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(54) **INTELLIGENT PATIENT MONITOR PENDANT**

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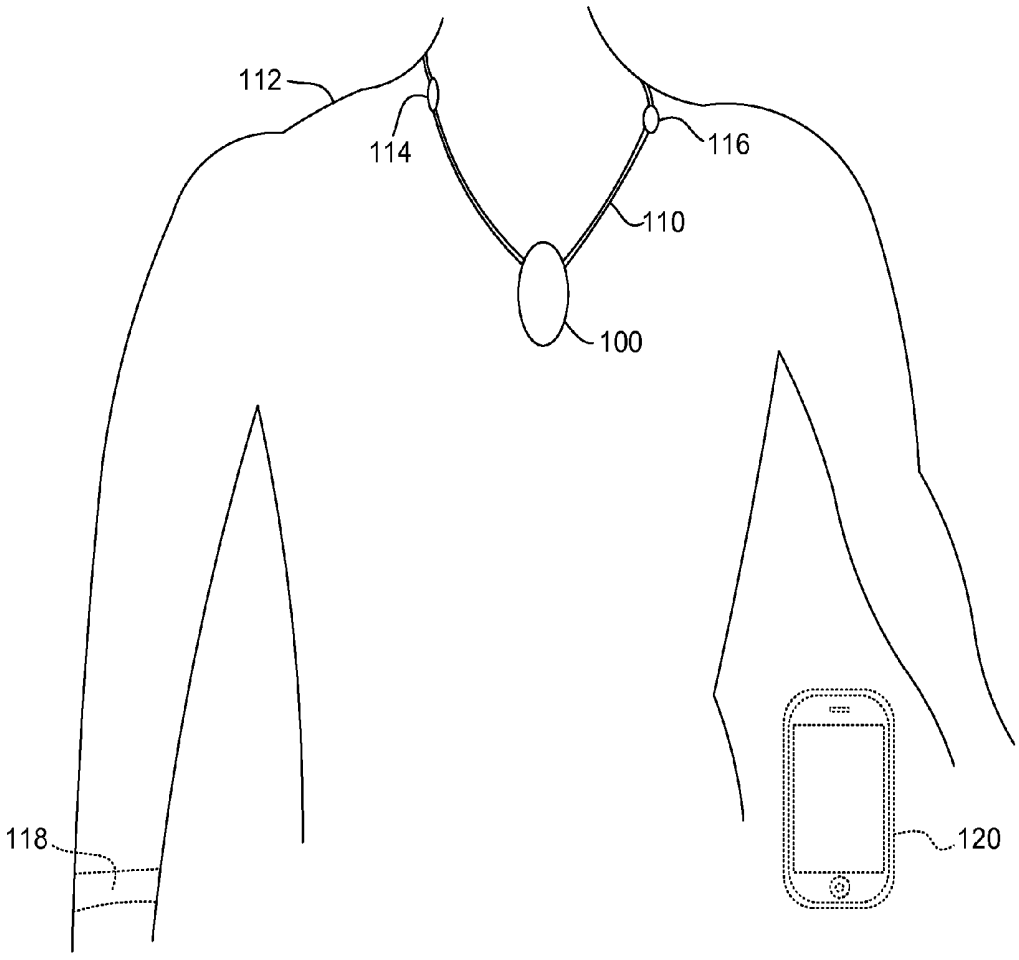
USPC **600/301**; 600/382; 600/384; 607/44

(57) **ABSTRACT**

A patient monitor system includes a pendant configured to be worn around a neck of a patient. The pendant includes an electrode to sense transthoracic electrical activity and a processor in communication with the electrode. The processor analyzes the transthoracic electrical activity to detect a cardiac event. The pendant also includes a position sensor to determine an orientation of the pendant so as to detect whether the patient is in a horizontal or upright position. The processor determines the accuracy of the detected cardiac event based on data from the position sensor. The patient monitor system may also include additional electrodes connected to the pendant through a necklace. The pendant may also include a verbal verification module to execute verbal communication routines that automatically detect an ability of the patient to communicate verbally so as to further determine the accuracy of the detected cardiac event.



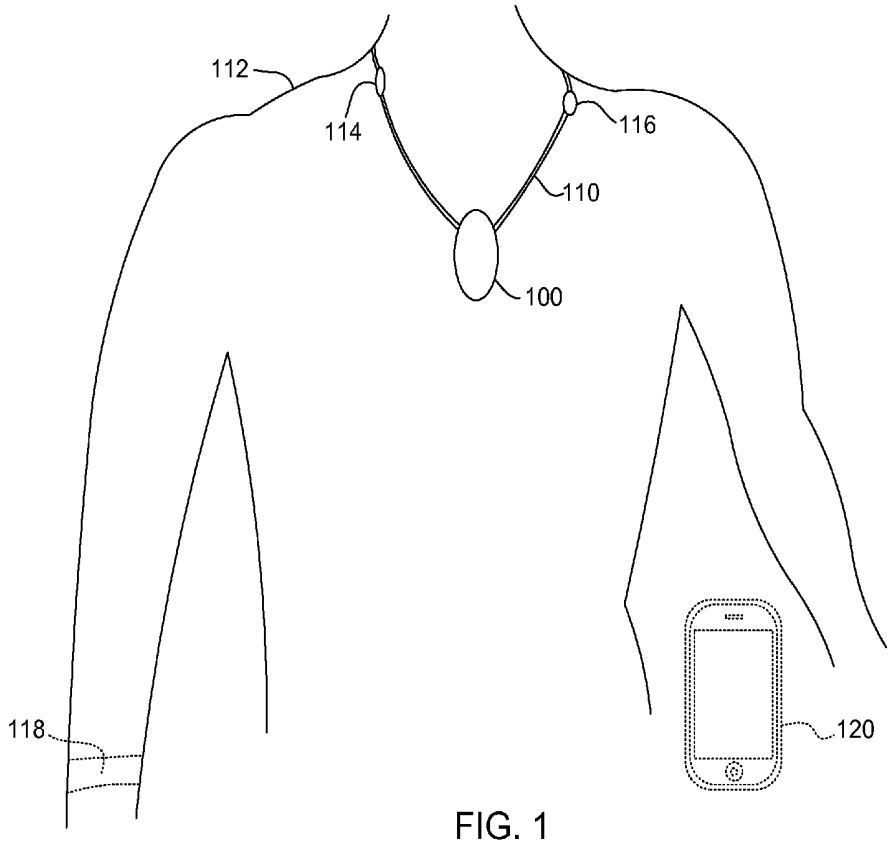


FIG. 1

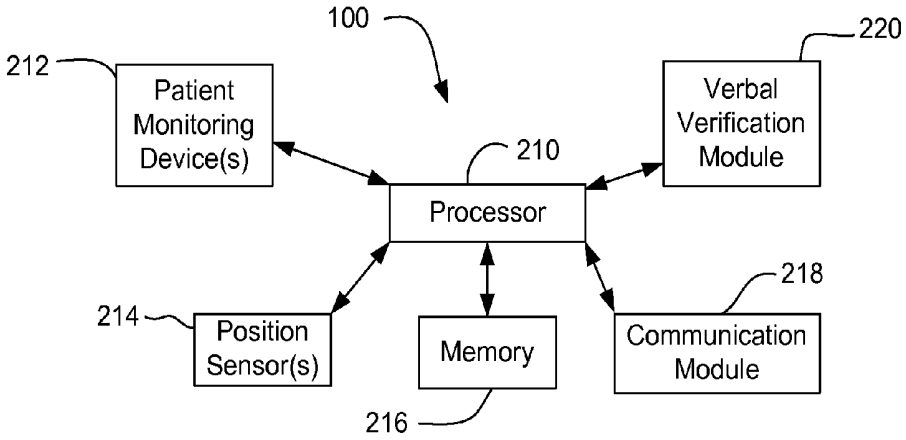

100
212
Patient Monitoring Device(s)
220
Verbal Verification Module
210
Processor
214
Position Sensor(s)
Memory
218
Communication Module
216

FIG. 2

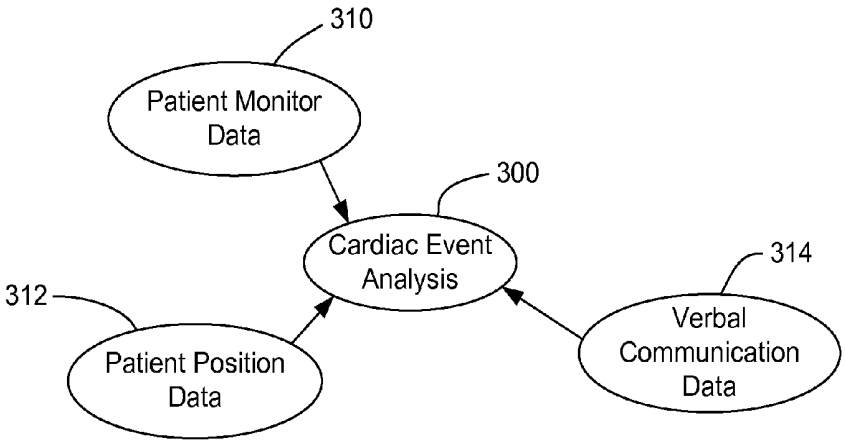

310
Patient Monitor Data
300
Cardiac Event Analysis
314
312
Patient Position Data
Verbal Communication Data

FIG. 3

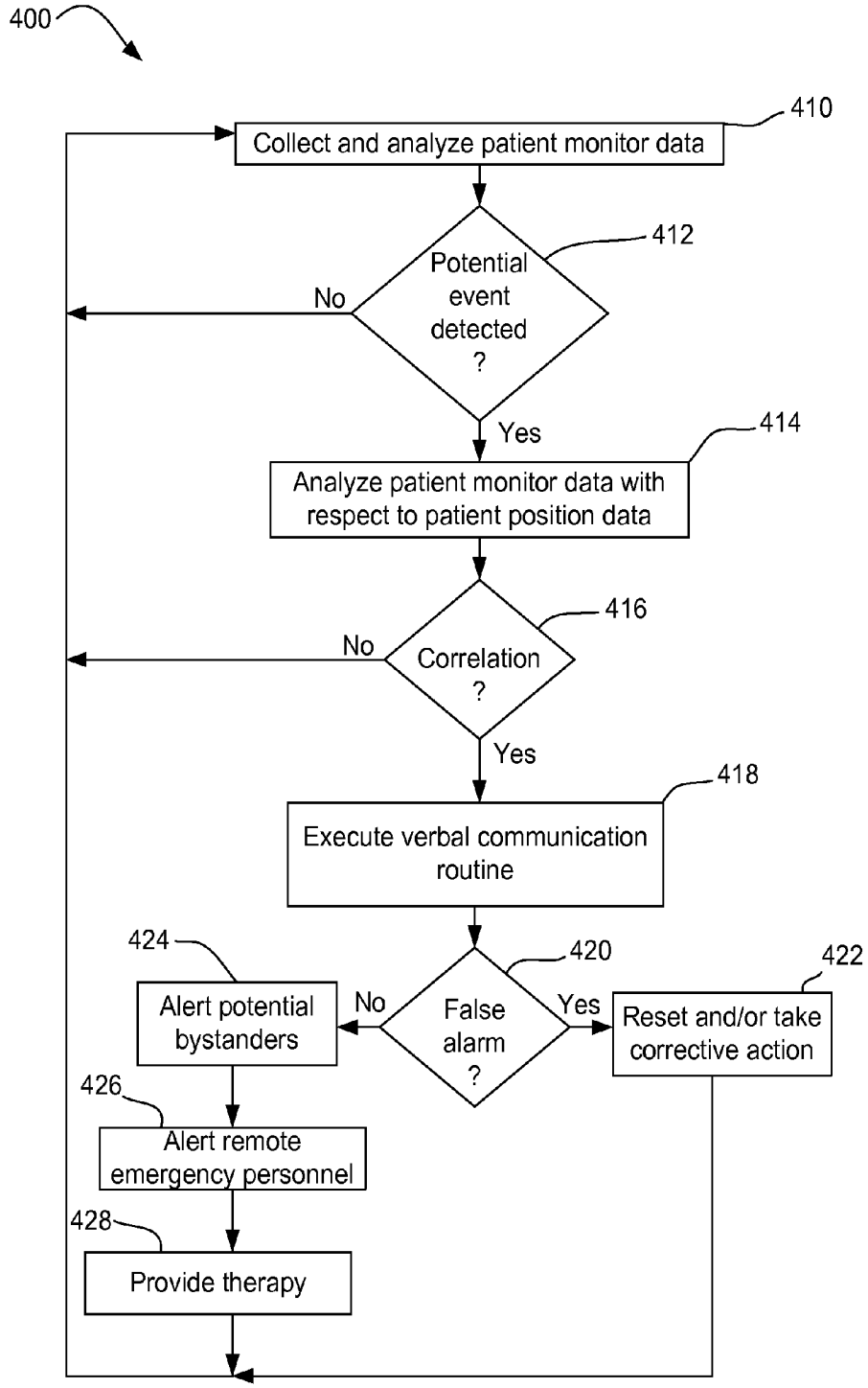

400
410
Collect and analyze patient monitor data
412
Potential event detected ?
No
Yes
414
Analyze patient monitor data with respect to patient position data
416
Correlation ?
No
Yes
418
Execute verbal communication routine
420
False alarm ?
No
Yes
422
Reset and/or take corrective action
424
Alert potential bystanders
426
Alert remote emergency personnel
428
Provide therapy

FIG. 4

INTELLIGENT PATIENT MONITOR PENDANT

RELATED APPLICATION

[0001] This application claims the benefit under 35 U.S.C. §119(e) of U.S. Provisional Application No. 61/716,262, filed Oct. 19, 2012, which is hereby incorporated by reference herein in its entirety.

TECHNICAL FIELD

[0002] This disclosure is related to patient monitoring. In particular, this disclosure is related to sensing and responding to biological parameters.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIG. **1** illustrates an intelligent pendant worn around a neck of a patient according to one embodiment.

[0004] FIG. **2** is a block diagram of the intelligent pendant according to one embodiment.

[0005] FIG. **3** is a schematic diagram illustrating inputs to a cardiac event analysis according to one embodiment.

[0006] FIG. **4** is a flow chart of a method for monitoring a patient according to one embodiment.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0007] Heart disease is the leading cause of death in the United States. A heart attack (also known as an acute myocardial infarction (AMI)) typically results from a thrombus that obstructs blood flow in one or more coronary arteries. AMI is a common and life-threatening complication of coronary heart disease. The sooner that perfusion of the myocardium is restored (e.g., with injection of a thrombolytic medication or with angioplasty), the better the prognosis and survival of the patient from the heart attack. The extent of damage to the myocardium is strongly dependent upon the length of time prior to restoration of blood flow to the heart muscle.

[0008] Myocardial ischemia is caused by a temporary imbalance of blood (oxygen) supply and demand in the heart muscle. It is typically provoked by physical activity or other causes of increased heart rate when one or more of the coronary arteries are obstructed by atherosclerosis. Patients will often (but not always) experience chest discomfort (angina) when the heart muscle is experiencing ischemia.

[0009] Acute myocardial infarction and ischemia may be detected from a patient's electrocardiogram (ECG) by noting an ST segment shift (e.g., voltage change) over a relatively short (e.g., less than 5 minutes) period of time. Both AMI and ischemia can cause lethal arrhythmias and death if not detected and treated early. Other conditions may also be determined from ECG data. However, approximately 25% of people that have acute myocardial infarction do not feel any symptoms. Thus, certain embodiments disclosed herein measure and analyze ECG data and other patient parameters to detect a patient's condition. Such embodiments may also include methods triggered by the detected patient's condition to communicate with the patient to further assess the patient's condition, to provide instructions to the patient, and/or to provide treatment to the patient. For example, a method may ask a patient whether she/he is feeling chest pains and/or is experiencing a shortness of breath. Based on the patient's condition and/or responses to the queries, the method may instruct the patient to contact her/his doctor or to go to the nearest emergency room. In addition, or in other embodiments, the method may communicate the patient's ECG data to the patient's doctor for further evaluation.

[0010] The present disclosure includes an intelligent pendant that may be worn by a patient with heart disease to monitor the patient's current condition, detect cardiac events, verify the detected events through the patient's position and/or through verbal communication with the patient, and communicate with bystanders or remote emergency personnel. Such cardiac events may include, by way of example and not by limitation, ventricular tachycardia (VT or V-tach), ventricular fibrillation, and other cardiac conditions. The pendant may be worn around the patient's neck and includes at least three electrodes and a processor to detect and interpret transthoracic electrical activity of the heart over a period of time. One or more additional electrodes or other biological sensors may be located at other locations on the patient (e.g., in a wristband or in a band worn around the patient's chest, waist, leg, head, or ankle) and may be configured to communicate with the intelligent pendant and/or an external device (e.g., a smart phone or other processing device).

[0011] Reference is now made to the figures in which like reference numerals refer to like elements. For clarity, the first digit of a reference numeral indicates the figure number in which the corresponding element is first used. In the following description, numerous specific details are provided for a thorough understanding of the embodiments disclosed herein. However, those skilled in the art will recognize that the embodiments can be practiced without one or more of the specific details, or with other methods, components, or materials. Further, in some cases, well-known structures, materials, or operations are not shown or described in detail in order to avoid obscuring aspects of the invention. Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

[0012] Embodiments may include various steps, which may be embodied in machine-executable instructions to be executed by a general-purpose or special-purpose computer (or other electronic device). Alternatively, the steps may be performed by hardware components that include specific logic for performing the steps or by a combination of hardware, software, and/or firmware.

[0013] Embodiments may also be provided as a computer program product including a non-transitory, machine-readable medium having stored thereon instructions that may be used to program a computer (or other electronic device) to perform the processes described herein. The machine-readable medium may include, but is not limited to, hard drives, floppy diskettes, optical disks, CD-ROMs, DVD-ROMs, ROMs, RAMs, EPROMs, EEPROMs, magnetic or optical cards, solid-state memory devices, or other types of media/computer-readable medium suitable for storing electronic instructions.

[0014] FIG. **1** illustrates an intelligent pendant **100** worn on a necklace **110** around a neck of a patient **112** according to one embodiment. The intelligent pendant **100** includes one or more patient monitoring devices such as electrode(s) to detect electrical signals (corresponding to transthoracic electrical activity) passing along the outer surface of the patient's skin. In this example, the necklace **110** includes at least two additional electrodes **114**, **116**, which may be positioned at any location along the necklace **110** (including any location along the patient's chest, neck, or back). The necklace **110** may

include electrically conductive wires to provide communication between the intelligent pendant and the electrodes **114**, **116**.

[0015] As discussed below, the intelligent pendant **100** may include a processor, memory, and other circuitry to perform the functions described herein. It should be noted that one or more of the devices or elements described as being within or part of the intelligent pendant **100** may be located external to the intelligent pendant **100** in certain embodiments. For example, one or more processors, memories, patient monitors, devices, and/or circuitry may be located in an optional wristband **118**, smart phone **120**, or other user device. Further, certain elements (e.g., processors and/or memory) may be distributed among the intelligent pendant **100**, electrodes **114**, **116**, wristband **118**, smart phone **120**, or other user device.

[0016] FIG. **2** is a block diagram of the intelligent pendant **100** according to one embodiment. In this example, the intelligent pendant **100** includes a processor **210** in communication with one or more patient monitor devices **212**, one or more position sensors **214**, a memory device **216**, a communication module **218**, and a verbal verification module **220**. The processor **210** is configured to perform the functions described herein, including analyzing ECG signals to detect cardiac events such as ventricular tachycardia (VT or V-tach), ventricular fibrillation, and sudden cardiac death.

[0017] As discussed above, the one or more patient monitoring devices **212** may include electrodes to detect ECG signals. The one or more patient monitoring devices **212** (or any other element on the necklace **110** or wristband **118**) may also include other sensors to detect, for example, blood pressure, blood oxygen saturation, pulse rate, temperature, and other biological parameters. In one embodiment, for example, a sensor may be used to detect biological parameters through the patient's skin such as sweat, sweat rates, skin temperature, and blood oxygen saturation. In addition, or in other embodiments, respiration sensor may be used to determine a respiration rate and/breathing patterns. In one embodiment, a wrist band or other device is configured to automatically measure the patient's blood pressure.

[0018] The one or more position sensors **214** are configured to determine the patient's position (e.g., standing or lying position). The position sensors **214** may include, for example one or more accelerometer, gyroscope, magnetometer, and/or global positioning satellite (GPS) receiver.

[0019] The memory device **216** may include any type of memory for storing computer readable data. The memory device **216** may store, for example, executable instructions for the processor **210** and/or ECG or other sensor data.

[0020] The communication module **218** is configured to communicate with external devices and/or emergency personnel. For example, the communication module may use WiFi, Bluetooth, or other wireless communication protocols to communicate with the wristband **118**, the smart phone **120**, and/or other user devices (e.g., a wireless router or internet gateway). In addition, or in other embodiments, the communication module **218** may be configured to communicate directly through a cellular phone network (e.g., 3G or 4G/LTE network). The communication module **218** may communicate ECG data or other sensed biological parameters. The data may be stored, for example, the in the smart phone **120** and/or communicated to a central monitoring station. The communication module **218** may also provide direct communication between the patient **112** (or bystanders) and emergency personnel such as police, emergency medical technicians (EMTs), doctors, and/or hospitals. Communications with emergency personnel may include GPS location information to assist the emergency personnel in quickly locating the patient.

[0021] The verbal verification module **220** is configured to execute verbal communication routines to verify the occurrence of a cardiac event. The verbal verification module **220** may include, for example, an audio processor, speaker, audio amplifier, microphone, and speech recognition algorithms.

[0022] FIG. **3** is a schematic diagram illustrating inputs to a cardiac event analysis **300** according to one embodiment. As discussed above, patient monitor data **310** (including ECG and other biological parameter data), patient position data **312**, and verbal communication data **314** are provided to the cardiac event analysis **300** to determine whether an actual cardiac event has occurred that requires a response, or whether detected signals are false alarms. In other words, interaction with the patient reduces the likelihood of false alarms and increases the likelihood that appropriate assistance is provided when needed and in a timely manner. For example, if the sensors detect a flat ECG signal, the disclosed system can verbally speak to the patient and receive a verbal response from the patient to verify whether the patient is conscious or experiencing any difficulty. As another example, an alarm may be immediately triggered if a certain cardiac event is detected at about the same time that the patient position data **312** indicates a sudden change from a standing position to a lying position.

[0023] FIG. **4** is a flow chart of a method **400** for monitoring a patient according to one embodiment. The method **400** includes collecting and analyzing **410** patient monitor data and querying **412** or analyzing the patient monitor data to determine whether a potential event is detected. If a potential event has been detected, the method **400** includes analyzing **414** the patient monitor data with respect to patient position data, and querying **416** whether a correlation exists between patient monitor data and the patient position data. If a correlation exists, the method **400** includes executing **418** a verbal communication routine to obtain verbal input from the patient, if possible to validate or invalidate the existence of the event.

[0024] Based on at least one of the position data and the verbal communication data, the method determines **420** whether a false alarm condition exists. If a false alarm condition exists, the method resets **422** and/or takes other corrective action (including, e.g., providing verbal instructions to the patient to correct the problem). If a false alarm condition does not exist and the event is determined to be correct, the method **400** includes alerting **424** potential bystanders (e.g., by sounding an alarm or through verbal communication) and/or alerting **426** remote emergency personnel.

[0025] In certain embodiments, the method **400** optionally includes providing **428** therapy. The therapy may include, for example, defibrillation and/or pacing. For example, if the detected event includes a cardiac arrhythmia of ventricular fibrillation or ventricular tachycardia in a patient, the intelligent pendant **100** may provide an electrical shock to stop the arrhythmia and allow the heart to reestablish an effective rhythm. As another example, the detected event may be an increase in the patient's physical activity that requires an increase in the artificial base pacing rate, or detection of intrinsic cardiac activity such as atrial and ventricular depolarizations that indicates a need to change the artificial base

pacing rate, and the intelligent pendant **100** may respond by providing the pacing according to pacing rate response algorithms. In certain embodiments, the intelligent pendant **100** directly provides therapies such as defibrillation and/or pacing. In other embodiments, the intelligent pendant **100** controls one or more other devices to provide therapies such as defibrillation and/or pacing. For example, the intelligent pendant **100** may control a separate vest or other device worn by the patient that provides external defibrillation and/or pacing.

[0026] Skilled persons will recognize from the disclosure herein that the method **400** may be modified based on the particular application. For example, one or more of the steps may be omitted, or the step of executing **418** the verbal communication routine may occur before the step of analyzing **414** the patient monitor data with respect to the patient position data.

[0027] It will be understood to those having skill in the art that many changes may be made to the details of the above-described embodiments without departing from the underlying principles of the invention. The scope of the present invention should, therefore, be determined only by the following claims.

1. A patient monitor, comprising:
- a pendant configured to be worn around a neck of a patient, the pendant comprising:
  - a first electrode to sense transthoracic electrical activity;
  - a processor in communication with the first electrode, the processor to analyze the transthoracic electrical activity to detect a cardiac event; and
  - a position sensor to determine an orientation of the pendant so as to detect whether the patient is in a horizontal or upright position,
- wherein the processor is further configured to determine the accuracy of the detected cardiac event based on data from the position sensor.

2. The patient monitor of claim **1**, further comprising:
- a second electrode attached to the pendant through a necklace; and
- a third electrode attached to the pendant through the necklace,
- wherein the second electrode and the third electrode are configured to further sense the transthoracic electrical activity and to communicate respective sensed portions of the transthoracic activity to the processor.

3. The patient monitor of claim **2**, further comprising:
- a fourth electrode in wireless communication with the processor and configured to further sense the transthoracic electrical activity, the fourth electrode configured to be worn by the patient separate from the necklace.

4. The patient monitor of claim **3**, wherein the fourth electrode is integrated with a band configured to be worn by the patient, the band selected from a group comprising a wristband, a chest band, a waist band, a leg band, a head band, and an ankle band.

5. The patient monitor of claim **4**, wherein at least one of the pendant, the necklace, and the band further comprises a sensor to detect a biological parameter selected from a group comprising blood pressure, blood oxygen saturation, pulse rate, temperature, skin temperature, sweat, sweat rate, respiration rate, and breathing patterns.

6. The patient monitor of claim **1**, wherein the pendant further comprises:
- a verbal verification module to execute verbal communication routines that automatically detect an ability of the patient to communicate verbally so as to further determine the accuracy of the detected cardiac event.

7. The patient monitor of claim **6**, wherein the verbal verification module comprises:
- an audio processor to provide prompts to the patient;
- a speaker to provide audible output from the audio processor;
- a microphone to detect audio; and
- a speech recognition module to determine that the detected audio includes verbal communication from the patient.

8. The patient monitor of claim **1**, further comprising a communication module to communicate the detected cardiac event and the determined accuracy to a remote location.

9. The patient monitor of claim **8**, wherein the communication module is further configured to communicate at least one of sensed biological parameters to remote medical personnel and global positioning satellite (GPS) data to emergency response personnel.

10. The patient monitor of claim **8**, wherein the communication module is further configured to provide verbal communication between remote personnel and the patient or bystanders.

11. The patient monitor of claim **1**, wherein the position sensor comprises one or more module selected from the group comprising an accelerometer, a gyroscope, a magnetometer, and a global positioning system (GPS) receiver.

12. A method for monitoring a patient, the method comprising:
- collecting and analyzing patient monitor data to detect a potential event;
- determining a correlation between the patient monitor data and patient position data;
- executing a verbal communication routine that outputs verbal communication data corresponding to an attempted detection of verbal input from the patient;
- based on at least one of the patient position data and the verbal communication data, determining whether a false alarm condition exists; and
- communicating, to a remote location, an indication of whether the false alarm condition exists.

13. The method of claim **12**, further comprising:
- providing verbal instructions to the patient to correct the false alarm condition.

14. The method of claim **12**, wherein if the false alarm condition does not exist, executing one or more actions selected from a group comprising sounding an alarm, establishing verbal communication with bystanders, and notifying remote emergency personnel.

15. The method of claim **12**, wherein at least a portion of the patient monitoring data is received from a pendant worn around the patient's neck.

16. The method of claim **15**, wherein if the false alarm condition does not exist, providing treatment to the patient through the pendant.

17. The method of claim **16**, wherein the treatment is selected from the group comprising defibrillation and pacing.

18. The method of claim **12**, further comprising:
- automatically querying the patient, using the verbal communication module, for input corresponding to the patient's condition; and
- in response to receive the requested input from the patient, providing at least one of instructions and treatment to the patient.

19. The method of claim **18**, wherein automatically querying the patient comprises verbally asking the patient a question related to a group comprising chest pain and shortness of breath.

20. The method of claim **18**, further comprising communicating electrocardiogram (ECG) data associate with the patient to a doctor for further evaluation.

* * * * *

专利名称(译)	智能病人监护仪挂件		
公开(公告)号	US20140114142A1	公开(公告)日	2014-04-24
申请号	US13/801159	申请日	2013-03-13
[标]申请(专利权)人(译)	SHAOULIAN EMANUEL		
申请(专利权)人(译)	SHAOULIAN，伊曼纽尔		
当前申请(专利权)人(译)	SHAOULIAN，伊曼纽尔		
[标]发明人	SHAOULIAN EMANUEL		
发明人	SHAOULIAN, EMANUEL		
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CPC分类号	A61B5/02055 A61B5/0006 A61B5/0024 A61B5/0205 A61B5/0404 A61B5/1116 A61B5/6822 A61B5/746 A61B5/749 A61N1/37247 A61N1/37258 G16H40/63 G16H50/20		
优先权	61/716262 2012-10-19 US		
外部链接	Espacenet USPTO		

摘要(译)

一种患者监测系统包括配置成佩戴在患者颈部周围的挂件。该吊坠包括用于感测经胸电活动的电极和与电极连通的处理器。处理器分析经胸电活动以检测心脏事件。悬挂装置还包括位置传感器，用于确定悬垂装置的方向，以便检测患者是处于水平位置还是直立位置。处理器基于来自位置传感器的数据确定检测到的心脏事件的准确性。患者监测系统还可以包括通过项链连接到吊坠的附加电极。该挂件还可以包括口头验证模块，用于执行口头通信例程，该口头通信例程自动检测患者口头通信的能力，以便进一步确定检测到的心脏事件的准确性。