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(54) **ISCHEMIA-DETECTOR AND METHOD FOR OPERATING SUCH DETECTOR**

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(75) Inventor: **Raul Chirife**, Buenos Aires (AR)

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Correspondence Address:  
**HAHN LOESER & PARKS, LLP**  
**One GOJO Plaza**  
**Suite 300**  
**AKRON, OH 44311-1076 (US)**

(57) **ABSTRACT**

An ischemia detection apparatus comprises an impedance measuring stage connected to an electrode lead connector. The electrode lead connector is adapted to be connected to at least two intracardiac and/or epicardial electrodes and to produce an impedance signal indicative of a measured impedance between the electrodes. An ischemia detector is connected to the impedance measuring stage and a memory for impedance signal values. The ischemia detector is adapted to evaluate the impedance signal by determining a change in endsystolic impedance consistent with ischemia and to develop a control signal indicative of ischemia (ischemia signal).

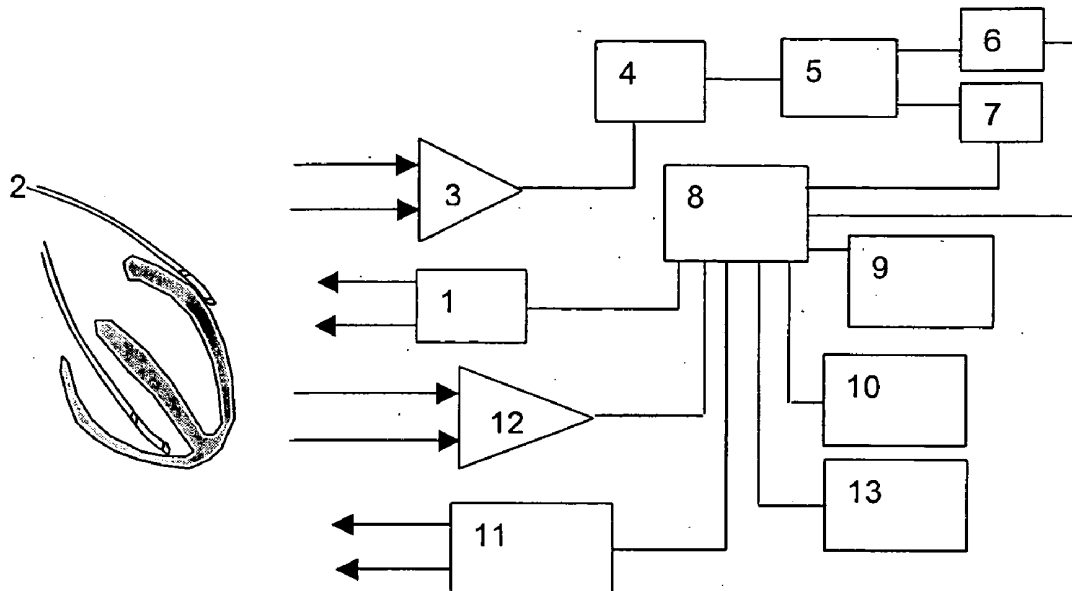
(73) Assignee: **BIOTRONIK CRM Patent AG**, Baar (CH)

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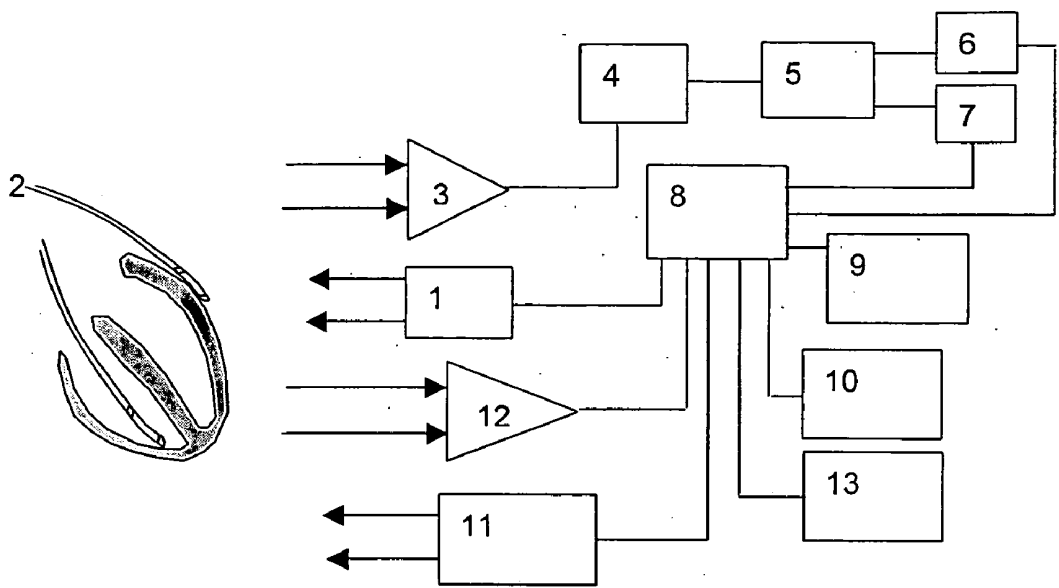


Fig. 1

### HEMODYNAMICS DURING ISCHEMIA

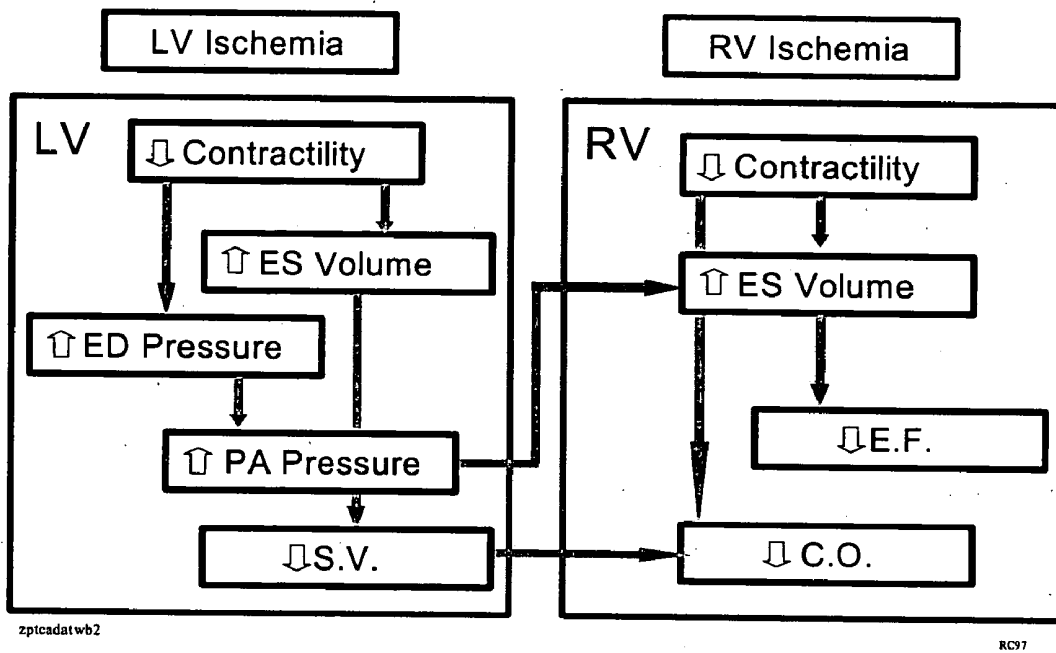


Fig. 2

## ISCHEMIA-DETECTOR AND METHOD FOR OPERATING SUCH DETECTOR

### BACKGROUND OF THE INVENTION

[0001] The invention relates to an ischemia detection apparatus comprising an ischemia detector. The invention also relates to an implantable medical device comprising such ischemia detector. The implantable medical device preferably is a heart stimulator such as a cardiac pacemaker, defibrillator, cardioverter or the like. Such medical implantable device becomes an ischemia detection apparatus by virtue of such ischemia detector.

### SUMMARY OF THE INVENTION

[0002] The ischemia detection apparatus comprises an impedance measuring stage being connected to an electrode lead connector. Said electrode lead connector is adapted to be connected to at least two intracardiac and/or epicardial electrodes and to produce an impedance signal indicative of a measured impedance between said at least two electrodes. When operating the ischemia detection apparatus, the measured impedance is an intracardiac impedance which depends to a major extent on the blood filling of a heart's chamber like a right or a left ventricle of the heart.

[0003] An ischemia detector is connected to the impedance measuring stage and a memory for impedance signal values. The ischemia detector is adapted to determine the presence of an ischemia by evaluating measured intracardiac impedance values.

[0004] Ischemia detection apparatuses or implantable medical devices (IMDs) incorporating an ischemia detector responsive to a measured intracardiac impedance are known from the prior art, see U.S. Pat. Nos. 6,604,000 and 6,256,538. Known methods to determine the presence of an acute ischemia based on measured intracardiac impedance values rely on the evaluation of magnitude of the impedance waveform during a cardiac cycle as this magnitude reflects the difference between the maximum and the minimum of blood filling during one cardiac cycle.

[0005] The invention seeks to provide for an alternative ischemia detection apparatus and an alternative ischemia detector responsive to intracardiac impedance values.

[0006] According to the invention, this object is achieved by an ischemia detector in an ischemia detection apparatus or an implantable medical device (IMD) as set out in the introduction, wherein the ischemia detector is adapted to respond to a change in an impedance signal reflected in the endsystolic impedance of at least two different cardiac cycles.

[0007] The ischemia detector according to the invention responds to the ratio of or the difference between an actual endsystolic impedance value and a stored reference endsystolic impedance value, respectively. Both the ratio or the difference between an actual and a stored impedance value are characteristic for a change of endsystolic impedance.

[0008] As further discussed later in this document, the invention is based on the fact, that a change in endsystolic impedance alone can be used to detect the onset of ischemia. This fact is not reflected in the prior art.

[0009] Preferably, the ischemia detector compares an actual endsystolic impedance value to a reference impedance value depending on at least one past endsystolic impedance value.

[0010] As an endsystolic impedance value for a single cardiac cycle, the maximum value of the measured intracardiac impedance during the cardiac cycle can be taken as will be set out later in this document. Therefore, in a preferred embodiment, the ischemia detector is adapted to determine an endsystolic impedance value for cardiac cycle by determining the maximum impedance measured by the impedance measuring stage during a cardiac cycle.

[0011] Preferably, the ischemia detector comprises a long term averaging stage being adapted to determine a long term average value from a plurality of endsystolic impedance values, the long term averaging stage being connected to a long term endsystolic impedance average memory. Said long term average impedance value preferably constitutes the reference impedance value, which is to be compared to an actual impedance value in the preferred embodiment.

[0012] In the preferred embodiment, the ischemia detector comprises a short term averaging stage being adapted to determine a short term average value from a plurality of endsystolic impedance values, the short term averaging stage being connected to a short term endsystolic impedance average memory. The short term average endsystolic impedance value is preferably used as the actual impedance value to be compared to the reference impedance value in the preferred embodiment.

[0013] For comparing the actual impedance value with the reference impedance value in a preferred embodiment, the ischemia detector comprises a comparator, said comparator being adapted to compare an actual endsystolic impedance value to a stored impedance value. The stored impedance value forms the reference value and is given by the long term average impedance value. The actual impedance value depends on the short term average impedance value derived from measured endsystolic impedance values determined for a plurality of cardiac cycles.

[0014] Both, the short term average endsystolic impedance value and the long term average endsystolic impedance value are preferably calculated as moving averages of measured endsystolic impedance values for a number of cardiac cycles. Of course, the number of cardiac cycles considered to calculate the long term average endsystolic impedance value is larger than the number of cardiac cycles considered to calculate the short term average endsystolic impedance value.

[0015] In a preferred embodiment, it is the comparator of the impedance detector, which is adapted to determine whether or not the ratio or the difference between the actual endsystolic impedance value and the stored impedance value exceeds a preset threshold value. Therefore, it can be stated, that the impedance detector according to the invention compares the actual impedance value with stored impedance value, thereby generating a signal reflecting the ratio or the difference between the two values as a result of this kind of comparison. The signal thus generated is then compared to a threshold value for the ratio or the difference in a second kind of comparison. Both the kinds of comparison may be considered as to parts of a more general comparison between

the actual (short term) and the stored (long term, reference) endsystolic impedance values.

[0016] In a particularly preferred embodiment, the comparator is connected to a timer, said timer being adapted to determine the duration of a time period during which the ratio or difference between the actual endsystolic impedance value and the stored impedance value exceeds the preset threshold value. Only if the ratio or the difference between the actual and the stored endsystolic impedance value exceeds the preset threshold value for more than a preset time period, an ischemia signal reflecting the detection of cardiac ischemia is generated by the ischemia detector or the ischemia detecting apparatus, respectively. The time may be of the time out type, which generates a time-out signal if not reset before a preset time. In such an embodiment, the time out timer would be started by the comparator, if the ratio or the difference between the actual and the stored impedance value exceeds the preset threshold. The timer would be reset, if the comparator detects that the ratio or the difference between the actual and the stored impedance value becomes smaller than the preset threshold value while the timer is running. If the timer runs out prior to its timeout, that is, if the timer is not reset or stopped by the comparator prior to time out, a time out signal is generated which corresponds to a ischemia signal, or, which in fact is the ischemia signal. It will be appreciated that such ischemia detector can easily be realized by one skilled in the art.

[0017] The apparatus and method for myocardial ischemia detection according to the invention uses intracardiac impedance. Unlike conventional hemodynamic sensors, the impedance sensor does not require sensor hardware in the leads since it uses conventional pacing-type electrodes. The device could be implantable or external, and uses specific changes in the impedance waveform to detect the onset and end of an ischemic episode. Impedance detection is achieved using a plurality of standard implantable grade electrodes placed within the ventricle, on the surface of the heart (epicardial or coronary transvenous) or any combination thereof. The impedance apparatus is preferably DC-coupled, and the signal is analyzed by an algorithm that takes into account the time course, duration and extent of one or more hemodynamic parameters obtained from cardiac impedance. Ischemia detection by implantable devices could be used to warn the patient to contact his/her doctor, to transmit the event to monitoring devices, to store the event for further analysis and to effect a change in the operating characteristics of the device, such as rate reduction (pacemaker), drug infusion, nerve stimulation and the like.

[0018] Ischemia is the imbalance between myocardial oxygen supply and demand. It is generally the result of obstruction of the blood vessels providing nourishment to the heart muscle, the coronary arteries. Obstruction of these blood vessels occurs slowly due to a variety of genetic, dietary, environmental and other causes known as risk factors, and is clinically manifested when the obstruction is severe and when the patient is subject to cardio-circulatory stress, such as emotion, exercise, high blood pressure and/or fast heart rate. All of these cause an increase in the oxygen demands by the myocardium, and since the supply is limited by obstruction of the arteries, the clinical manifestations of ischemia ensue. These are chest pains, arrhythmias, heart failure and eventually a myocardial infarction, which is the permanent damage caused by prolonged, unrelenting

ischemia. Although typical chest pain is an easily recognized symptom, this is not always the rule, for some patients may have ischemia without pain. The substrate of ischemia is the partial obstruction of the coronary arteries by an atheromatous plaque, diminishing blood flow to the heart muscle. Coronary arteries may present blockage of about 90% of the lumen of the vessel without symptoms at rest, due to the coronary flow reserve. Since the coronary arteries may also suffer from spasms that further reduce blood supply, ischemic episodes result from a combination of a fixed obstruction and spasm or spasm alone, which allows ischemia to occur during exercise as well as at rest.

[0019] Due to the high prevalence of ischemic heart disease, it is likely that a patient receiving a cardiac pacemaker implant may also suffer from ischemic heart disease, whether it be the typical variety with chest pain, or silent, without symptoms during the ischemic episode. Naturally, as soon as ischemia starts, a reduction of heart rate may prove beneficial to the patient, since heart rate is a major determinant of myocardial oxygen consumption. In fact, most patients with ischemia are treated with beta blockers. These are drugs that by virtue of reducing heart rate and the force of contraction, reduce also myocardial oxygen consumption, thus protecting the myocardium.

[0020] There are several clinical manifestations of ischemia.

[0021] Myocardial ischemia produces numerous clinical, electrocardiographic, hemodynamic, and metabolic manifestations. Typically, the clinical diagnosis of an acute ischemic episode is made by the analysis of the electrocardiogram, myocardial perfusion studies, radionuclide ventriculography, and others. Detection of ischemia from the intracardiac electrogram obtained from pacemakers is not possible, because the right ventricular endocardial electrode will show ischemic changes only when ischemia takes place in the close vicinity of the electrode. With biventricular pacemakers having an additional electrode in the surface of the left ventricle, detection may be slightly improved but still is severely limited, especially because biventricular pacing for the treatment of heart failure is permanent. Since ventricular capture interferes with ischemia detection, pacing may need to be temporarily stopped to visualize the intrinsic, unpaced electrogram for ischemia diagnosis.

[0022] There are also several hemodynamic manifestations of ischemia.

[0023] In the presence of reduced oxygen and nutrient supply, the heart muscle (myocardium) metabolism suffers and important functional changes take place. Both the force of systolic contraction (contractility) and the relaxation properties of the myocardium are adversely affected. Reduction of the force of contraction is manifested by a reduction of cardiac ejection fraction (the ratio between stroke volume and end-diastolic volume) and of cardiac output. Ischemia also affects the relaxation properties of the heart muscle by increasing its stiffness, that is, decreasing compliance. Alterations of the systolic function by ischemia have been documented by numerous publications of studies done in patients with coronary artery disease during exercise, using radionuclide ventriculography. This method allows the non-invasive measurement of global and regional myocardial contractility during exercise. In normal individuals, the ejection fraction and cardiac output increase during exercise, while in

patients with coronary lesions, at the onset of ischemia during effort there is a prompt and significant decrease in ejection fraction, reversing the normal, non-ischemic behavior. These changes usually appear promptly, and frequently precede the onset of chest pain and of alterations in the electrocardiogram, such as ST segment displacement and/or T wave inversion. These observations abound in the literature, and tests conducted in many patients using radionuclide ventriculography, confirm the value of hemodynamic indices to signal the onset of acute ischemia. Another typical hemodynamic marker of alterations of cardiac diastolic properties is a rise of left ventricular end-diastolic pressure. Also, there is abundant literature demonstrating that ischemia will cause a rise ventricular end-diastolic pressure, whichever the coronary artery or cardiac region is affected. In the clinical setting, left ventricular ischemia is far more common than right ventricular ischemia, but accessing the left ventricular cavity to measure end-diastolic pressure is more difficult and far more risky. Assessment of left ventricular end-diastolic pressure can be made by various non-invasive and invasive procedures. Among the former, the response of the arterial blood pressure during the Valsalva maneuver (forced expiration with closed glottis) marks the presence of an elevated end-diastolic pressure, and using invasive means, the introduction of a pressure catheter in the pulmonary artery through a venous puncture gives an estimate of diastolic left ventricular pressures. This procedure is facilitated by a balloon-tipped catheter (Swan-Ganz) which is guided by blood flow into the desired pulmonary vessel. The pulmonary artery pressure rises during left ventricular ischemia as a consequence of backward transmission of the left ventricular diastolic pressure through the pulmonary veins, capillaries, and branches of the pulmonary artery.

[0024] The invention is based on a novel approach for the diagnosis of ischemia using intracardiac impedance sensor.

[0025] Unpublished studies carried out during percutaneous transcoronary angioplasty (PTCA) or balloon angioplasty of the coronary arteries while recording right ventricular impedance (a marker of ventricular chamber volume) have shown significant and consistent changes of hemodynamic parameters obtained from the impedance waveform during occlusive balloon inflation in any of the main branches of the coronary arteries. The PTCA procedure is aimed at reopening a critical lesion in one or more coronary vessels by using a small balloon near the tip of a catheter guided by X-rays into the affected coronary artery. Inflation of the balloon causes flattening of the atheromatous plaque and reopening of the lumen, thus re-establishing blood flow. As expected, balloon inflation within a coronary artery the vessel is completely occluded by the balloon, thus causing a temporary ischemic episode similar in its clinical, hemodynamic, and metabolic manifestations to the spontaneous ischemic attack in the ambulatory patient. During balloon inflation patients frequently present typical ECG changes, drop in the arterial blood pressure and/or chest pains. Whether ischemia is caused by an increase of metabolic demands (due to rate and/or blood pressure rise) or coronary artery spasm (decreased supply), the hemodynamic manifestations are similar. In the above mentioned unpublished study, an immediate change in impedance-derived right ventricular hemodynamic parameters was observed when any coronary vessel (left anterior descending, circumflex, diagonal branch, right coronary artery and marginal branches) was occluded by balloon inflation. Naturally,

balloon inflation in arteries irrigating dead, infarcted myocardium did not cause any hemodynamic change nor any clinical manifestation. Of note is that occlusion of coronary arteries irrigating left ventricular myocardium also caused hemodynamic changes in the right ventricle. Findings are comparable to those observed with radionuclide ventriculography during exercise: reduction in ejection fraction is observed only when viable, although ischemic myocardium is present. Balloon angioplasty for the treatment of blocked coronary arteries thus offered an excellent model to study the hemodynamic manifestations of acute ischemia, and was also used to validate the hypothesis of this invention.

[0026] The object of the present invention is a pacemaker, defibrillator or other implantable or external device embodying an impedance sensor sensitive to ischemia that can be used for diagnosis or treatment. In the diagnostic mode, the device may warn the patient, transmit a signal via telemetry to monitoring devices and/or store data in the device memory for further analysis by the doctor. In the therapeutic mode, ischemia detection may effect a change in pacing parameters, produce nerve stimulation and/or initiate a drug delivery.

[0027] The IMD or ischemia detection according to the invention uses cardiac impedance as a hemodynamic marker.

[0028] There are numerous publications supporting the value of DC-coupled cardiac impedance as a marker of cardiac preload (right ventricular end-diastolic volume), contractility (ejection fraction, residual volume) and pump function (cardiac output). Above studies of patients during PTCA procedures indicated that DC-coupled intracardiac impedance provides estimates of key hemodynamic variables that are affected, whether the ischemia occurs in the right or left ventricle. These studies revealed that changes of end-systolic systolic impedance, a marker of end-systolic volume (residual volume) are indicators of the onset of ischemia, although the mechanisms by which the changes are apparent may differ depending on the site of ischemia. For example, left ventricular ischemia produced by temporary occlusion of the left anterior descending or diagonal coronary arteries (both irrigating left ventricular myocardium) would cause an immediate change in left ventricular diastolic compliance which in turn would cause a backward rise in the pulmonary veins, pulmonary capillaries and ultimately in the pulmonary artery. A pressure rise in the pulmonary artery causes an immediate change in right ventricular afterload (that is, the load the ventricle has to overcome to eject blood), and as a consequence of this, a rise in right ventricular end-systolic volume. In addition, it is well known that whatever hemodynamic changes take place in the left ventricle will be manifested in the right and vice-versa. Therefore, cardiac output changes occurring during left ventricular ischemia will be detected after a few seconds in the right side of the heart. FIG. 2 depicts above mechanisms.

#### BRIEF SUMMARY OF THE SEVERAL VIEWS OF THE DRAWINGS

[0029] A preferred embodiment of the invention shall now be disclosed with respect to the drawings. The drawings show in

[0030] FIG. 1: a cardiac pacemaker with an ischemia detector according to the invention; and

[0031] **FIG. 2:** a graphical representation of the hemodynamics during ischemia.

#### DETAILED DESCRIPTION OF THE INVENTION

[0032] Although there are numerous applications of the ischemia detection sensor, a cardiac pacemaker is described as an example for an ischemia detection apparatus in **FIG. 1**.

[0033] An apparatus comprises:

[0034] a) an impedance sensor, formed by an impedance detection circuit

[0035] b) a special ischemia detector

[0036] c) electrical and/or mechanical means to take an action after ischemia is detected.

[0037] In this example, a DC-coupled intracardiac impedance sensor is used allowing absolute values of end-diastolic (EDZ) and end-systolic impedance (ESZ) to be measured. The difference between EDZ and ESZ is the stroke impedance, a marker of stroke volume.

[0038] The impedance sensor circuit has a carrier oscillator **1** coupled to two or more cardiac electrodes **2**, which could be either intraventricular, epicardial or any combination thereof. The epicardial approach could be direct (epicardial electrode) or using a lead passed through a coronary vein. The resulting voltage of two or more of the sensing electrodes is directed to amplifier means **3**. Signal conditioner circuit **4** and amplifier means **3** are as described in U.S. Pat. No. 5,154,171.

[0039] The example herein refers to one of the various possible impedance methods. ESZ, a marker of end-systolic volume (residual volume) is used both as an index of right ventricular contractility and as an indicator of increased pulmonary artery pressure (a marker of left ventricular end-diastolic pressure). ESZ is measured in **5** and values are stored in a short-term moving average register **6** and a long term moving average register **7**. A CPU **8** incorporating memory and software calculates the ratio between the short-term over the long-term moving averages (ratio of registers **6** and **7**). If said ratio exceeds a programmable threshold value (to be assessed clinically in each patient), and lasts more than a programmable time as measured by timer circuit **9**, a signal is processed according to one or more of the following options: a) reducing pacing rate to diminish myocardial oxygen demands; b) send a warning signal to the doctor or hospital via remote monitoring systems; c) produce an audible or vibratory signal to warn the patient, d) activate a drug-delivery system and e), store the time and duration of the event in register **10**. Output means **11** deliver pacing pulses to intracardiac electrodes **2**. QRS sensing amplifier **12** implement conventional pacemaker demand function. Telemetry means **13** communicate with external programmer and/or monitoring device. Event register **9** may also have the capability to transmit by telemetry or in real time event markers detectable by surface ECG.

[0040] Now, the ischemia detection algorithm shall be described in detail:

[0041] The impedance sensor continuously measures ESZ, and the output is fed simultaneously to a long term

moving average register (which stores the value of ESZ averaged over several minutes, a programmable variable) and to a short term moving average register (which stores the value of ESZ of the last 30 seconds, also a programmable feature). The short/long term average ratio (S/L) is calculated and the resulting value reaches a decision node where if the ratio is smaller than a programmable value, there is indication of a significant and abrupt increase in ESZ, consistent with depressed contractility, or with a rise of LVEDP associated with ischemia. In this case, the long term average register is stopped, holding the last value as a future reference (at the end of ischemia), and an elapsed-time ischemia timer is initiated. If the duration of ischemia exceeds a programmable value, the pacemaker takes an action, as defined previously. In this example, the ischemia warning is stored in the pacemaker memory register **10** (**FIG. 2**). If ischemia detection time is shorter than a preselected threshold, the long term/short-term moving averages are restarted and the device is reset.

[0042] Thus, in order for ESZ change to be attributable to ischemia, the following two conditions must be met: 1. It must present a certain rate of change (a certain amount over a certain time). This is determined by the SA/LA ratio. The ischemia signal should also persist for at least a minimum programmable time (usually 1 to 3 minutes). This is determined by ischemia timer **9**.

[0043] If above two conditions are met, ischemia is suspected and a warning flag is set.

What is claimed is:

1. An ischemia detection apparatus comprising:

an impedance measuring stage connected to an electrode lead connector, said electrode lead connector being adapted to be connected to at least two intracardiac and/or epicardial electrodes and to produce an impedance signal indicative of a measured impedance between said at least two electrodes, and

an ischemia detector connected to the impedance measuring stage and a memory for impedance signal values, the ischemia detector being adapted to evaluate the impedance signal by determining a change in endsystolic impedance consistent with ischemia and to develop a control signal indicative of ischemia (ischemia signal).

2. An ischemia detection apparatus according to claim 1, wherein the ischemia detector is adapted to determine an endsystolic impedance value for a cardiac cycle by determining the maximum impedance measured by the impedance measuring stage during a cardiac cycle.

3. An ischemia detection apparatus according to claim 1, wherein the ischemia detector comprises a long term averaging stage adapted to determine a long term average value from a plurality of endsystolic impedance values, the long term averaging stage being connected to a long term endsystolic impedance average memory.

4. An ischemia detection apparatus according to claim 1, wherein the ischemia detector comprises a short term averaging stage being adapted to determine a short term average value from a plurality of endsystolic impedance values, the short term averaging stage being connected to a short term endsystolic impedance average memory.

5. An ischemia detection apparatus according to claim 1, wherein the ischemia detector comprises a comparator, said

comparator being adapted to compare an actual endsystolic impedance value to a stored impedance value.

6. An ischemia detection apparatus according to claim 5, wherein the stored impedance value is a long term endsystolic impedance average value.

7. An ischemia detection apparatus according to claim 5, wherein the actual impedance value is the short term endsystolic impedance average value.

8. An ischemia detection apparatus according to claim 7, wherein the comparator is adapted to determine whether or not the ratio or the difference between the actual endsystolic impedance value and the stored impedance value exceeds a preset threshold value.

9. An ischemia detection apparatus according to claim 7, wherein the comparator is connected to a timer, said timer being adapted to determine the duration of a time periode during which the ratio or the difference between the actual endsystolic impedance value and the stored impedance value exceeds the preset threshold value.

10. An ischemia detection apparatus according to claim 9, wherein the apparatus comprises a memory for storing impedance sensor values and/or waveform and/or ischemia detector output signals and for transmitting them via telemetry to a pacemaker programmer, to a patient warning device, to a home monitoring device or to a doctor's office.

11. An ischemia detection apparatus according to claim 10, wherein the apparatus comprises a pulse generator and a controller adapted for applying said control signal sensitive to ischemia to a pulse generator and/or a drug delivery system, to cause the pulse generator to generate pacing pulses to be applied to a pacing electrode to reduce myocardial oxygen consumption, and alleviate ischemia.

12. An ischemia detection apparatus according to claim 5, wherein the comparator is connected to a timer, said timer being adapted to determine the duration of a time periode during which the ratio or the difference between the actual endsystolic impedance value and the stored impedance value exceeds the preset threshold value.

13. An ischemia detection apparatus according to claim 1, wherein the apparatus comprises a drug delivery system and a controller adapted for applying said control signal sensitive to ischemia to the drug delivery system to cause the drug delivery system to deliver a drug to reduce myocardial oxygen consumption, and alleviate ischemia.

14. An ischemia detection apparatus according to claim 13, wherein the apparatus includes a VVI, DDD or multi-chamber cardiac pacemaker, comprising:

- a) a variable timing electronic pulse generator adapted for determining a rate at which pacing pulses are delivered to the heart, guided by a primary rate responsive sensor,

- b) a pulse applicator for applying said pulses to the heart,

- c) a memory for storing short term moving average values of the ischemia sensor,

- d) a memory for storing long term moving average values of the ischemia sensor,

- e) a calculator responsive to said short and long term moving average values to compute a ratio,

- f) a timer adapted to measure time over which said ratio exceeds a preprogrammed time limit,

- g) a computer to establish ischemia criteria based on said ratio and said time limit, and

- h) a controller adapted to reduce a primary sensor rate if ischemia criteria are met.

15. An ischemia detection apparatus according to claim 14, wherein the apparatus is adapted to communicate with an external programmer and to send the ischemia signal to a programmer and/or to a device for displaying a surface electrocardiogram to display the ischemia signal together with the electrocardiogram.

16. An ischemia detection apparatus according to claim 15, wherein said ischemia detector is adapted to generate an ischemia signal proportional to myocardial ischemia.

17. An ischemia detection apparatus according to claim 16, wherein the apparatus comprises a controller responsive to ischemia sensor signals alone or in combination with other detected parameters.

18. An ischemia detection apparatus according to claim 5, wherein the apparatus comprises a drug delivery system and a controller adapted for applying said control signal sensitive to ischemia to the drug delivery system to cause the drug delivery system to deliver a drug to reduce myocardial oxygen consumption, and alleviate ischemia.

19. An ischemia detection apparatus according to claim 3, wherein the stored impedance value is a long term endsystolic impedance average value.

20. An ischemia detection apparatus according to claim 1, wherein the apparatus comprises a memory for storing impedance sensor values and/or waveform and/or ischemia detector output signals and for transmitting them via telemetry to a pacemaker programmer, to a patient warning device, to a home monitoring device or to a doctor's office.

\* \* \* \* \*

专利名称(译)	缺血检测器和操作这种检测器的方法		
公开(公告)号	<a href="#">US20060241357A1</a>	公开(公告)日	2006-10-26
申请号	US11/349834	申请日	2006-02-08
[标]申请(专利权)人(译)	百多力CRM专利公司		
申请(专利权)人(译)	BIOTRONIK CRM专利AG		
当前申请(专利权)人(译)	CHIRIFE, 劳尔		
[标]发明人	CHIRIFE RAUL		
发明人	CHIRIFE, RAUL		
IPC分类号	A61B5/00		
CPC分类号	A61N1/36521 A61B5/0535		
优先权	2005075347 2005-02-09 EP		
外部链接	<a href="#">Espacenet</a> <a href="#">USPTO</a>		

摘要(译)

缺血检测装置包括连接到电极引线连接器的阻抗测量级。电极引线连接器适于连接到至少两个心内和/或心外膜电极，并产生指示电极之间测量的阻抗的阻抗信号。缺血检测器连接到阻抗测量级和用于阻抗信号值的存储器。缺血检测器适于通过确定与缺血一致的舒张末期阻抗的变化来评估阻抗信号，并产生指示缺血的控制信号（缺血信号）。

