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(54) **PROGRAMMABLE CARDIOPULMONARY RESUSCITATION (CPR) DETECTION DEVICE**

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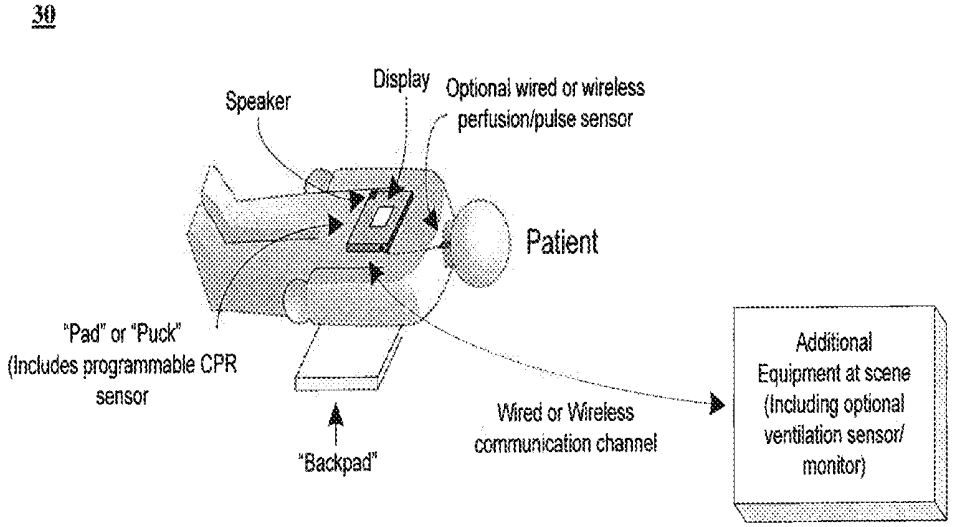
G16H 40/63	(2006.01)

(52) **U.S. Cl.**

CPC ... ***A61H 31/005*** (2013.01); *A61H 2201/5079* (2013.01); ***A61N 1/37258*** (2013.01); ***A61B 5/11*** (2013.01); ***A61B 5/742*** (2013.01); ***A61B 5/6843*** (2013.01); ***A61H 31/007*** (2013.01); ***A61N 1/3993*** (2013.01); ***G16H 40/63*** (2018.01); *A61H 2201/5035* (2013.01); *A61H 2201/501* (2013.01); *A61H 2201/5007* (2013.01); *A61H 2201/0184* (2013.01); *A61H 2201/5038* (2013.01); *A61H 2201/5043* (2013.01); *A61H 2201/5048* (2013.01); *A61H 2201/5061* (2013.01); *A61H 2201/5071* (2013.01); *A61H 2201/5097* (2013.01); *A61H 2230/045* (2013.01); *A61H 2201/5076* (2013.01); ***A61N 1/37247*** (2013.01)

(57) **ABSTRACT**

Time after time studies find that often, even when administered by trained professionals, cardiopulmonary resuscitation (CPR) compression rates and depth are inadequate. Too week, shallow or too forceful compressions may contribute to suboptimal patient outcome. Several parameters are crucial for optimal and properly-administered CPR. Crucial parameters include proper hand positioning on the patient's chest, depth of compression of 4-5 cm, and compression rate of 100 compressions per minute. The crucial parameters are often affected by patient parameters, and relative to the patient, rescuer parameters, such as patient thoracic volume; weight; age; gender; and rescuer's, relative to the patient's, parameters, such as weight, height; physical form, etc. Proposed is an automated CPR feedback device with user programmable settings for assisting with real-time feedback and subsequently correcting rescuers patient customized CPR technique.



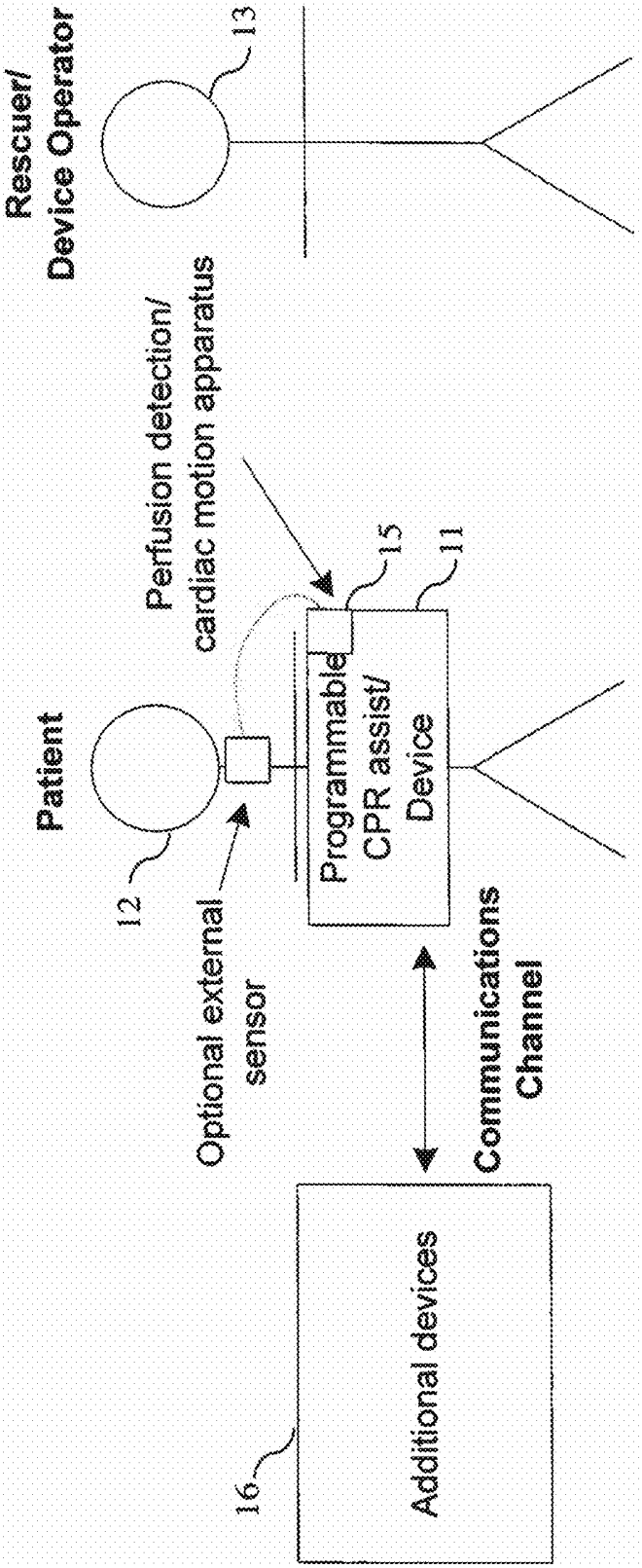

Rescuer/
Device Operator
13
Perfusion detection/
cardiac motion apparatus
15
11
Patient
Programmable
CPR assist/
Device
12
Optional external
sensor
Communications
Channel
16
Additional devices

Fig. 1

10

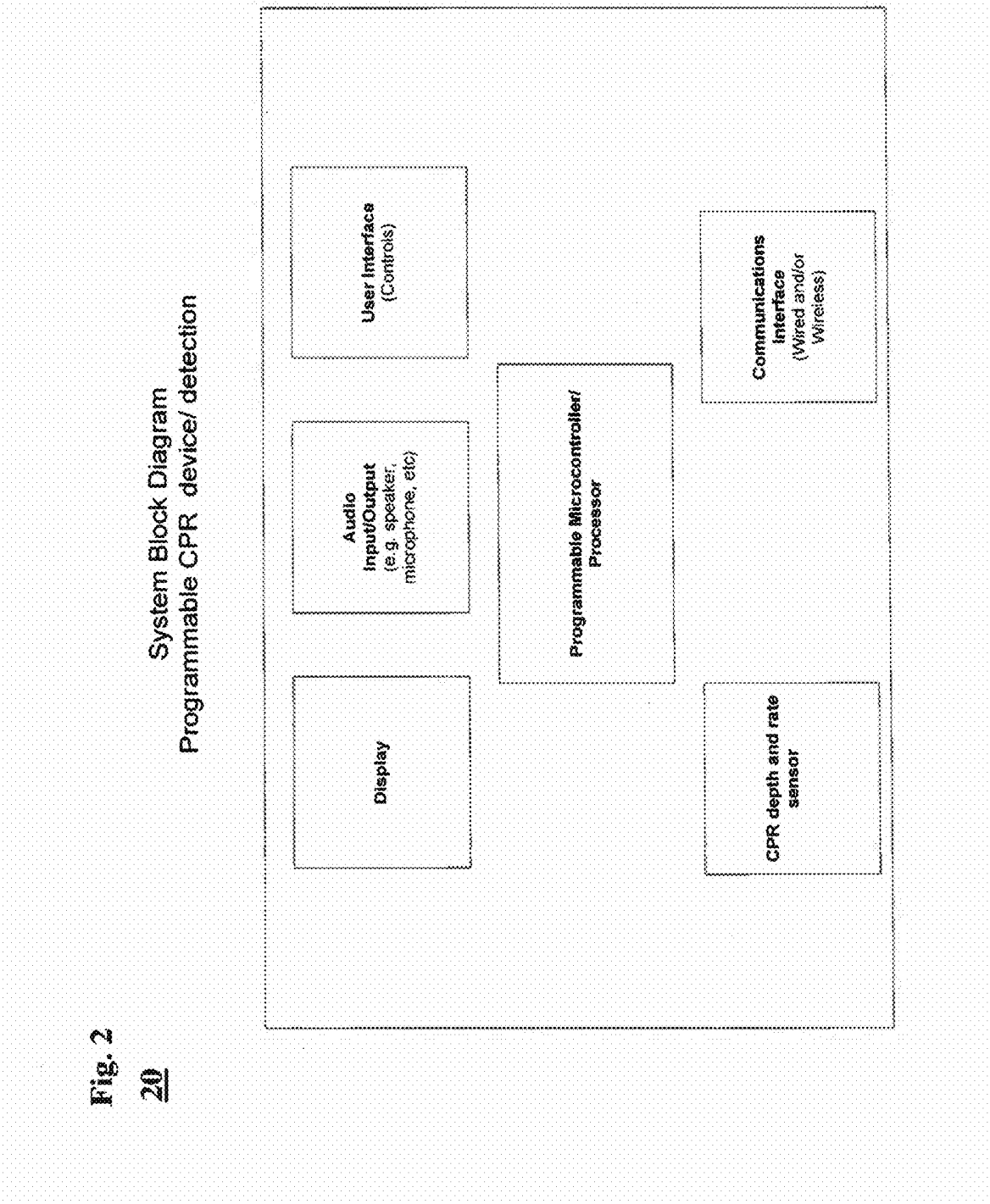

System Block Diagram
Programmable CPR device/ detection
20
Display
Audio Input/Output (e.g. speaker, microphone, etc)
User Interface (Controls)
Programmable Microcontroller/ Processor
CPR depth and rate sensor
Communications Interface (Wired and/or Wireless)

Fig. 2

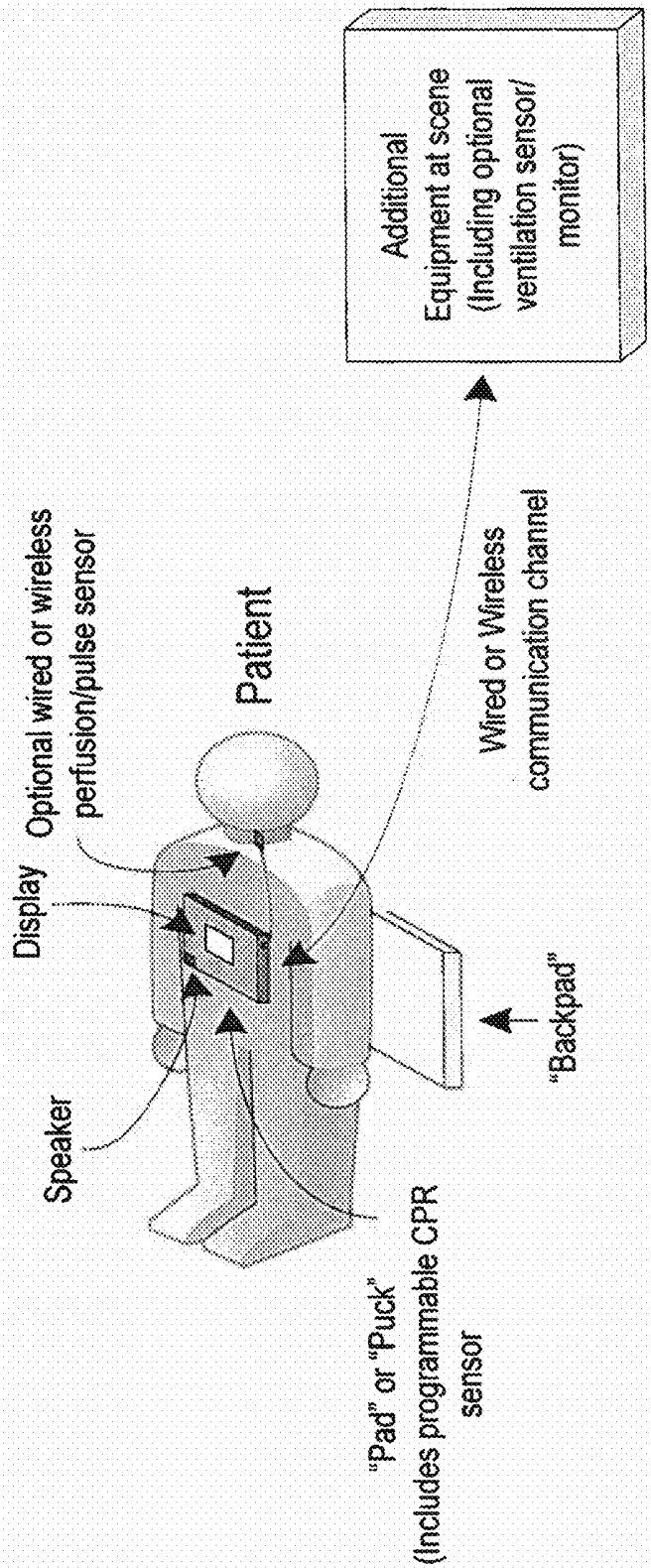

Additional Equipment at scene (Including optional ventilation sensor/ monitor)
Wired or Wireless communication channel
Patient
Optional wired or wireless perfusion/pulse sensor
Display
Speaker
"Backpad"
"Pad" or "Puck" (Includes programmable CPR sensor

Fig. 3

30

Fig. 4

40

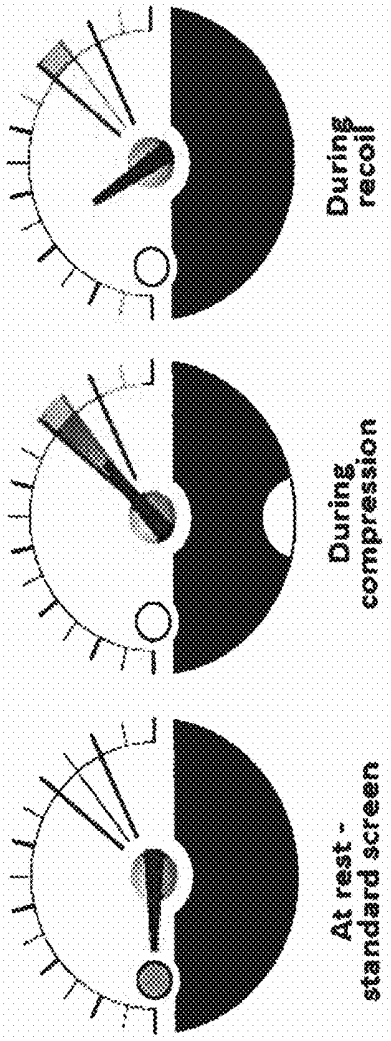


Fig. 5

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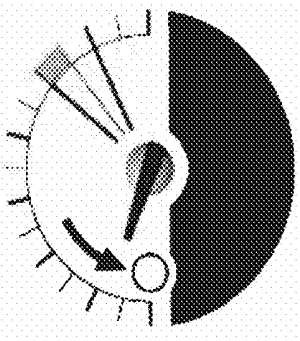

Fig. 6

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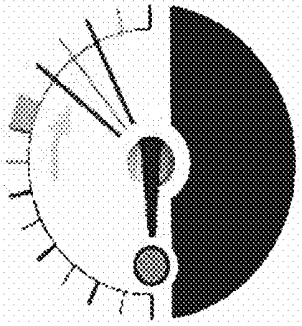
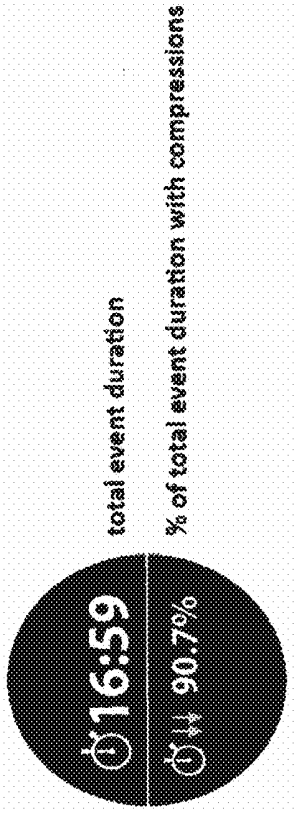
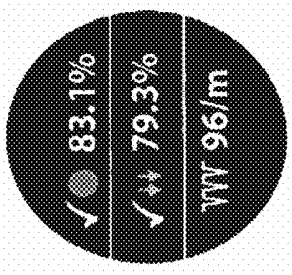


Fig. 7

70


16:59
total event duration
90.7%
% of total event duration with compressions


83.1%
% of compressions with proper recoil
79.3%
% of compressions with depth in target range
96/m
trimmed mean compression rate

PROGRAMMABLE CARDIOPULMONARY RESUSCITATION (CPR) DETECTION DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This disclosure is a continuation of U.S. application Ser. No. 14/837,773, filed Aug. 27, 2015, which will as U.S. Pat. No. 10,182,965 on Jan. 22, 2019, which is a continuation of U.S. application Ser. No. 13/306,933, filed Nov. 29, 2011, now U.S. Pat. No. 9,149,411, issued on Oct. 6, 2015, which claims benefit of U.S. Provisional Application Ser. No. 61/417,801, filed Nov. 29, 2010; each disclosure of which is hereby incorporated by reference in their entirety.

TECHNICAL FIELD

[0002] The present invention relates generally to cardiopulmonary resuscitation (CPR) feedback systems.

BACKGROUND

[0003] By forcing blood through the circulatory system and thereby maintaining oxygen distribution throughout a patient's body, cardiopulmonary resuscitation (CPR) can drastically improve the chance of survival for the patient experiencing cardiac failure.

[0004] According to the 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care, in most emergencies, the quality of CPR provided by the rescuer can make the difference between life and death. An effective compression rate is recommended as that of 100 chest compressions per minute at a compression depth of about 4-5 cm. Unfortunately, even trained professionals often do not perform CPR correctly. An automated audio-visual CPR feedback device can greatly assist a rescuer in correcting his or her CPR administering technique and thereby improve a patient's chance of survival.

[0005] Attempts are being made to develop and improve CPR automated-feedback devices. The chest compression rate is highly correlated to the spontaneous return of circulation after cardiac arrest. CPR feedback devices to-date are stand-alone devices, unable of real-time communication and corroboration with other devices, including medical devices. Often, CPR is administered when unnecessary or is not administered when necessary. Studies have found that compressions are often not delivered when cardiovascular circulation was absent. Corroboration with other devices would be highly desirable in selecting the most appropriate course of therapy. Further, existing CPR feedback devices lack programmable user-interfacing and setting options. Such device/user interfacing would be most desirable in providing patient and user custom-tailored and flexible CPR feedback most fit to both the patient and the rescuer.

[0006] Time after time studies find that often, even when administered by trained professionals, cardiopulmonary resuscitation (CPR) compression rates and depth are inadequate. Too week, shallow or too forceful compressions may contribute to suboptimal patient outcome. Several parameters are crucial for optimal and properly-administered CPR. Crucial parameters include proper hand positioning on the patient's chest, depth of compression of 4-5 cm, and compression rate of 100 compressions per minute. The crucial parameters are often affected by patient parameters, and relative to the patient, rescuer parameters, such as patient thoracic volume; weight; age; gender; and rescuer's, relative to the patient's, parameters, such as weight, height; physical form, etc. Proposed here is an automated CPR feedback device with user programmable settings for assisting with real-time feedback and subsequently correcting rescuers patient customized CPR technique.

[0007] Accordingly, a CPR feedback device that is capable of being pre-programmed by a user and further able to communicate with additional devices would be highly desirable. Furthermore, other desirable features and characteristics of the present invention will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and the foregoing technical field and background.

BRIEF SUMMARY

[0008] A programmable device for cardiopulmonary resuscitation ("CPR device") integrates a voice module and an automated rescue feedback. In one embodiment the CPR device is programmed to automatically provide real-time synchronization with an Automated External Monitor/Defibrillator (AED), allowing the AED to take control over the CPR device. The AED becomes a master controlling device dictating the rate and assessing performance of the CPR device. Feedback on chest compression rate, depth and quality are transmitted to the master controlling device, which then assesses and guides a user in providing an optimal quality CPR compression rate and performance, and further assess and select a best-fit treatment protocol.

[0009] In one embodiment, a user pre-programs voice prompts, compression rate, tones, rhythm, volume, and other biophysical parameters needed for resuscitation or communications. Configuration of the CPR device can also be managed remotely, either by a hand-held device, or a computer, such as a laptop or desktop.

[0010] The CPR feedback device includes an application interface, allowing real-time display of information on a remote display, which may include an AED, a hand-held device such as a mobile phone, a personal computer, a laptop. The data can be displayed in real time as well as post-event. The display of CPR activity, in one embodiment, comprises depth compression waveforms, force compression waveforms, biophysical parameters, inactive time, elapsed time, compressions delivered, ventilations delivered, proper hand repositioning warnings.

[0011] In a further embodiment, the CPR device settings can be changed by a user. The settings comprise target or range of compression depth; fixed compression depth range; relative to chest size and thickness compression depth range, compression rate, prompting language, prompting volume level, time allowed for inactivity; audio alarms; visual alarms; event timing; custom configuration to an individual patient; ventilation prompts; on and off prompts; number of ventilations, number of compressions before ventilations. Other CPR activity and settings may be pre-set.

[0012] In a further embodiment, the CPR device communicates with a plurality of external and internal devices. For example, the CPR device is able through either wired or wireless settings to communicate with other devices. The CPR device is capable of receiving and sending data. The CPR device is further able to receive data regarding settings and is programmed and reprogrammed by another device

within a network. The data can also be stored and transferred from the CPR device for a post-event review and analysis.

[0013] In a further embodiment, the CPR device and an AED are synchronized and corroborate to carry out the most optimal CPR and shock delivery and therapy engaging different therapy protocols depending on baseline assessment of the individual patient.

[0014] Different therapy protocols can be automatically recommended and engaged based upon patient parameters detected by both the CPR device and an AED. Thus, based on corroboration between the CPR device with an AED, accelerates decision-making and therapy within crucial to the patient time window. For example, based on the data acquired by the CPR device/AED combination, a stimulus signal is applied to a patient. The stimulus signal elicits mechanical and electrical cardiac response from the heart. The stimulus signal maintains mechanical capture until defibrillation therapy is administered. The application of the stimulus signal is desirable to enhance the patient's responsiveness to the defibrillation therapy, and is used instead of continuing CPR.

[0015] Still other embodiments of the present invention will become readily apparent to those skilled in the art from the following detailed description, wherein is described embodiments of the invention by way of illustrating the best mode contemplated for carrying out the invention. As will realized, the invention is capable o other and different embodiments and its several details are capable of modifications in various obvious respects, all without departing from the spirit and the scope of the present invention. Accordingly, the drawings and detailed description are to be regarded as illustrative in nature and not as restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] A more complete understanding of the present invention may be derived by referring to the detailed description and claims when considered in conjunction with the following figures, wherein like reference numbers refer to similar elements throughout the figures.

[0017] FIG. **1** is an illustration of a programmable CPR device applied to an emergency event environment, in accordance with one embodiment;

[0018] FIG. **2** is a block representation of a programmable CPR device, in accordance with an example embodiment of the invention;

[0019] FIG. **3** is a block diagram of one embodiment of a programmable CPR device, according to an example embodiment of the invention;

[0020] FIG. **4-6** are illustrative examples of one embodiment of CPR device representations of feedback to a user; and

[0021] FIG. **7** is an illustration of post-event data obtained using one of the resuscitation protocols selected via optimization process, in accordance with one embodiment.

DETAILED DESCRIPTION

[0022] The following detailed description is merely exemplary in nature and is not intended to limit the invention or the application and uses of the invention. For example, a practical embodiment of the invention may be deployed in connection with CPR feedback device, an automatic or automated external defibrillator, a semi-automatic or semi-automated external defibrillator, a manual external defibrillator, patient monitoring systems, and possibly implantable defibrillator devices. Furthermore, there is no intention to be bound by any expressed or implied theory presented in the preceding technical field, background, brief summary or the following detailed description.

[0023] The invention may be described herein in terms of functional and/or logical block components and various processing steps. It should be appreciated that such block components may be realized by any number of hardware, software, and/or firmware components configured to perform the specified functions. For example, an embodiment of the invention may employ various integrated circuit components, e.g., memory elements, digital signal processing elements, logic elements, look-up tables, or the like, which may carry out a variety of functions under the control of one or more microprocessors or other control devices. In addition, those skilled in the art will appreciate that the present invention may be practiced in conjunction with any number of practical CPR, defibrillator systems, emergency and hospital wired and wireless networks, and that the system described herein is merely one exemplary application for the invention.

[0024] For the sake of brevity, conventional techniques related to CPR devices and systems, detection of non-perfusing cardiac rhythms, estimation of the probability of defibrillation pulse success based on VF waveform characteristics, defibrillator device operation, the detection of electrical capture of the heart, the detection of mechanical capture of the heart, resuscitation techniques and protocols, and other functional aspects of the systems (and the individual operating components of the systems) may not be described in detail herein. Furthermore, the connecting lines shown in the various figures contained herein are intended to represent example functional relationships and/or physical couplings between the various elements. It should be noted that many alternative or additional functional relationships or physical connections may be present in a practical embodiment.

[0025] As mentioned above, a device configured in accordance with the invention detects, in response to a diagnostic signal applied to the patient, physiologic responses from the patient. As used herein, a "physiologic response" means a measurable or detectable reaction, condition, effect, or characteristic of the patient or any biological system of the patient, including, for example, a neurological response, a muscular response, a cardiac response, or the like. Resuscitation protocols include one of or a combination of CPR, drugs, defibrillation therapy, or the like.

[0026] FIG. **1** depicts a programmable CPR assist/device in a network system **10** that is configured to optimize and deliver CPR/defibrillation therapy to a patient **12**, such as a victim of ventricular fibrillation ("VF"). The environment system **10** includes, but is not limited to, a the CPR feedback device ("CPR device") **11**, external sensors and perfusion sensors **15**, and any additional devices **16** such as by way of example an external defibrillator device having a wired and/or wireless communication channel between one or more devices and external network communicating with emergency and hospital unit (not shown). The environment system **10** further includes a user who is the rescuer, or device operator. As used herein, a "user" of a CPR feedback device or defibrillator or monitoring system includes, without limitation: an operator, a caregiver; a rescuer; medical personnel; a clinician; or any person having manipulative

access to the CPR device, defibrillator or monitoring system. Unless otherwise indicated, these terms may be interchangeably used in the following description.

[0027] A therapy protocol may begin be recommended for initiating CPR in lieu of immediate defibrillation. In situations where electrical cardiac response is not obtained, it might be better to administer CPR and possibly other modes of therapy rather than spend valuable time performing defibrillation. In practice, CPR is performed by the caregiver. In addition to CPR, it may be recommend or administer other modes of therapy prior to defibrillation. For example, one or more of the following may be performed at this time: CPR; ventilation; drug therapy; pacing; PESP; or other electrical therapy. In a practical embodiment, resuscitation process may be re-entered at query task after an appropriate amount of CPR has been administered to the patient. Consequently, the diagnostic techniques described above can be utilized before and/or after defibrillation therapy.

[0028] FIG. **2** is a block diagram for the programmable CPR device **20**, comprising a display, an audio input/output, such as a speaker and a microphone, user interface including controls, programmable microcontroller/processor for entering setting variables and processing inputs and output, a CPR depth and rate sensor, and a communications interface, which could be wired or wireless. The CPR device settings can be changed by a user or a remote device. The settings comprise target or range of compression depth; fixed compression depth range; relative to chest size and thickness compression depth range, compression rate, prompting language, prompting volume level, time allowed for inactivity; audio alarms; visual alarms; event timing; custom configuration to an individual patient; ventilation prompts; on and off prompts; number of ventilations, number of compressions before ventilations. Other settings apparent to one skilled in the art are possible.

[0029] Several parameters are crucial targets for optimal and properly-administered CPR. Target parameters include proper hand positioning on the patient's chest, depth of compression of 4-5 cm, and compression rate of 100 compressions per minute. The crucial parameter settings are often affected by patient parameters, and relative to the patient, rescuer parameters, such as patient thoracic volume; weight; age; gender; and rescuer's, relative to the patient's, parameters, such as weight, height; physical form, etc. Proposed here is an automated CPR feedback device with user programmable settings for assisting with real-time feedback and subsequently correcting rescuers patient customized CPR technique. Other settings apparent to one skilled in the art are possible.

[0030] FIG. **3** is an illustration of one embodiment of the programmable CPR device **11** positioned on a patient's chest. The CPR device includes a visual display, a speaker and a programmable CPR sensor, which may also be called a "pad" or "puck." A backpad is used when needed to ensure proper reflective support against compressions. In one embodiment, a resuscitation protocol performed when the patient does not respond to the diagnostic signal, i.e., neither mechanical cardiac response nor electrical cardiac response is detected.

[0031] The CPR device preferably includes a user interface. FIGS. **4-6** are illustrations of one type of visual display and feedback to the user. In this embodiment, the visual display is configured to represent outputs measured during resuscitation event. The information is available to the user who then can visually verify or improve his or her compressions rhythm and depth as exerted on a patient in real-time. For example, display can feature a dial, or a speedometer indicating relative compression depths with ranges indicative of rest state, optimal compression, and recoil. A counter per minute can sound out each compression and a series of sequential rhythm or sounds for each compression cycle. The hand or arrow in the dial or speedometer responds to each compression cycle and shows the user whether optimal or sub-optimal compression has been achieved. The display can further keep track of number of compressions and issue commands and responses which can either instruct to correct or maintain the rhythm and depth. In a further embodiment, voice prompts and feedback are included. In one example, a rhythmic sound of compressions is accompanied with feedback advising of the percentage of recoil, or depth target reached. Other visual and audio representations are possible.

[0032] FIG. **7** illustrates one embodiment of post-event feedback comprising percentage of compressions with proper recoil; percent of compressions with depth in target range; trimmed mean compression rate; total event duration; and percentage of total duration with compressions.

[0033] Alternatively, or additionally, post-event data may be transferred to a remote computing device using portable storage media. For example, the post-event data can be transferred or copied from memory onto a portable storage device for transport to the remote computing device.

[0034] Although the present invention has been particularly shown and described with reference to embodiments, those skilled in the art will understand that the foregoing and other changes in form and detail may be made therein without departing from the spirit and scope of this disclosure. Further, presently unforeseen or unanticipated alternatives, modifications, variations, or obvious improvements therein may be subsequently made by those skilled in the art, which are also intended to be encompassed by the following claims.

1. A method of delivering a resuscitation therapy protocol to a patient, comprising:

receiving, at a cardiopulmonary resuscitation (CPR) device, at least a portion of one or both of perfusion and cardiac motion of the patient;

receiving, at a medical device configured to deliver defibrillation therapy to the patient, at least a portion of the one or both of the perfusion and the cardiac motion of the patient;

determining a baseline assessment of the patient based, at least in part, on the one or both of the perfusion and the cardiac motion of the patient;

instructing the CPR device and the medical device to initiate a synchronized therapy protocol that coordinates delivery of CPR by the CPR device with defibrillation therapy by the medical device, the synchronized therapy protocol based on the baseline assessment of the patient.

2. The method of claim **1**, further comprising receiving the one or both of perfusion and cardiac motion of the patient from one or more sensors coupled to the patient and configured to detect one or both of the perfusion and the cardiac motion of the patient.

3. The method of claim 2, further comprising:
determining the baseline assessment of the patient at both the CPR device and the medical device configured to deliver defibrillation therapy to the patient;
corroborating the baseline assessment of the patient determined by the CPR device with the baseline assessment of the patient determined by the medical device; and
instructing the CPR device and the medical device to initiate the synchronized therapy protocol based on the corroborated baseline assessment of the patient.

4. The method of claim 1, further comprising automatically instructing the CPR device and the medical device to initiate the synchronized therapy protocol.

5. The method of claim 1, wherein the at least the portion of the one or both of the perfusion and the cardiac motion of the patient received by the CPR device differs from the one or both of the at least the portion of the perfusion and the cardiac motion of the patient received by the medical device.

6. The method of claim 1, wherein the at least the portion of the one or both of the perfusion and the cardiac motion of the patient received by the CPR device is the same as the one or both of the at least the portion of the perfusion and the cardiac motion of the patient received by the medical device.

7. The method of claim 1, wherein the synchronized therapy protocol includes delivering CPR before delivering defibrillation therapy to the patient.

8. The method of claim 1, wherein the synchronized therapy protocol includes delivering CPR and determining whether defibrillation therapy is indicated for the patient after delivery of the CPR.

9. The method of claim 1, further comprising delivering a stimulus signal to the patient based on the baseline assessment, the stimulus signal eliciting a mechanical and electrical cardiac response from the patient.

10. The method of claim 9, further comprising, via the stimulus signal, maintaining mechanical capture of the patient based on the mechanical and electrical cardiac response elicited by the stimulus signal.

11. The method of claim 10, further comprising maintaining the mechanical capture until defibrillation therapy is delivered to the patient according to the synchronized therapy protocol.

12. The method of claim 10, further comprising instructing the CPR device to stop delivering or never begin CPR of the patient while the mechanical capture of the patient is maintained and until defibrillation therapy is delivered.

13. A resuscitation therapy system, comprising:
a one or more patient sensors configured to detect one or both of perfusion and cardiac motion of a patient;
a CPR device configured to deliver CPR therapy to the patient, the CPR device also configured to receive at least a portion of the one or both of perfusion and cardiac motion of the patient from the one or more patient sensors;
a medical device configured to deliver defibrillation therapy to the patient, the medical device also configured to receive at least a portion of the one or both of perfusion and cardiac motion of the patient from the one or more patient sensors; and
a processor configured to:
determine a baseline assessment of the patient based on the one or both of perfusion and cardiac motion of the patient received by the CPR device and the medical device;
identify a synchronized therapy protocol that includes delivery of one or both of CPR and defibrillation therapy to the patient, the synchronized therapy protocol based, at least in part, on the determined baseline assessment of the patient;
instruct the CPR device and the medical device to initiate the synchronized therapy protocol.

14. The system of claim 13, wherein the one or more patient sensors are integrated into both of the CPR device or the medical device.

15. The system of claim 13, wherein a first portion of the one or more patient sensors are integrated into the CPR device and a second portion of the one or more patient sensors are integrated into the medical device.

16. The system of claim 13, wherein the processor is further configured to:
determine the baseline assessment both:
based on the at least the portion of the one or both of the perfusion and the cardiac motion of the patient received by the CPR device, and
based on the at least the portion of the one or both of the perfusion and the cardiac motion of the patient received by the medical device;
corroborate the baseline assessment determined for the CPR device with the baseline assessment determined for the medical device; and
identify the synchronized therapy protocol based, at least in part, on the corroborated baseline assessment.

17. The system of claim 13, wherein the at least the portion of the one or both of the perfusion and the cardiac motion of the patient that is received at the CPR device differs from the at least the portion of the one or both of the perfusion and the cardiac motion of the patient received at the medical device.

18. The system of claim 13, wherein the at least the portion of the one or both of the perfusion and the cardiac motion of the patient that is received at the CPR device is the same as the at least the portion of the one or both of the perfusion and the cardiac motion of the patient that is received at the medical device.

19. The system of claim 13, wherein the synchronized therapy protocol includes delivering CPR to the patient, receiving additional perfusion and cardiac motion of the patient after delivery of CPR, and assessing whether to deliver CPR after receiving the additional perfusion and cardiac motion of the patient after delivery of the CPR.

20. The system of claim 13, wherein the processor is further configured to:
deliver a stimulus signal to the patient based on the baseline assessment, the stimulus signal eliciting a mechanical and electrical cardiac response from the patient;
with the stimulus signal, maintain a mechanical capture of the patient based on the mechanical and electrical cardiac response elicited by the stimulus signal, the mechanical capture of the patient maintained instead of delivering CPR to the patient; and
identify the synchronized therapy protocol to deliver defibrillation therapy to the patient during or after the maintenance of the mechanical capture of the patient.

* * * * *

专利名称(译)	可编程心肺复苏（CPR）检测装置		
公开(公告)号	US20190151191A1	公开(公告)日	2019-05-23
申请号	US16/250819	申请日	2019-01-17
申请(专利权)人(译)	生理控制，INC.		
当前申请(专利权)人(译)	生理控制，INC.		
[标]发明人	COLEMAN MICHA NOVA RICHARD C WILKINSON MAEGAN P DAYNES JOHN C APPERSON RYAN W		
发明人	COLEMAN, MICHA NOVA, RICHARD C. WILKINSON, MAEGAN P. DAYNES, JOHN C. APPERSON, RYAN W.		
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优先权	61/417801 2010-11-29 US		
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摘要(译)

一次又一次的研究发现，即使由经过培训的专业人员进行管理，心肺复苏（CPR）压缩率和深度也不足。太周，浅或过强的按压可能导致患者不理想的结果。几个参数对于最佳和适当管理的CPR至关重要。关键参数包括患者胸部的适当手部定位，4-5厘米的压缩深度和每分钟100次按压的压缩率。关键参数通常受患者参数影响，并且相对于患者，救助者参数，例如患者胸部容积;重量;年龄;性别;和救援人员相对于患者的参数，如体重，身高;提出了一种自动CPR反馈设备，其具有用户可编程设置，用于辅助实时反馈并随后纠正救援人员定制的CPR技术。