where the sternal notch alignment point 11 of the precordial device will be positioned relative to a patients chest, it is possible to determine the correct position of any sensor of the least one measurement device of the precordial device 16 in relation to the sternal notch alignment point 11. The position of any sensor of the least one measurement device of the precordial device 16 has a constant positional relationship to the sternal notch alignment point 11.

The precordial device is correctly positioned on the patients chest when the sensor(s) 10 of the at least one measurement device are positioned on the patients chest such that accurate and consistent measurements can be obtained.
Instead of indexing by means of visual aligning the sternal notch with the precordial device's sternal notch indicator, an extrusion index point or pointers can also be used to be placed superior of the sternal notch in the hollow area between the medial heads of the clavicles as indicated in figures 20 and 21. This indicator can for instance be a ball as indicated by point 2001. This indicator can also be a laser pointing device.

In another embodiment the superior-inferior height can be changed by some electronic mechanical means for instance by one or more linear actuators 2202 and 2203 depending on the anthropometric height of the sternum. This change in height can also be done by adjusting the superior and inferior halves of the device physically by pushing the two pieces together or pulling them apart or by turning a knob on the device that will pull and push the top and bottom portions apart and together.

In another embodiment, the medio-lateral distance can also be changed in the same manner as their superior-inferior height can be changed.

In another embodiment the device either can be rigid (made out of ABS available from 3M) of or semi flexible (made out of flexible PC boards for instance). If the device is rigid then there might be certain moving part on the device like electrodes that can protrude depending on the distance from the skin or stethoscopes that can swivel in any direction and move to and from the skin of the precordium, so as to make good contact with the skin and it does not matter the angle of the skin or how far the skin is from the stethoscope when the precordial device is applied to the precordium. In a rigid device there might be hinges as demonstrated by 2301 in Figure 23 whereby piece 2302 and 2303 forms part of the precordial device, but is connected via a hinge.

In another embodiment as demonstrated in Figure 23 some of the sensor points (mainly electrodes and accelerometers) can be attached to the precordial device (16) main body via blade springs (2304 and 2306 as examples). These springs can be manufactured out of steel or ABS plastics. Flexible PC boards or cables can run with these blade springs towards the tip of the spring where the sensors will be situated (2305). These springs ensures better contact with the skin in a variety of patient sizes.
Suction tips can be attached to the distal ends of the blade springs that will ensure that the distal ends are sucked to the skin of the precordium.

In another embodiment, sensors can be attached to the device with a cable and the sensors will then be stuck onto the patient. A good example is the Left leg ECG lead where the electrode can be stuck onto the left hip and a wire connects the electrode to the main device.

In another embodiment a blade spring 2307 (or any other sensor placed on a blade spring) can slide in and out so as to increase the length of the blade and effectively the position of the sensor where it touches the skin of the patient. This will typically be the situation with blade 2307 that represents ECG lead V6. The position of V6 must typically be mid-axillary and depending on the size of the patient this can change and the position can electronically be recorded so as to ensure the same position the next time the patient is tested. With an accelerometer / inclinometer on the tip of this sensor and the patient lying on his back, one can electronically determine whether the sensor touches the skin vertical to the horizontal of the earth. This helps with compliance so that a caregiver interpreting the results in a telemedical environment can be sure that V6 was positioned correctly. The caregiver can also be prompted to position V6 later.

Figure 2 illustrates the position 1601 at which a stethoscope chest piece sensor must be arranged in order to detect the Aortic valve sounds; the position 1602 at which a stethoscope chest piece sensor must be arranged in order to detect the Pulmonary valve sounds; the position 1603 at which a stethoscope chest piece sensor must be arranged in order to detect the Tricuspid valve sounds; and the position 1604 at which a stethoscope chest piece sensor must be arranged in order to detect the Mitral valve sounds. Figure 2 also illustrates the actual position 1601A of the Aortic valve; the actual position 1602A of the Pulmonary valve; the actual position 1603A of the Tricuspid valve; and the actual position 1604A of the Mitral valve on the precordium.

As can be seen in figure 2, the Aortic valve sensor 12, must be positioned between the second and third rib, in the second intercostal space to the right of the sternum. The Pulmonary valve sensor 13, must be positioned between the second and
third rib, in the second intercostal space, to the left of the sternum. The Tricuspid valve sensor 14, must be positioned between the fifth and sixth rib, in the fifth intercostal space, to the left of the sternum. The Mitral valve sensor 15 must be positioned between the fifth and sixth rib, in the fifth intercostal space, to the left of the sternum at the heart's apex (midclavicular line). These are only example positions. Stethoscopes might be arranged differently.

Therefore, when the sternal notch alignment point 11 of a precordial device 16 comprising a stethoscope chest piece device is aligned with the suprasternal notch of a patient, the Aortic valve sensor 12 is at position 1601, the Pulmonary valve sensor 13 is at position 1602, the Tricuspid valve sensor 14 is at position 1603, and the Mitral valve 15 sensor 15 is at position 1604.

Since a precordial device 16 of the invention can be correctly positioned on the patients chest such that the sensor(s) of the at least one measurement device are positioned accurately, it is possible to easily and repeatedly position a precordial device 16 of the invention in the same place on a patients chest. Consequently, measurements obtained from the at least one measurement device are always taken at the same position relative to the patient chest. Therefore, better comparisons can be made between tests taken at different times on the same patient.

Furthermore, even if the positioning of the sensor differs between patients, due to the minimal size differences in sternum length, the sensor(s) will always be arranged at constant positions for each patient so that recordings made at different dates can be compared with each other.

As illustrated in figure 1B a precordial device 16 of the invention comprises a plurality of ECG sensors (electrodes) strategically placed to touch the precordial thorax skin of a patient in order to perform a full twelve lead ECG test. Lead aVf is the difference between Right Arm grounded with Left arm compared with Left leg — the same counts for Leads aVL, aVR, aVf. Lead I is the difference between Right Arm and Left Arm lead — thus 6 derivatives from 3 points plus the added V1-V6 = 12 — thus 9 physical leads (plus the active ground electrode on the right leg) — 10, but 12 lead results. In an examination situation where a user just wants to do a quick spot
check of the current state of a patient's cardiovascular status a precordial device 16 of the invention is ideal. In one embodiment, there is only one single wire connecting the precordial device 16 to a computer for recording and analysing the data measured by the ECG sensors. In another embodiment, the precordial device 16 is able to communicate wirelessly with a computer or the computer with a human interface component may reside within the device itself. Consequently, minimal skills are necessary in order to use the precordial device 16 of the invention successfully in order to obtain accurate measurements. In another embodiment the data can be displayed directly on a screen that forms part of the precordial device. If the device is battery driven then there will be no wires to be connected with the precordial device when a measurement is taken.

In one embodiment, the ECG Lead Right Arm 7 and the ECG Lead Left Arm 8 can also be positioned more lateral and/or superior. In addition, the ECG Lead Left Foot 9 can be positioned more medial and inferior, and the ECG Lead Right Foot 10 can be positioned more lateral or inferior.

A precordial device 16 of the invention may encounter problems if a Stethoscope sensor is to be positioned over an area where an ECG sensor needs to contact the patient. In order to overcome this problem, an electrode connection point is built into the diaphragm of the stethoscope sensor. The ECG sensor is then electrically connected to the electrode connection point which is built into the diaphragm of the stethoscope sensor. This arrangement is disclosed in British Patent Application No. 061 681 8.1.

Furthermore will the ambient microphones as described in the above British patent also be positioned to measure ambient sound noise.

In another embodiment of the invention, it is possible to filter out any noise created by movement of the patient and/or any noise created by the positioning of the precordial device 16 by the user as he holds it. In one embodiment as illustrated in figure 3, a foam 201 is provided on the exterior surface of the precordial device 16 where the user puts his hand 202 to press the precordial device 16 against the patient's chest. The foam must be of a type which is able to absorb typical user movement
(below 50 10 Hz) effectively. An example of such foam is QUASH FR2000 (sound management foam) or Soundseal available from Sondor in South Africa (www.sondor.cc.zb). Silicone gel products can also be used.

In another example illustrated in figures 4A and 4B, a handle 301 having low frequency (0.1 Hz - 50Hz) noise/movement absorbing properties is provided on the exterior surface of the precordial device 16. An example of such a handle 301 is a solid piece of material (such as ABS plastic, GE Plastics, ComAlloy) formed so that the user can comfortably hold the precordial device 16. The handle 301 is fixed to the precordial device 16 by means of a layer of noise absorbing foam 303 that absorbs low frequency noise generated by movement of the user or patient. The foam may be of the same material as the foam used with reference to figure 3.

In a further embodiment, the handle 301 has built in shock absorbing properties so as to filter out the low frequency noise created by tremors from the user or any other movement caused by the user.

In another embodiment, the precordial device comprises a sensor capable of monitoring and recording any movement of the user holding the device, i.e. tremors and/or any movement of the patient, i.e. shivering. An accelerometer sensor may be used to detect the user and/or patient movement, as described in more detail below with reference to figure 6. User and/or patient movement produces noise which can affect the accuracy of the measurements obtained by the measurement device, such as a stethoscope chest piece device, an ICG device, an ECG device, an apical impulse sensor, a sternal heave sensor or an Oxygen Saturation device.

In a telemedicine environment, a doctor/nurse may be remote from the patient when the precordial device 16 of the invention is used by an unskilled user in order to obtain and record measurements, which are then sent to the doctor/nurse for examination and interpretation. When the doctor/nurse examines the measurements they are not aware of the environment in which the measurements were taken and therefore are not aware whether the measurement are subject to noise. Since the precordial device 16 of the invention is capable of monitoring and recording movement noise, the doctor/nurse is also provided with an indication of the quality of the recording.
Figure 5 illustrates the internal surface of a precordial device 16 of the invention 15 comprising only a stethoscope chest piece device. The stethoscope chest piece device comprises stethoscope sensors 501 to 510. Stethoscope sensor 501 is arranged to listen to tracheal sounds; stethoscope sensor 502 is arranged to listen to Aortic valve sounds; stethoscope sensor 503 is arranged to listen to Pulmonary valve sounds; stethoscope sensor 504 is arranged to listen to other heart sounds; stethoscope sensor 505 is arranged to listen to Tricuspid valve sounds; stethoscope sensor 506 is arranged to listen to Mitral valve sounds; stethoscope sensor 507 is arranged to listen to basal respiratory sounds; stethoscope sensor 508 is arranged to listen to abdominal sounds; stethoscope sensor 509 is arranged to listen to Carotid artery sounds on the left side of the neck; and stethoscope sensor 510 is arranged to listen to Carotid artery sounds on the right side of the neck.

A precordial device 16 of the invention enables a plurality of heart sounds, lung sounds and abdominal sounds to be measured and recorded at the same time. Therefore, a more accurate sound analysis of a patient's heart can be gained, such that different heart sounds can be synchronised or compared with each other in the same time domain and spatial comparative analysis can indicate spatial location of certain identified sounds. When these sounds are synchronised with the ECG for instance these results can identify ejection times. When the sounds are for instance synchronized with an ICG, a better determination of valve closure time can be established that will increase the accuracy of ICG stroke volume calculations.

Figure 6 illustrates a precordial device 16 of the invention wherein the measurement device is an accelerometer device. The accelerometer device comprises of any multiples of one/two/three axis accelerometers, in this example four three-axis accelerometer sensors 601, 602, 603 and 604. The accelerometer sensor 601 is a superior sternal accelerometer sensor; the accelerometer sensor 602 is an inferior sternal accelerometer sensor; the accelerometer sensor 603 is a lateral chest accelerometer sensor and the accelerometer sensor 604 is an abdominal accelerometer sensor. However, any amount of accelerometer sensors can be placed at any desired positions in the precordial device 16.
The accelerometer sensors 601 to 604 may be any known accelerometer sensor, such as the ADXL320 dual axis accelerometer available from Analog Devices, Inc.; a three axis sensor or MMA7260QT (Freescale) or SCA3000-E01 3-AXIS ultra low power accelerometer with digital SPI interface (VTI Technologies) or SCA6IT inclinometer series (VTI Technologies).

The accelerometer device can be used to measure and record user movement and tremors by analysing the acceleration changes in any of the accelerometer sensors 601 to 604 and/or by comparing the relative angle changes between the accelerometer sensor 602 and the accelerometer sensor 603, or by comparing the relative angle changes between the accelerometer sensor 602 and the accelerometer sensor 604. These movements will typically be in the range of 0.1 Hz to 50Hz.

The accelerometer device can also be used to measure and record patient movement and tremors by analysing any deviations of the same nature, in all the accelerometer sensors in the same time domain 601 to 604.

The accelerometer device can also be used to measure and record a patients breathing rate and inhalation and exhalation breathing curve by comparing the relative changes in angle in the breathing rate frequency range (10Hz to 60Hz) between the accelerometer sensor 602 and the accelerometer sensor 603. A short inspiration with a long expiration of a patient's inhalation and exhalation breathing curve indicates that the patient has asthma as a point of illustration.

The accelerometer device can also be used to estimate a patient's chest circumference by comparing the relative average angle over time between the accelerometer sensor 602 and the accelerometer sensor 603. The difference between inhaled and exhaled circumference can also be derived. By knowing the angle between the most lateral part of the precordial device 16 and the pre-sternal portion of the precordial device 16 together with knowledge of anthropometry (ethnic, age and gender) combined with empirical studies still to be undertaken it is possible to calculate the circumference of the chest. A more accurate empirical method will be described later with the gel embodiment.
Precordial device 16 can also extend superior towards the neck with the accelerometers touching the antero-lateral portion of the neck. These extensions can be used to measure movement of the skin over the carotid artery and vein and typical acv-waves over the jugular vein area can be measured and plotted. These waves are specifically relevant if compared to the other parameters the precordial device can record in the time domain.

The accelerometer device can also be used to measure and record a patients abdominal breathing rate and abdominal inhalation and exhalation breathing curve by comparing the relative changes in angle in the breathing rate frequency range (10Hz to 60Hz) between the accelerometer sensor 602 and the accelerometer sensor 604.

The accelerometer device can also be used to indicate the relationship between chest and abdominal breathing by comparing the amplitude of chest breathing with the amplitude of abdominal breathing.

The accelerometer device can also be used to measure and record a patients roll to left and right angle and patients sifting up inclination angle. The average angle to the horizontal plane in the accelerometer sensor 601 and the accelerometer sensor 602 will indicate the angle at which the patient is tilted sideways as well as the patient's anterior-posterior inclination. An inclinometer can also be used to determine these properties.

It is important to determine the position of the patient i.e. whether the patient is supine, sitting up, lying on his side or bending forward since the position information is needed to evaluate ECG, ICG, apical heartbeat recordings, sternal heave recordings and stethoscope measurements objectively. In the telemedicine set-up where the interpreter can not see the patient, or in the situation where recordings are done and interpreted at a later stage, the interpreter must have an idea of the position of the patient in order to properly interpret the results.
The accelerometer device can also be used to measure and record a patient's sternal heave by measuring the amplitude changes in the accelerometer sensor 602 at a frequency equal to the heart rate (as determined by analysing an ECG device measurements). A sternal heave is an abnormal, sustained outward movement of the precordium and is indicative of abnormal heart functionality and typically an abnormal right ventricle.

The accelerometer device can also be used to measure and record the effectiveness of external cardiac massage by measuring and analysing the dramatic amplitude changes in the accelerometer sensor 602 during external cardiac massage. The person performing the cardiac massage can get feedback on how regular, at what rate and at what amplitude he is massaging the heart. The external cardiac massage is performed by doing compressions directly on the precordial device 16 of the invention. The accelerometer devices (Comparing 602 with 603 and 604) can also give an indication of how effective a patient is ventilated and the person performing the ventilation can get feedback on how regular, at what rate and at what amplitude he is ventilating the patient. The ventilation is performed by blowing air into the lungs by means of mouth to mouth / mouth to nose ventilation techniques or by means of standard Ambubag® / ventilator medical techniques.

The accelerometer in 602 or 601 can also be used to sense whether the precordial device is aligned vertically to the horizontal in a patient in an erect or semi-erect position. This acts as an indicator whether the precordial device has been placed compliantly onto the precordium of the test subject.

Figure 7 illustrates a precordial device 16 of the invention comprising 8 ECG sensors 1 to 6, 8 and 10, four stethoscope chest piece sensors 12 to 15 and two pads 701 and 702. The pads 701 and 702 are for both defibrillation and external cardiac pacing. Pad 701 is positioned just below the right clavicle and pad 702 is an Apical pad. Pad 701 can extend to cover a larger surface area including the area over stethoscope 12. A method of how these pads and the stethoscope can share the same surface area will be described later in this document. Sharing of surface area also applies to the pad 702 whereby pad 702 can extend over the surface area of stethoscope 15. A
healthcare professional can then defibrillate the patient from remote or even do external cardiac pacing from remote if the need arises.

Drugs can be administrated by the precordial device in different ways. One way is by administering drugs transcutaneous for instance the device can pump nitro-glycerine onto the skin of the patient that can be absorbed to relief angina pain. Furthermore can syringes be included in the device with for instance standard drugs for resuscitation i.e. Adrenaline (Efedrine), Atropine, Propranolol and others that can be administered subcutaneously, intravascular in the neck into the jugular vein and carotid artery, or directly to the venae cavae or aorta for example, or even intra ventricular. These drugs can then be administrated from remote by a healthcare professional where the patient is waiting for emergency response healthcare professionals to arrive and especially in the circumstances where no professional will arrive as is the case in underdeveloped countries where the shortage of doctors is vast.

Figure 8 illustrates two embodiments of the precordial device 16 of the invention comprising an oxygen saturation device. Oxygen saturation is an essential parameter in evaluating the functionality of the heart and lungs.

The oxygen saturation device comprises light emitting diodes (LEDs) 801 and light receivers 802. In the first embodiment, the oxygen saturation sensor is connected to the precordial device 16, such that when the precordial device is positioned on a patient the oxygen saturation of the patient can be determined. The oxygen saturation sensor is positioned between the precordial device 16 and the skin of the patient. The oxygen saturation sensor can either be positioned near the sternal notch alignment point 11 such as the oxygen saturation sensor 805, or positioned to the lower left hand side of the precordial device 16, such as the oxygen saturation sensor 807. Only one oxygen saturation sensor is required. A second, third or fourth sensor(s) can be added to increase the compliance whereby the recordings and results of both sensors can be compared with each other and as long as they display the same result within a percentage margin (+/- 1% suggested) the user can be sure to trust the oxygen saturation recording results. The cumulative results can also be used to determine more accurate average oxygen saturation.
In the second embodiment, the oxygen saturation sensor may be a separate oxygen saturation sensor 803 that can be affixed to the skin of the patient, such as with glue, and connected to the precordial device 16 of the invention with wires or even a standard earlobe probe or finger probe or forehead probe or ear channel probe placed with these probes are intended to be placed with the wire or wires being connected to the precordial device 16. These devices can of course also communicate wirelessly with the electronics inside the precordial device.

Light emitters 801 of the different wavelengths that current oxygen saturation probes use (typically about 910 nm and 670 nm) are positioned spread out in a circular fashion around a light receiver 802. The light receiver 802 will be centred in the middle of this circle. Whenever a precordial device 16 of the invention is placed on a patient's chest the light of the emitters 801 will be reflected back by the ribs or sternum. There will always be a rib or the sternum underneath an emitter 801 as long as the radius of the circle of light emitters is more than 20mm in adults. This is specifically relevant to precordial devices fixed to the chest without much movement like a precordial device fixed to a patient's chest while having anaesthesia, to monitor the cardiac functions under anaesthesia and at the same time monitoring the oxygen saturation. This circular fashion of emitters also ensures a higher degree of light that can reach the receiver though the means of diffraction as well as reflectance from cellular and other tissue walls meaning that a large physical structure like a rib or sternum is not needed to reflect the light back to the receiver.

Figure 9 illustrates the precordial device 16 of the invention comprising an apical impulse measuring device 901. The apical impulse is the maximum impulse that a heart generates and is typically visible and palpable over the area of the fourth to sixth ribs to the left of the sternum, in the mid clavicular line. Consequently, the apical impulse sensor device 901 is positioned to the lower left hand side of the precordial device 16. Preferably, the patient is lying on his left side when the apical impulse is measured.

The apical impulse sensor 901 may be a sensor, such as that disclosed in British Patent Application No. 061 681 8.1.
In one embodiment the apical impulse sensor 901 is a semi-curved object that follows the contour of the precordium with a grid of pressure sensors on the precordial side of this semi-curved object. The apical impulse sensor 901 must have the ability to deform slightly so that it can more closely follow the curvature of the chest of the patient. The apical impulse sensor 901 is positioned over the area of the fourth to sixth ribs to the left of the sternum, in the mid clavicular line, such that the sensors pick up the pressure changes (typically 0.2Hz to 20Hz) of the apical heart beat/thump that gets transmitted through the skin to the sensor 901. The detected pressure changes can then be recorded and evaluated digitally.

In another embodiment the apical impulse sensor 901 is a grid of accelerometers in 1, 2 or 3 dimensions. The apical impulse sensor 901 is positioned over the area of the fourth to sixth ribs to the left of the sternum, in the mid clavicular line, such that the sensors measure the acceleration changes over the area of the fourth to sixth ribs.

In another embodiment, the pressure sensors, all accelerometers, can reside on the skin interior surface of a thick soft silicone gel or a bag filled with air or a bag filled with fluid (preferably a high viscous fluid).

In a further embodiment, the apical impulse sensor 901 is positioned over the apex of the heart. A method how stethoscopes and accelerometers can share the same "real estate" / surface area will be described later.

The apical impulse can also produce disturbances on ECG due to movement of the electrodes touching the skin (especially in lead V4 and V5). A high amplitude apical impulse will be able to pick up the reason for noise to the ECG recorder and will help the user to know he has compliant ECG data results.

The measured apical impulse can be used to interpret the size and functionality of the left ventricle of the heart. Some heart diseases cause the left ventricular hypertrophy dilatation or both. In these cases the apical impulse is displaced laterally and inferiorly and sustained and it may be shifted to the left and upward in right ventricular hypertrophy, dilatation or both. Pneumothorax and pleural effusion will
displace the apical impulse to the normal side. Pleural-adhesion and atelectasis will result in a displacement of impulse toward the diseased side. The apical impulse also can be displaced by large mass, massive ascites. The apical impulse may have increased amplitude and duration in those persons with a thin chest, anemia, fever, hyperthyroidism and anxiety. In CHF, myocarditis and myocardiopathy the intensity of the apical heartbeat is decreased and this can especially be picked up when by regular precordial device examinations. In Massive pericardial effusion the apical impulse will disappear. In Left Ventricular Hypertrophia the apical impulse will be a forceful lift through systole with greater amplitude and more than 2cm in diameter.

These impulse measuring sensors can also be placed all over the patient surface of the precordial device so as to pick up other abnormal impulses. These might include the following: Right ventricular hypertrophy (RVH). The impulse is clearly seen in left third fourth intercostal space. In ascending or arch aortic aneurysm, one may detect abnormal pulsations in the aortic area, with bulging or pulsation in systole. Pulmonary hypertension with dilatation the pulsation in systole may be detected in left second intercostal space to the edge of sternum.

These impulse sensors can also record frequencies lower than 20Hz to 50Hz. Thrills are palpable murmurs somewhat similar to the sensation on the throat of a purring cat. Thrills are actually palpable fine vibrations, most commonly produced by blood from one chamber of the heart to another through a restricted or narrowed orifice, it may occur in systole, diastole, pre-systole and at times may be continuous. The lowest effective frequency to listen to though an electronic stethoscope is typically 20Hz or even higher. Any lower frequencies are typically more easily palpable with the hand than heard listening to then with a stethoscope. Accelerometers that are more effective in frequency range of thrills will pick up the above said thrills better than a typical electronic stethoscope.

In a further embodiment of the invention (not illustrated) multiple contact temperature sensors can be positioned at different positions on the precordial device 16 of the invention, such that the temperature sensors are positioned between the skin of the patient and the precordial device 16, touching the skin of the patient so as to measure the local skin temperature of the patient at a any locality between the
precordial device and the skin of the patient. In another embodiment (not illustrated) temperature sensors are provided on the outer surface side of the precardial device 16 of the invention such that the temperature sensors can measure the ambient temperature.

The temperature sensors may be either infrared sensor or a contact sensor. In one example, the temperature sensors are an insulated lead interchangeable chip thermistors available from General Electric, Melexis Integrated Systems and the like.

Figure 11 illustrates a further embodiment of the invention wherein a percussion hammer is provided on the precardial device 16 of the invention. 1101 indicates the rubber part of the percussion hammer provided to be in contact with the patients skin, 1102 illustrates the moving part of the solenoid that hits the rubber part of the percussion hammer and 1103 indicates the solenoid fixed to the precardial device 16 of the invention.

A percussion hammer can excite the sternum, by hitting the patient's chest to produce a sound that is transmitted into the chest. By listening to the sound generated, the interpreter (doctor/nurse) can get an indication of the size of the heart and whether the patient has lung diseases.

Although figure 11 only illustrates one percussion hammer, the precardial device 16 of the inventions can be provided with multiple percussion hammers. For example, the precardial device 16 may comprise a series of percussion hammers as indicated by 1002 in Figure 10 placed in a row from the sternum on the precardial device 16 towards the left. By alternately causing each percussion hammer to excite the sternum, the size of the heart can be determined. An interpreter (healthcare professional) does this by listening to the produced sounds using an electronic stethoscope that forms part of the precardial device 16. A change in dullness between two percussion hammers next to each other will indicate the lateral left wall position of the heart, for example. Hammers can be placed at any position on 16 so as to determine the size of the heart as typically percussed by a healthcare professional to determine the dullness borders of the heart and aorta.
Preferably, the rubber part 1101 of the percussion hammer is a rubber, such as a Silicon Rubber, Tire Rubber or Natural Rubber which in use is pressed against the patients chest. The solenoids are known solenoids and can be sourced from Bicron Electronics Company or Trombetta Motion Technologies.

Many other percussion devices can be described, e.g. devices with hammers that are spring-loaded that the user triggers or the user may even tap are in an area to produce percussion sounds.

By attaching an accelerometer to the hammer of the percussion device, one can monitor the speed at which the accelerometer moves and hits the rubber part and one can also determine the movement of the rubber part after the hammer hit the rubber part and continues to move with the rubber part in the direction of the force applied. One can also attach an accelerometer to the rubber part of the percussion device to determine the impact movement. One can also attach a pressure sensor between the rubber part and the skin of the precordium to determine that adequate pressure has been applied to the skin and precordium before the hammer hits the rubber part. One can thus determine whether the percussion device compliantly within normal limits exercised the correct energy and nature of energy into the patient.

Instead of using an accelerometer a bone vibrator can also be applied to the precordium. A bone vibrator has the benefit that it can excite pure tones, pure tone sweeps as well as noise to the precordium. A pressure sensor can be placed between the bone vibrator and the skin of the precordium so as to measure whether adequate pressure has been applied to the precordium. A bone vibrator has the added benefit that it can excite different amplitudes compliantly that will increase the diagnostic capacity as stethoscope sound recordings over the precordium. An example of such a bone vibrator described is the bone vibrator used in audiology to determine bone conduction hearing levels. RadioEar, a USA based company, and the like manufactures such bone vibrator devices.

In another embodiment of the invention at least one pressure sensor can be provided on the precordial device 16 in order to measure the pressure and the
distribution of pressure between the precordial device 16 and the patient. A feedback as to the measured pressure can then be given to the user so that he can change the pressure he is applying to press the precordial device 16 against the patient. For example, if the pressure of the Mitral valve stethoscope sensor 15 against the patient is not adequate, then results of that stethoscope sensor 15 can not be trusted. The same will apply to the oxygen saturation sensors, ECG electrodes and others.

In another embodiment, the user is informed whether or not all the pressure sensors touch 25 the patient. The measured pressure applied to the precordial device 16 and the pressure distribution will indicate to the user whether he is holding and pressing the precordial device 16 in a compliant manner, so that he can change the pressure he is applying to press the precordial device 16 against the patient if required. For example, if the pressure of the Mitral valve stethoscope sensor 15 against the patient is not adequate, then the user may be informed and can re-adjust how he is holding the precordial device.

In another embodiment, the pressure sensors form part of the measuring devices. For example, the pressure sensors form part of the stethoscope sensors.

In one embodiment, a precordial device 16 of the invention has a built in hub for other medical devices and other peripheral devices to plug into i.e. a non-invasive blood pressure (NIBP) machine, an external thermometer or an external pulse oxygen saturation meter. This hub ensures communication between different sensors inside the precordial device 16 as well as to any device or computer the precordial device 16 connects to i.e. a personal computer. This functionality is needed because some devices might need input from other devices in order to perform calculations, for example the NIBP (non-invasive blood pressure) results are required by the ICG in order to calculate the cardiac index. In one embodiment, the precordial device comprises a USB hub part into which a NIBP machine can be connected. However, a hub for USB, Serial connectivity, FireWire or a wireless hub may be utilised.

Figure 12 illustrate a precordial device 16 of the invention comprising a conductive substance dispenser, such as an electrode gel, saline water or any other conductive substance. The conductive substance dispenser comprises an enlarged
electrode 1201 (1202 is a cross section of the enlarge electrode 1201). As can be seen from the cross section 1202 of the enlarged electrode 1201, the electrode 1201 comprises a hole 1203 and a tube 1204 from which the conductive substance is dispensed.

A reservoir (not illustrated) is used to store the conductive substance. The reservoir is connected to the tube 1204 and thus the electrode hole 1203 either directly or via another tube. The conductive substance may be dispensed from the reservoir, through the hole 1203 exiting the electrode 1201, by any known means, such as by compression of a bag (the reservoir) filled with the conductive substance, or a pump on the tube going from the reservoir to the electrode 1201. Consequently, the precordial device 16 of the invention will with the push of a button or automatically by means of mechatronic components, dispense the correct volume of conductive substance through a hole 1203 in the electrode to the correct point where it will be needed.

In a further embodiment of the invention, a disposable cover is provided with the precordial device. The disposable cover is manufactured out of different materials so that some areas of the disposable cover are conductive (so as to propagate electrical properties of the skin to the sensors directly lying underneath the disposable cover) and some areas of the disposable cover are not conductive. Furthermore, some areas of the disposable cover are provided with adhesive glue properties to stick to the skin of the patient. In addition, some areas of the disposable cover are provided with a conductive substance (a fluid or gel).

The disposable cover shields the patient from the precordial device in order to help prevent cross contamination between different patients.

Figure 13 illustrates one embodiment of the precordial device 16 of the invention comprising a sub-clavicular pad 1301 for defibrillation, external pacemaking and a right arm lead for the ECG; a gel or fluid filled bag 1302 to decrease the noise to the stethoscope sensors due to scratching; a window 1304 that allows light to travel though the precordial device, the light having a frequency in the range of 650 nm to 950 nm; an ECG sensor 1305 covered with a dry gel; a high temperature conductive area 1306; an apical pad 1307; and a disposable sheet 1308.
Preferably, the gel 1302 is a dry gel primarily composed of cross linked synthetic polymers or interpolymer matrixes, or is a wet gel. The window 1304 may be, for example manufactured from plastic such as Lexan™ or any other polycarbonate. The high temperature conductive area 1306 is a very thin layer of any plastic resin manufactured out of biodegradable plastic resins such as polylactic acid polymers. Finally, the disposable sheet 1308 is provided with holes where the electrodes from the precordial device 16 must make contact with the conductive gels for the electrode pads.

Figures 14 and 15 illustrate a precordial device 16 of the invention comprising an ICG (impedance cardiograph) measuring device and having two neck potions. The ICG measuring device comprises a left neck top ICG sensor (electrode) 1401; a left neck bottom ICG sensor 1402; a right neck top ICG sensor 1403; a right neck bottom ICG sensor 1404; a left thorax top ICG sensor 1405; a left thorax bottom ICG sensor 1406; a right thorax top ICG sensor 1407; and a right thorax bottom ICG sensor 1408. The distance between the centre of the ICG sensors 1401 and 1402 will be the same as the distance between the centre of the ICG sensors 1403 and 1404, the 5 centre of the ICG sensors 1405 and 1406, and the centre of the ICG sensors 1407 and 1408. This distance is typically 0mm to 60mm. The distance is constant for all paired points.

Technically electronically there is no reason for the points that are close apart from each other to be two separate points. The same data can be recorded if these points are the same point thus reducing the total points to half. Furthermore must it be realised that these electrode points can be positioned anywhere on the patient side of the precordial device 16. The superior 4 electrodes can with all likelihood be replaced with only one electrode that touches the skin just superior of the sternum or just inferior to the sternal notch. Electrode points 1407 & 1405 can be one long electrode from point 1407 to point 1405 in a semi-circular fashion touching the patient's skin.

An ICG measuring device is used to measure the beat-to-beat changes of thoracic bio impedance via the sensors 1401 to 1408 applied to the neck and thorax of a patient in order to calculate the stroke volume (SV) of the heart for instance.
The electrodes which function as the ICG sensors illustrated in figure 14 can also function as ECG sensors in order to determine ICG and ECG measurements. For example, the electrode 1408 used to detect ICG may also function as the electrode 6 used to detect ECG in figure 1. Furthermore, the electrode 1406 used to detect ICG may also reside on the diaphragm of a stethoscope sensor so that basal lung sounds can be measured. Furthermore, the electrode 1406 used to detect ICG may also have self dispensing functionality of a conductive substance.

In another embodiment the patient side of the precordial device can be fully or partly covered with a gel like substance for example a Silicone based gel or a unknown molecular structure gel as manufactured by Trulife in Ireland at a thickness of for example 20mm. Fluid filled bags instead of gel as described above will also suffice. A liquid with a high viscosity will be ideal because it will not be prone to bouncing impulses (waves) as when low viscous fluids are used with resulting less noise impulses. This gel of fluid can be covered with a thin stretchable plastic layer membrane so as to prevent direct contact of the gel with the patient or to contain the fluid. It might be appropriate rather for the gel to stick to the patient's skin especially in single use devices or single user devices like were a patient might have his own device at home because of the risk of cross contamination. This gel / fluid will ensure a pliable inner layer of the embodiment 16 that will take on the contours of the chest wall to some extreme limits. In this instance the stethoscopes will not directly touch the skin of the patient but will rather touch the gel. Some degree of attenuation of stethoscope sounds will take place but because the gel is a good conductor of sound, this is minimal and anyway constant if comparing results on the same person and thus the amplitude can be amplified to calibrated standards. The surface of the gel touching the patient can have attached to it different electrodes, pads and other sensors described earlier. These electrodes can include ECG and ICG electrodes and the pads can be defibrillation pads. Dry electrodes and dry defibrillation pads are the preferred electrodes for this type of embodiment described (available from 'Fraunhofer Institute Biomedizinische Technik'). The wires to these electrodes can run inside the gel or on the outside of the gel. Furthermore can thermometers, oxygen saturation light emitters and receivers as well as accelerometers be attached to the outside of the membrane closest to the skin or just on the inside so as to come in close contact with the skin of
the patient. These electronic parts can be fitted on flexible PC-boards with minimal weight so as to pick up impulses as well as to let sound past them to be propagated to the stethoscopes. The embodiment described above ensures that electrodes, pads, accelerometers, thermometers and oxygen saturation meters can share the same surface area space as the stethoscopes. Accelerometers placed everywhere on the gel surface close to the skin of the precordium will indicate the patient's chest contour and will be more accurate to determine the circumference of the chest compared to only comparing the inclination differences of 603 with 602 in figure 6.

The disposable cover described earlier can be a silicon-based gel with different thickness in different areas to ensure good contact to the skin of the patient. Different types of covers that have different thicknesses of gel at different areas can exist for the same precordial device. These different covers can be used to accommodate the different topography of the chest wall of different people. So, for instance, one cover can cater for individuals with a pectus excavatum or to accommodate different sizes and positions of the mammary glands.

Typically, this device will be pressed to the chest of patient by the arms of a caregiver or even by the arm or hands of the patient himself. In one embodiment of the invention, the precordial device 16 can be attached to a patient by the use an elastic belt around the chest, strapping or glue such as a dry gel, for example or by means of suction.

Figure 24 illustrates a cross section of one example of the precordial device as applied to the precordium of the patient 2418. 2413 illustrates the skin of the patient. 2431 illustrates the sternal notch. 2401 illustrates the sternal notch alignment portion of the rigid precordial device 2404. 2402 illustrates the disposable patient barrier. The gel or fluid filled bag is illustrated by 2421. On the patient side of the gel one can find multiple sensors. 2429 is one such sensor and illustrates in this figure the cross section of an electrode for the ICG or ECG. 2428 illustrates a conductive portion in the patient barrier 2402 that acts as a conductive window so that the electrode 2429 can be electrically connected to the skin 2413 of the patient. 2430 and 2418 illustrates different configuration placements for pressure sensors. 2417 illustrates the cavity of an electronic stethoscopes with diaphragm 2419. It is clearly visible that the electrode
2429 and pressure sensor 2430 can share the same real estate surface area of the precardial skin with the stethoscope 2416. 2405 illustrates an external microphone to monitor the ambient sound conditions so that the user, even if he is situated miles from the patient, can know whether the ambient noise levels was soft enough to interpret the stethoscope sounds compliantly. 2420 illustrates an ultrasound probe grid able to record 4D ultrasound visuals. 2420 can also be used to determine vibrations / impulses transmitted from the body to the skin. Software can be used determine the demarcation line between the gel and the skin and in real time at a high enough sample rate the position changes in this line will be the impulses coming from the heart. Many other techniques like for instance measuring acceleration in tissue can also be used to record the impulses. If the sample rate is high enough, can the ultrasound probe also be used as a stethoscope making the traditional electronic stethoscope illustrated in this example obsolete. 2422 illustrates an array of accelerometers that can extend into two dimensions that can measure impulses transmitted from the patient as well as the contour of the precardium. 2423 illustrates a temperature sensor touching the skin of the patient. This sensor can also extend to the axilla of the patient to record more accurate core body temperature results. 2434 records the ambient temperature. 2424 illustrates a light receiver of a pulse oxymeter that analysis the light coming from sensors 2425. A hole though the patient barrier 2402 makes it possible for an automated dispenser 2415 to dispense drugs onto the skin of the patient that can be absorbed by the patient as part of the treatment of a patient in need of urgent treatment. 2426 illustrates a pad that can act as a defibrillator or as an external pacemaker while 2427 represents a conductive substance that connects the skin 2413 of the patient 2403 electrically with the electrode pad 2426. A non-invasive blood pressure machine is illustrated in 2406 that can measure the blood pressure of the patient while the patient holds the precardial device to his chest for instance. It might also be appropriate for the patient just to touch an electrode while an ECG recording is done. 2407 illustrates different configurations of how electrodes can be implemented. 2408 illustrates a finger tip pulse oxymeter that also have an electrode 2407 incorporated. 2409 is a suction pump that connects to a suction tip 2412 though a tube 2410. 2414 will have negative pressure allowing 2412 to press the electrode 2411 against the skin of the patient. 2411 might be any type of sensor like for instance an electronic stethoscope. 2432 will measure the inclination relative to 2433 so as to determine whether the electrode 2411 was positioned compliantly onto the patient.
In another embodiment of the invention, the precordial device 16 can feed back information to the user and patient by means of sound, LED's or screen displays built into the device and visible to the user and/or patient.

A precordial device 16 of the invention may comprise any combination of the above mentioned measurement devices. For example, in one embodiment the precordial device of the invention may comprise an ECG device. In another embodiment, the precordial device of the invention may comprise an ECG device and a stethoscope chest piece device. In another embodiment, the precordial device of the invention may comprise an ECG device, a stethoscope chest piece device, an ICG device, an accelerometer device, an oxygen saturation device, a non-invasive blood pressure device, an apical impulse device, a temperature sensor, a percussion hammer, a pressure sensor, a hub, a conductive substance dispenser and a disposable cover etc.

Furthermore, measurements obtained from different measurement devices of the precordial device 16 may measure the same parameters. Consequently, it is possible to perform compliance testing on the precordial device 16 of the invention. The obtained measurements are correlated with each other to ensure accurate data acquisition. For example, the measured breathing results using the accelerometers are compared with the impedance ECG breathing monitor data as well as the impedance ICG breathing monitor data as well as the respiratory inspiration and expiration sound data. So the different stethoscope sounds will also be compared with each other to pick up external noise on for instance one stethoscope that does not exist on the recordings of the other stethoscopes at the same time. As earlier described accelerometer data can also be used to pick up noise on certain ECG leads.

Furthermore the time related data of one device can be synchronised with another device better to extract features from the mentioned device. The heart sounds will be synchronised with the ECG data so as to identify the first and second heart sounds and systole and diastole. The apical impulse sensor can be synchronised with the ECG and heart sounds to more easily extract the apical impulse and oxygen saturation data though narrow band filters making use of Fourier transform filters for
instance. The impedance changes in time can be synchronised with the ECO data and stethoscope sound features so as to better do ICG feature extractions.

Those skilled in the art will appreciate that while the foregoing has described what is considered to be the best mode and, where appropriate, other modes of performing the invention, the invention should not be limited to the specific configurations and methods disclosed in this description of the preferred embodiment. Those skilled in the art will recognise that the invention has a broad range of applications in many different types of precordial devices, and that the embodiments may take a wide range of modifications without departing from the inventive concept as defined in the appended claims.
CLAIMS:

1. A precordial device comprising:
   a sternal notch alignment portion; and
   at least one measurement device connected to the precordial device,
   wherein when the sternal notch alignment portion is aligned with a sternal notch
   of a patient, the precordial device is in alignment with the patients chest such that
   consistent result can be obtained by the at least one measurement device.

2. A precordial device according to claim 1, wherein the at least one measurement device comprises an electrocardiogram (ECG) device.

3. A precordial device according to claim 2, wherein the ECG device comprises at least some of an ECG Lead V1; an ECG Lead V2; an ECG Lead V3; an
   ECG Lead V4; an ECG Lead V5; an ECG Lead V6; an ECG Lead V7; an ECG Lead V8; an
   ECG Lead V9; an ECG Lead rV1; an ECG Lead rV2; an ECG Lead rV3; an ECG
   Lead rV4; an ECG Lead rV5; an ECG Lead rV6; an ECG Lead rV7; an ECG Lead rV8;
   an ECG Lead rV9; an ECG Lead Right Arm; an ECG Lead Left Arm; an ECG Lead Left
   Foot; and an ECG Lead Right Foot.

4. A precordial device according to claim 3, wherein the ECG Lead Right Arm and the ECG Lead Left Arm are on an exterior surface of the precordial device
   where the patient can touch the leads with his upper limbs.

5. A precordial device according to claims 2 or 3, wherein the ECG device is capable of connection, via a single connection means to a computer.

6. A precordial device according to claims 2 or 3, wherein the ECG device is capable of wireless connection to a computer.
7. A precordial device according to claims 2 or 3, further comprising a computer with a human interface device built into the precordial device in communication with the ECG.

8. A precordial device according to any one of claims 2 to 7, wherein the at least one ECG measuring device also functions as an impedance cardiograph (ICG) measuring device.

9. A precordial device according to any preceding claim, wherein the at least one measurement device comprises a stethoscope chest piece device.

10. A precordial device according to claim 9, wherein the stethoscope chest piece device comprises an Aortic valve stethoscope sensor; a Pulmonary valve stethoscope sensor; a Tricuspid valve stethoscope sensor; and Mitral valve stethoscope sensor.

11. A precordial device according to claim 9, wherein the chest piece device further comprises a tracheal sound stethoscope sensor; an other heart sound stethoscope sensor; a basal respiratory sound stethoscope sensor; an abdominal sound stethoscope sensor; a left side Carotid artery stethoscope sensor; and a right side Carotid artery stethoscope sensor.

12. A precordial device according to claim 10 or 11, wherein a diaphragm of any one of the stethoscope sensors comprises an electrode connection portion.

13. A precordial device according to claim 12, wherein an ECG or ICG sensor is electrically connected to the electrode connection portion.

14. A precordial device according to any one of claims 10 to 13, wherein the stethoscope sensors comprise a pressure sensor.

15. A precordial device according to claim 10 or 14, wherein a diaphragm of any one of the stethoscope sensors comprises an impedance cardiograph (ICG) sensor or an electro cardiograph (ECG) sensor.
16. A precordial device according to any preceding claim, further comprising:
   an ultrasound probe or an ultrasound stethoscope

17. A precordial device according to claim 16, wherein the ultrasound probe or
   stethoscope covers a full surface area of the precordium, in use.

18. A precordial device according to any preceding claim, further comprising:
   foam, gel or fluid filled bags provided on an exterior surface of the precordial
   device.

19. A precordial device according to claim 18, wherein the foam or gel is able to
   absorb noise having a frequency below 50 Hz.

20. A precordial device according to any preceding claim, further comprising:
    a handle connected to an exterior surface of the precordial device.

21. A precordial device according to claim 20, wherein the handle has elastic
    properties.

22. A precordial device according to claim 20, wherein the handle has shock
    absorbing properties.

23. A precordial device according to any preceding claim, wherein the at least
    one measurement device comprises a sensor capable of monitoring any movement of a
    user holding the device and/or any movement of a patient.

24. A precordial device according to claim 23, wherein the sensor is an
    accelerometer or inclinometer.

25. A precordial device according to any preceding claim, wherein the at least
    one measurement device comprises an accelerometer device.
26. A precordial device according to claim 25, wherein the accelerometer device comprises a one and/or two and/or three-axis accelerometer sensor.

27. A precordial device according to claim 25 or 26, wherein the accelerometer device comprises a superior sternal accelerometer sensor; an inferior sternal accelerometer sensor; a lateral chest accelerometer sensor; and an abdominal accelerometer sensor.

28. A precordial device according to any preceding claim, wherein the at least one measurement device comprises at least one defibrillation and external cardiac pacing electrode pad.

29. A precordial device according to claim 28, comprising a right Clavicle defibrillation and external cardiac pacing electrode pad and an Apical defibrillation and external cardiac pacing electrode pad.

30. A precordial device according to any preceding claim, wherein the at least one measurement device comprises at least one oxygen saturation device.

31. A precordial device according to claim 30, wherein the oxygen saturation device comprises:
   at least one light emitting device; and at least one light receiving device.

32. A precordial device according to claim 30 or 31, wherein the oxygen saturation device is positioned below the sternal notch alignment portion.

33. A precordial device according to claim 30 or 31, wherein the oxygen saturation device is positioned to the lower left hand side of the precordial device.

34. A precordial device according to claim 30 or 31, wherein the oxygen saturation device is connected to the precordial device with wires.
35. A precordial device according to any one of claims 31 to 34, wherein the at least one light emitting device is capable of emitting light having a wavelength of substantially 890nm or 900nm or 910nm.

36. A precordial device according to any one of claims 31 to 34, wherein the at least one light emitting device is capable of emitting light having a wavelength of substantially 670nm or 680nm.

37. A precordial device according to any one of claims 31 to 36, comprising a plurality of light emitting devices arranged to form a circle around the at least one light receiving device.

38. A precordial device according to claim 37, wherein the plurality of light emitting devices form a circle having a radius greater than or equal to 20 mm.

39. A precordial device according to any preceding claim, which further comprises:
   a finger probe on the anterior side of the precordial device.

40. A precordial device according to any preceding claim, wherein the at least one measurement device comprises an apical impulse device.

41. A precordial device according to claim 40, wherein the apical impulse device is provided to the lower left hand side of the precordial device.

42. A precordial device according to claim 40 or 41, wherein the apical impulse device comprises:
   a semi-curved base following the contour of the precordium; and
   a grid of pressure sensors provided on the precordium side of the semi-curved base.

43. A precordial device according to claim 40 or 41, wherein the apical heartbeat device comprises:
   a grid of one, two or three dimensional accelerometer sensors.
44. A precordial device according to any preceding claim, wherein the at least one measurement device comprises a temperature sensing device.

45. A precordial device according to claim 44, wherein the temperature sensing device comprises an infrared sensor.

46. A precordial device according to claim 45, wherein the temperature sensing device comprises a contact sensor.

47. A precordial device according to any one of claims 44 to 46, wherein the temperature sensing device comprises at least one temperature sensor capable of measuring local skin temperature of a patient.

48. A precordial device according to claim 44 to 46, wherein the temperature sensing device comprises at least one temperature sensor capable of measuring ambient temperature.

49. A precordial device according to claim 48, wherein the at least one temperature sensor is provided on an exterior surface of the precordial device.

50. A precordial device according to any preceding claim, wherein the at least one measurement device comprises at least one percussion hammer.

51. A precordial device according to claim 50, wherein the at least one percussion hammer comprises:
   a rubber portion capable of contacting a patients skin; and
   a solenoid connected to the precordial device, wherein when in use a moving portion of the solenoid contacts the rubber portion.

52. A precordial device according to claim 50 or 51, wherein the at least one percussion hammer comprises a plurality of percussion hammers placed in a row.
53. A precordial device according to claim 51 or 52, wherein the rubber portion of the percussion hammer is a high density rubber.

54. A precordial device according to any one of claims 50 to 53, wherein the percussion hammer further comprises:
   a pressure sensor operable to measure the pressure exerted by the rubber part on the skin; and
   an accelerometer operable to measure an acceleration of the hammer and of the rubber part.

55. A precordial device according to any one of claims 50 to 54, wherein the percussion hammer includes a bone vibrator and can measure a bone vibrator pressure against the precordium.

56. A precordial device according to any preceding claim, wherein the at least one measurement device comprises at least one pressure sensor.

57. A precordial device according to any preceding claim, further comprising:
   a hub to which peripherals devices are capable of connection.

58. A precordial device according to claim 57, wherein the hub comprises a USB hub; a Serial connectivity hub; a FireWire hub; a wireless hub; or a ZigBee hub.

59. A precordial device according to any preceding claim, further comprising:
   a conductive substance dispenser.

60. A precordial device according to claim 59, wherein the conductive substance dispenser comprises:
   an enlarged electrode comprising a hole and a tube from which the conductive substance is dispensed.

61. A precordial device according to claim 59 or 60, wherein the conductive substance comprises an electrode gel or saline water.
62. A precordial device according to any preceding claim, further comprising:
   a disposable cover.

63. A precordial device according to claim 62, wherein an area of the
disposable cover is conductive and an area of the disposable cover is not conductive.

64. A precordial device according to claim 62 or 63, wherein an area of the
disposable cover is provided with adhesive glue.

65. A precordial device according to any one of claims 62 to 64, wherein an
area of the disposable cover is provided with a conductive substance.

66. A precordial device according to any one of claims 62 to 65, wherein the
cover has varying thickness.

67. A precordial device according to any preceding claim, wherein the at least
one measurement device comprises an impedance cardiograph (ICG) measuring
device.

68. A precordial device according to claim 67, further comprising two neck
portions.

69. A precordial device according to claim 68, wherein the ICG measuring
device comprises a left neck top ICG sensor; a left neck bottom ICG sensor; a right
neck top ICG sensor; a right neck bottom ICG sensor; a left thorax top ICG sensor; a
left thorax bottom ICG sensor; a right thorax top ICG sensor; and a right thorax bottom
ICG sensor.

70. A precordial device according to claim 69, wherein the distance between a
centre of the left neck top ICG sensors and the left neck bottom ICG sensor is the same
as the distance between a centre of the right neck top ICG sensor and the right neck
bottom ICG sensor, is the same as the distance between a centre of the left thorax top
ICG sensor and the left thorax bottom ICG sensor, and is the same as the distance
between a centre of the right thorax top ICG sensor and the right thorax bottom ICG sensor, for symmetrical placement either side of the neck.

71. A precordial device according to claim 70, wherein the distance is constant for all paired points.

72. A precordial device according to claim 70 or 71, wherein the distance is in a range of substantially 0mm to 60mm.

73. A precordial device according to any one of claims 67 to 72, wherein the impedance cardiograph (ICG) measuring device is capable of dispensing a conductive substance.

74. A precordial device according to any preceding claim, further comprising hooks for an elastic belt to enable the precordial device to be affixed to a patient.

75. A precordial device according to any preceding claim, further comprising strapping to enable the precordial device to be affixed to a patient.

76. A precordial device according to any preceding claim, further comprising an adhesive to enable the precordial device to be affixed to a patient.

77. A precordial device according to any preceding claim, further comprising an adhesive to enable the precordial device to be affixed to a patient.

78. A precordial device according to any one of claims 1 to 48 and 51 to 77, wherein the at least one measurement device is connected to an interior surface of the precordial device.

79. A precordial device according to any one of claims 1 to 48 and 51 to 77 wherein the interior precordial surface of the precordial device is a gel substance or a fluid filled bag.
80. A precordial device comprising:
an electrocardiogram (ECG) device connected to the precordial device; and
at least one other measurement device connected to the precordial device.

81. A precordial device according to claim 80, wherein the ECG device comprises an ECG Lead V1; an ECG Lead V2; an ECG Lead V3; an ECS Lead V4; an ECS Lead V5; an ECG Lead V6; an ECS Lead Right Arm; an ECS Lead Left Arm; an ECO Lead Left Foot; and an ECG Lead Right Foot.

82. A precordial device according to claim 80 or 81, wherein the at least one other measurement device comprises a stethoscope chest piece device.

83. A precordial device according to claim 82, wherein the stethoscope chest piece device comprises an Aortic valve stethoscope sensor; a Pulmonary valve stethoscope sensor; a Tricuspid valve stethoscope sensor; and Mitral valve stethoscope sensor.

84. A precordial device according to claim 83, wherein the chest piece device further comprises a tracheal sound stethoscope sensor; an other heart sound stethoscope sensor; a basal respiratory sound stethoscope sensor; an abdominal sound stethoscope sensor; a left side Carotid artery stethoscope sensor; and a right side Carotid artery stethoscope sensor.

85. A precordial device according to any one of claims 80 to 84, wherein the at least one measurement device comprises a sensor capable of monitoring any movement of a user holding the device and/or any movement of a patient.

86. A precordial device according to any one of claims 80 to 85, wherein the at least one measurement device comprises an accelerometer device.

87. A precordial device according to claim 86, wherein the accelerometer device comprises a three-axis accelerometer sensor.
88. A precordial device according to claim 86 or 87, wherein the accelerometer device comprises a superior sternal accelerometer sensor; an inferior sternal accelerometer sensor; a lateral chest accelerometer sensor; and an abdominal accelerometer sensor.

89. A precordial device according to any one of claims 80 to 88, wherein the at least one measurement device comprises at least one defibrillation and external cardiac massage pad.

90. A precordial device according to claim 89, comprising a right clavicle defibrillation and external cardiac massage pad and an apical defibrillation and external cardiac massage pad.

91. A precordial device according to any one of claims 80 to 90, wherein the at least one measurement device comprises at least one oxygen saturation device.

92. A precordial device according to claim 91, wherein the oxygen saturation device comprises:
   at least one light emitting device; and
   at least one light receiving device.

93. A precordial device according to claim 92, comprising a plurality of light emitting devices arranged to form a circle around the at least one light receiving device.

94. A precordial device according to claim 93, wherein the plurality of light emitting devices form a circle having a radius greater than or equal to substantially 20 mm.

95. A precordial device according to any one of claims 80 to 94, wherein the at least one measurement device comprises an apical heartbeat device.

96. A precordial device according to claim 95, wherein the apical heartbeat device comprises:
a semi-curved base; and a grid of pressure sensors provided on the concave side of the semi-curved base.

97. A precordial device according to claim 96, wherein the apical heartbeat device comprises:
   a grid of two dimensional accelerometer sensors.

98. A precordial device according to any one of claims 80 to 97, wherein the at least one measurement device comprises a temperature sensing device.

99. A precordial device according to any one of claims 80 to 98, wherein the at least one measurement device comprises at least one percussion hammer.

100. A precordial device according to claim 99, wherein the at least one percussion hammer comprises:
   a rubber portion capable of contacting a patient's skin; and a solenoid connected to the precordial device, wherein when in use a moving portion of the solenoid contacts the rubber portion.

101. A precordial device according to any one of claims 80 to 100, wherein the at least one measurement device comprises at least one pressure sensor.

102. A precordial device according to any one of claims 80 to 101, further comprising:
   a hub to which peripherals devices are capable of connection.

103. A precordial device according to claim 102, wherein the hub comprises an USB hub; a Serial connectivity hub, a FireWire hub or a wireless hub.

104. A precordial device according to any one of claims 80 to 103, further comprising:
   a conductive substance dispenser.
A precordial device according to claim 104, wherein the conductive substance dispenser comprises:

an enlarged electrode comprising a hole and a tube from which the conductive substance is dispensed.

A precordial device according to any one of claims 80 to 105, further comprising:

disposable cover.

A precordial device according to any one of claims 80 to 106, wherein the at least one measurement device comprises an impedance cardiograph (ICG) measuring device.

A precordial device according to claim 107, further comprising two neck potions.

A precordial device according to claim 108, wherein the ICG measuring device comprises a left neck top ICG sensor; a left neck bottom ICG sensor; a right neck top ICG sensor; a right neck bottom ICG sensor; a left thorax top ICG sensor; a left thorax bottom ICG sensor; a right thorax top ICG sensor; and a right thorax bottom ICG sensor.

A precordial device according to any one of claims 80 to 109, further comprising:

foam provided on an exterior surface of the precordial device.

A precordial device according to any one of claims 80 to 110, further comprising:

a handle connected to an exterior surface of the precordial device.

A precordial device according to any preceding claim, wherein the precordial device is sized and configured to match a particular patient.
113. A disposable cover for a precordial device, the disposable cover comprising:
   a conductive surface and a non-conductive surface.

114. A disposable cover according to claim 113, further comprising:
   an area provided with adhesive glue properties.

115. A disposable cover according to claim 113 or 114, further comprising:
   an area provided with a conductive substance.

116. A disposable cover according to any one of claims 113 to 115, wherein the
cover has varying thickness.