IMPLANTABLE MEDICAL DEVICE HAVING A HIS BUNDLE ELECTRODE LEAD PORT

The present invention relates to an implantable medical device for stimulating a human or animal heart according to the preamble of claim 1, to an arrangement comprising such implantable medical device according to the preamble of claim 9, and to a method for programming such an implantable medical device according to the preamble of claim 15.

Implantable medical devices for stimulating a human or animal heart, such as pacemakers, have been known for a long time. They can perform different functions. Different stimulation programs can be carried out by an appropriate pacemaker to restore the treated heart to a normal state. It is also known to use conventional pacemakers for stimulating the His bundle, i.e., for His bundle pacing (HBP).

The His bundle is a bundle of specific heart muscle cells that is part of the cardiac conduction system. The His bundle is located distally of the atrioventricular node towards the apex of the heart. The His bundle forms part of the ventricular conduction system.

In case of His bundle pacing, a detecting (sensing) and stimulation electrode is not implanted into apex of the ventricle of the human or animal heart to be treated, but rather at or near to the His bundle of the heart. Such use of a His bundle electrode enables a particularly physiologic stimulation of the human or animal heart.

In many cases, conventional pacemakers are used for His bundle pacing. In such a case, the port to which the His bundle electrode is connected is provided with specific stimulation/sensing parameters in order to achieve an appropriate sensing of electric signals at the His bundle and to allow a sufficient and more physiologic stimulation of the

His bundle in case His bundle pacing is applied. Thus, there are special requirements for the His channel of an implantable medical device.

Furthermore, there exists a plurality of different implantable medical devices for stimulating a human or animal heart for a plurality of different clinical indications. Each clinical indication requires a specific functionality for His bundle pacing. An implementation of a dedicated His bundle pacing system depicts a very sophisticated task not only from a technical point of view but also regarding usability and safety. An implementation of all desirable HBP configurations would require a large number of additional variants of conventional implantable medical devices and their software applications.

Conventional implantable medical devices do not comprise an electrode lead port for receiving a His bundle electrode. Therefore, depending on the user (physician), a His bundle electrode may be connected to any of the available electrode lead ports of such a conventional implantable medical device. This manifests in confusion, false interpretation of the settings and measured data and wrong programming by the attending physician during the implantation procedure and follow-up examinations. This may cause dangerous, life threatening conditions of a patient.

Embodiments may provide an implantable medical device that is intended to be used for His bundle pacing and that allows a safer operation than prior art devices.

According to one aspect an implantable medical device is provided for stimulating a human or animal heart having the features of claim 1. Such an implantable medical device comprises a first processor, a first memory unit, a stimulation unit, a detection unit, and a first electrode lead port. The stimulation unit serves for stimulating a cardiac region of a human or animal heart. The detection unit serves for detecting an electrical signal at the same or a different cardiac region of the same heart. The first electrode lead port serves for receiving an electrode lead.

According to an aspect, the first electrode lead port comprises a first marking element and a second marking element. In this context, the first marking element indicates a first possible

kind of electrode lead that can be received by the first electrode lead port. Furthermore, the first marking element indicates for which kind of electrode lead the first electrode lead port is designed to be configured. Thus, the first marking element does not only denote the general suitability of the first electrode lead port to receive a specific kind of electrode lead, but also the general ability of this electrode lead port to be configured such to operate a connected electrode lead in a sensible way.

The first possible kind of electrode lead is a His bundle electrode lead. Thus, the first marking element indicates which electrode lead port is specifically configured to receive a His bundle electrode lead and can furthermore be controlled in such a way that it detects electric signals at the His bundle of the human heart with a connected His bundle electrode lead and/or to stimulate the His bundle of the human heart with a connected His bundle electrode lead. Thus, the first marking element indicates that the first electrode lead port of the implantable medical device is specifically adapted for His bundle pacing.

The second marking element indicates a second possible kind of electrode lead that can be received by the first electrode lead port. Furthermore, the second marking element indicates that the first electrode lead port is designed to be configured for the operation of such a second possible kind of electrode lead. In this context, the second possible kind of electrode lead is chosen from the group consisting of an atrial electrode lead, a right ventricular electrode lead, and a left ventricular electrode lead.

Consequently, the presence of the first marking element and the second marking element indicates that the first electrode lead port is intended to receive either a His bundle electrode lead or one of an atrial electrode lead, a right ventricular electrode lead, and a left ventricular electrode lead. Furthermore, the first marking element and the second marking element indicate that the first electrode lead port can be specifically configured such to operate either a His bundle electrode lead or an electrode lead of the second possible kind of electrode lead in a way that allows proper functioning of such electrode lead.

Consequently, a user like a physician is no longer left in doubt which electrode lead port of the implantable medical device is configured to receive a His bundle electrode or, if no His

bundle pacing is to be applied, an electrode of another (specifically defined) kind of electrode lead. Therefore, no space is left for confusion, false interpretation of settings or measured data nor for wrong programming of the implantable medical device. This, in turn, significantly reduces the risk of dangerous, life-threatening conditions of a patient to whom the implantable medical device is implanted for applying cardiac stimulation.

The implantable medical device is likewise appropriate for conventional cardiac stimulation and for His bundle pacing. Due to the first and second marking elements, its use is facilitated for both use cases. Therefore, a proper allocation of the target device port for a His bundle electrode upon implantation is made possible for all kinds of clinical applications. Furthermore, during clinical follow-ups, the measured signals, pacing behaviour and His bundle specific settings applied to the His bundle channel of the implantable medical device can unmistakably assigned and interpreted.

Due to the presence of the first marking element and the second element as well as the specific configurations of the first electrode lead port bearing the first marking element and the second marking element, the number of implantable medical devices being able for His bundle pacing and the number of software variants can be significantly reduced in comparison to the present situation, wherein all desirable His bundle pacing use cases are still covered and can be applied by the implantable medical device. Since the first electrode lead port bears the first marking element and the second marking element, it is adapted to receive either a His bundle electrode lead or a conventional electrode lead (namely a second possible kind of electrode lead). Thus, a selection between conventional cardiac stimulation and His bundle pacing is made possible.

In an embodiment, the configuration of the first electrode lead port for the operation of the first possible kind of electrode lead, i.e., the His bundle electrode lead, comprises at least one of i) providing dedicated sensing and/or pacing parameters for His bundle pacing that are different to those used in a conventional pacing configuration, ii) ensuring specialized His bundle pacing timing settings for treating bradycardia, iii) providing a well-matched device feature set for His bundle pacing, iv) ensuring a proper and safe patient support in all possible device operating modes and conditions (such as permanent pacing mode (standard

condition of the device) standard/normal mode, magnetic resonance imaging (MRI) mode, backup mode and any of the temporary test pacing modes).

In an embodiment, the implantable medical device is an implantable pulse generator (IPG), an implantable cardioverter-defibrillator (ICD), or a device for cardiac resynchronization therapy (CRT).

In an embodiment, the first memory unit comprises a first computer-readable program that causes the first processor to perform the steps explained in the following when executed on the first processor. First, a dataset is retrieved or received. The dataset indicates whether an electrode lead of the first possible kind of electrode lead or an electrode lead of the second possible kind of electrode lead is connected to the first electrode lead port. Retrieving such a dataset can be done by restoring it from the second memory unit. Receiving such a dataset can be done by using a (wireless) communication unit. The dataset may be received from a programming device. Furthermore, the first electrode lead port is operated with stimulation and/or sensing parameters that are specifically adapted for His bundle pacing if an electrode lead of the first possible kind of electrode lead is connected to the first electrode lead port. Alternatively, the first electrode lead port is operated with stimulation and/or sensing parameters being appropriate for conventional cardiac pacing if an electrode lead of the second possible kind of electrode lead is connected to the first electrode lead port. Consequently, the retrieved or received dataset determines the kind of operation (His bundle pacing or conventional pacing) of the implantable medical device.

In an embodiment, the kind of electrode lead connected to the first electrode lead port is automatically detected by the implantable medical device. In such a case, no dataset indicating the kind of connected electrode lead is necessary. Then, the operation of the implantable medical device can be controlled on the basis of the previously determined kind of electrode lead connected to the first electrode lead port, as explained in the preceding paragraph.

In an embodiment, the first electrode lead port comprises a third marking element. In this context, the third marking element indicates a third possible kind of electrode lead that can

be received by the first electrode lead port and for operation of which possible kind of electrode lead the first electrode lead port is specifically adapted. The third possible kind of electrode lead is chosen from the group consisting of an atrial electrode lead, a right ventricular electrode lead, and a left ventricular electrode lead. Thus, the first electrode lead port can be used to connect an electrode lead out of a plurality of different kinds of electrode leads.

In an embodiment, the second possible kind of electrode lead is an atrial electrode lead and the third possible kind of electrode lead is a right ventricular electrode lead. In this embodiment, the first electrode lead port is specifically configured to receive either an atrial electrode lead or a right ventricular electrode lead or a His bundle electrode lead. Furthermore, the first electrode lead port is specifically adapted to operate either an atrial electrode lead or a right ventricular electrode lead or a His bundle electrode lead in this embodiment.

In an embodiment, the second possible kind of electrode lead is a right ventricular electrode lead. In case of only two marking elements, the first electrode lead port is specifically configured, in this embodiment, to receive either a right ventricular electrode lead or a His bundle electrode lead.

In an embodiment, the implantable medical device additionally comprises a second electrode lead port. In this context, the second electrode lead port comprises a fourth marking element. The fourth marking element indicates a fourth possible kind of electrode lead that can be received by the second electrode lead port. Furthermore, the fourth marking element indicates that the second electrode lead port is specifically adapted for operation of an electrode lead of a fourth possible kind of electrode lead. The fourth possible kind of electrode lead is an atrial electrode lead. A combination of this embodiment and the precedingly explained embodiment results in a dual chamber implantable medical device comprising a first electrode lead port configured to receive and to operate a right ventricular electrode or a His bundle electrode and a second electrode lead port configured to receive and to operate a right atrial electrode.

In an embodiment, the implantable medical device additionally comprises a third electrode lead port. The third electrode lead port comprises a fifth marking element. In this context, the fifth marking element indicates a fifth possible kind of electrode lead that can be received by the third electrode lead port and for an operation of which fifth possible kind of electrode lead the third electrode lead port is specifically adapted. The fifth possible kind of electrode lead is a left ventricular electrode lead. A combination of this embodiment and the precedingly explained two embodiments results in a triple chamber implantable medical device comprising three electrode lead ports. The first electrode lead port is configured to receive and to operate a right ventricular electrode or a His bundle electrode. The second electrode lead port is specifically adapted to receive and to operate a right atrial electrode. The third electrode lead port is adapted to receive and to operate a left ventricular electrode.

In an embodiment, the third electrode lead port does not only comprise the fifth marking element, but also a sixth marking element. In this context, the sixth marking element indicates a sixth possible kind of electrode lead that can be received by the third electrode lead port. Furthermore, the sixth marking element indicates that the third electrode lead port is specifically adapted for an operation of an electrode lead of the sixth possible kind of electrode lead. In this context, the sixth possible kind of electrode lead is a right ventricular backup electrode lead (hereinafter referred to as RV-backup). Such a RV-backup is typically implanted in an apical region of the right ventricle of the heart to be stimulated. It is used if a cardiac stimulation with the His bundle electrode does not function as intended, i.e., if His bundle pacing with the His bundle electrode is not successful. Then, the RV-backup is used for stimulating the right ventricle of the heart to be stimulated. The RV-backup generally functions like a conventional right ventricular electrode lead and, thus, requires for proper operation stimulation parameters similar or identical to stimulation parameters of the right ventricular electrode lead.

An aspect relates to an arrangement comprising an implantable medical device according to the preceding explanations and a programming device for programming this implantable medical device.

In an embodiment, the programming device comprises a second processor and a second memory unit. Furthermore, the second memory unit comprises a second computer-readable program that causes the second processor to perform the steps explained in the following when executed on the second processor.

First, a selection of one of at least two electrode lead configurations of the implantable medical device is made possible. In this context, the at least two electrode lead configurations comprise a first electrode lead configuration in which no His bundle electrode lead is connected to the implantable medical device. Furthermore, the at least two electrode lead configurations comprise a second electrode lead configuration in which a His bundle electrode lead is connected to the first electrode lead port of the implantable medical device.

If the first electrode lead configuration is selected, at least one sensing and/or stimulation parameter of the first electrode lead port is then set to a value being appropriate for conventional cardiac pacing. If, on the other hand, the second electrode lead configuration is selected, at least one sensing and/or stimulation parameter of the first electrode lead port is set to a value appropriate for His bundle pacing. In this context, this value appropriate for His bundle pacing differs from the value of the same sensing and/or stimulation parameter being appropriate for conventional cardiac pacing. Thus, the selection between the first electrode lead configuration and the second electrode lead configuration determines the kind of operation of the first electrode lead port and an associated electrode.

In an embodiment, the second computer-readable program causes the second processor to perform the steps explained in the following when executed on the second processor.

First, a selection of one of at least two electrode lead configurations of the implantable medical device is made possible. The at least two electrode lead configurations comprise a first electrode lead configuration and a second electrode lead configuration. In the first electrode lead configuration, an electrode lead of the first possible kind of electrode lead (i.e., a His bundle electrode lead) is connected to the implantable medical device. In the second electrode lead configuration, an electrode lead of the second possible kind of electrode lead is connected to the first electrode lead port (i.e., no His bundle electrode lead

is connected to the first electrode lead port, but rather one of an atrial electrode lead, a right ventricular electrode lead, and a left ventricular electrode lead).

Afterwards, a dataset is transmitted to the implantable medical device. The dataset indicates whether the first electrode lead configuration or the second electrode lead configuration has been selected. Afterwards, the implantable medical device uses, in an embodiment, this dataset for specifically adapting sensing and/or stimulation parameters of the first electrode port so as to be able to properly operate a His bundle electrode lead or an electrode lead other than a His bundle electrode lead. As an alternative or in addition the dataset could be specifically adapted to ensure specialized His bundle pacing timing settings for treating bradycardia, to provide a well-matched device feature set for His bundle pacing, and/or to ensure a proper and safe patient support in all possible device operating modes and conditions.

In an embodiment, the second electrode lead configuration comprises the setting explained in the following. On the one hand, the implantable medical device comprises only a single electrode lead port, namely, the first electrode lead port. On the other hand, a His bundle electrode lead is connected to the first electrode lead port. This second electrode lead configuration is appropriate for configuring a single chamber implantable medical device for His bundle pacing.

In an embodiment, the second electrode lead configuration comprises the setting explained the following. On the one hand, the implantable medical device comprises exactly two electrode ports, namely, the first electrode lead port and a second electrode lead port. On the other hand, a His bundle electrode lead is connected to the first electrode lead port and a right atrial electrode is connected to the second electrode lead port. This second electrode lead configuration is particularly appropriate for a dual chamber implantable medical device specifically adapted for His bundle pacing.

In an embodiment, the second electrode lead configuration comprises the setting explained the following. On the one hand, the implantable medical device comprises exactly three electrode lead ports, namely, the first electrode lead port, the second electrode lead port, and

a third electrode lead port. On the other hand, three different concrete electrode configurations are possible in this embodiment.

In the first configuration, a His bundle electrode is connected to the first electrode lead port, wherein no electrode is connected to the second electrode lead port. Furthermore, a right ventricular electrode lead is connected to the third electrode lead port. This configuration is particularly appropriate for a triple chamber implantable medical device specifically adapted for His bundle pacing, wherein the right ventricular electrode serves as RV-backup. Such a configuration can be used in case of atrioventricular node ablation scenarios in which no proper atrial sensing/pacing is any longer possible.

In the second configuration, a His bundle electrode is connected to the first electrode lead port, a right atrial electrode lead is connected to the second electrode lead port, and a right ventricular electrode lead is connected to the third electrode lead port. Such a setting is appropriate for physiologic His bundle pacing with a right ventricular electrode as RV-backup.

In a third configuration, a His bundle electrode lead is connected to the first electrode lead port, a right atrial electrode lead is connected to the second electrode lead port, and a left ventricular electrode lead is connected to the third electrode lead port. Such a configuration is particularly appropriate for cardiac resynchronization therapy.

An aspect relates to a method for programming an implantable medical device according to the preceding explanations with a programming device. In this context, the implantable medical device comprises a first data communication unit, and the programming device comprises a second data communication unit. The method comprises the steps explained in the following.

First, one of at least two electrode lead configurations of the implantable medical device is selected with the programming device. The at least two electrode lead configurations comprise a first electrode lead configuration and a second electrode lead configuration. In the first electrode lead configuration no His bundle electrode lead is connected to the

implantable medical device. In an embodiment, an electrode lead of the second kind of electrode lead is connected to the first electrode lead port in the first electrode lead configuration. In the second electrode lead configuration, a His bundle electrode lead is connected to a first electrode lead port of the implantable medical device.

After having made this selection, a dataset is generated with the programming device. This dataset comprises an appropriate sensing parameter and/or stimulation parameter (or a set of appropriate sensing parameters and/or stimulation parameters) for the electrode lead configuration selected on the programming device.

Afterwards, this dataset is transmitted with the second data communication unit from the programming device to the implantable medical device. At the implantable medical device, the dataset is received with the first data communication unit.

Finally, a sensing parameter of the detection unit and/or a stimulation parameter of the stimulation unit is set by using the received dataset.

In an embodiment, the first and second data communication units serve for transferring data from the programming device to the implantable medical device or vice versa in a wireless manner. All standard data transmission protocols or specifications are appropriate for such a wireless data communication. Examples of standard data transmission protocols or specifications are the Medical Device Radiocommunications Service (MICS), the Bluetooth Low Energy (BLE) protocol and the Zigbee specification.

In an embodiment, the method is carried out such that at least one sensing and/or stimulation parameter of the first electrode lead port is set to a value appropriate for conventional cardiac pacing if the first electrode lead configuration is selected. Furthermore, at least one sensing and/or stimulation parameter of the first electrode lead port is set to a value appropriate for His bundle pacing in case that the second electrode lead configuration is selected. In this context, the value of the at least one sensing and/or stimulation parameter appropriate for His bundle pacing differs from the value of the same sensing and/or stimulation parameter appropriate for conventional cardiac pacing. In doing so, the first electrode lead port is

specifically configured to an operational state allowing proper operation of different kinds of electrodes (namely on the one hand a His bundle electrode and, on the other hand, a right atrial electrode, a right ventricular electrode, or a left ventricular electrode) depending on the type of electrode connected to the first electrode lead port.

All embodiments of the implantable medical device can be combined in any desired way and can be transferred either individually or in any arbitrary combination to the described arrangement, and to the described method. Furthermore, all embodiments described with respect to the arrangement can be combined in any desired way and can be transferred either individually or in any arbitrary combination to the described implantable medical device and to the described method. Likewise, all embodiments of the described method can be combined in any desired way and can be transferred either individually or in any arbitrary combination to the implantable medical device and to the arrangement.

Further details of aspects of the present invention will be described in the following making reference to exemplary embodiments and accompanying Figures. In the Figures:

Figure 1A shows a first electrode lead configuration of a single chamber pacemaker;

Figure 1B shows a second electrode lead configuration of the single chamber pacemaker of Figure 1A;

Figure 1C shows a third electrode lead configuration of the single chamber pacemaker of Figure 1A;

Figure 2A shows a first electrode lead configuration of a dual chamber pacemaker;

Figure 2B shows a second electrode lead configuration of the dual chamber pacemaker of Figure 2A;

Figure 3A shows a first electrode lead configuration of a first triple chamber pacemaker;

Figure 3B shows a second electrode lead configuration of the first triple chamber pacemaker of Figure 3A;

Figure 3C shows a third electrode lead configuration of the first triple chamber pacemaker of Figure 3A;

Figure 3D shows a fourth electrode lead configuration of the first triple chamber pacemaker of Figure 3A;

Figure 4A shows a first electrode lead configuration of a second triple chamber pacemaker; and

Figure 4B shows a second electrode lead configuration of the second triple chamber pacemaker of Figure 4A.

Figure 1A shows a first electrode lead configuration of a single chamber pacemaker 1 serving as implantable medical device. This single chamber pacemaker 1 comprises a single electrode lead port 2 serving as first electrode lead port. This electrode lead port 2 comprises a first label “His” being representative for a first marking element, a second label “RV” being representative for a second marking element, and a third label “RA” representing a third marking element. Furthermore, a right atrial electrode 3 is connected to the electrode lead port 2. This right atrial electrode 3 contacts the cardiac tissue in an atrium 4 of a human heart 5 to be stimulated.

In this first electrode lead configuration, it is possible to sense atrial electric signals in the atrium 4 of the heart 5 with the help of the right atrial electrode 3. Furthermore, it is possible to stimulate the atrium 4 of the human heart 5 with the help of the right atrial electrode 3. For this purpose, stimulation pulses are applied by the pacemaker 1 via the electrode lead port 2 in a conventional way. Thus, the electrode lead port 2 is configured to apply stimulation pulses to the right atrial electrode 3 making use of conventional sensing/stimulation parameters, e.g., according to the established AAI modus.

A front view onto the electrode lead port 2 is depicted directly below the pacemaker 1. This front view serves for illustrating that a right atrial electrode 3 is connected to the electrode lead port 2 being appropriate for receiving of the right atrial electrode 3 as indicated by the label RA.

Figure 1B shows a second electrode lead configuration of the same single chamber pacemaker 1, wherein in this and in all following Figures similar elements are denoted with the same numeral reference.

In contrast to the embodiment depicted in Figure 1A, the electrode lead port 2 of the pacemaker 1 is configured to receive a right ventricular electrode 6 that is implanted in an apical region of a right ventricle 7 of the human heart 5. In this electrode lead configuration, the pacemaker 1 can be operated according to the established VVI modus.

As can be seen from the front view onto the electrode lead port 2, the electrode lead port 2 is configured to receive the right ventricular electrode 6, as indicated by the label RV. Furthermore, the electrode lead port 2 is specifically configured to be operated such to allow proper control and proper sensing/stimulation of the human heart 5 by means of the right ventricular electrode 6.

Figure 1C shows a third electrode lead configuration of the single chamber pacemaker 1, wherein a His bundle electrode 8 is connected to of the electrode lead port 2. The His bundle electrode 8 is implanted at the His bundle 9 of the human heart 5 and allows a particularly physiologic stimulation of the human heart 5. The electrode lead port 2 is configured to receive the His bundle electrode 8, as indicated by the label His. Furthermore, this label indicates that the electrode lead port is specifically adapted to operate the His bundle electrode 8 with His bundle specific stimulation/sensing parameters so as to be able to detect electric signals at the His bundle 9 of the human heart 5 and to apply appropriate stimulation pulses for His bundle pacing.

Figure 2A shows an electrode lead configuration for a dual chamber pacemaker 10 serving as implantable medical device. This dual chamber pacemaker 10 can particularly well be used for treating bradycardia. The dual chamber pacemaker 10 comprises a first electrode lead port 2 and a second electrode lead port 20. The first electrode lead port 2 is configured to receive either a right ventricular electrode (as indicated by the label "RV") or a His bundle electrode (as indicated by the label "His"). The second electrode lead port 20 is configured to receive a right atrial electrode, as indicated by the label "RA". In the electrode lead configuration depicted in Figure 2A, a right ventricular electrode 6 is connected to the first electrode lead port 2. Furthermore, this right ventricular electrode 6 is implanted in an apical region of the right ventricle 7 of the human heart 5. Furthermore, a right atrial electrode 3 is connected to the second electrode lead port 20 and is implanted near the atrioventricular node in the atrium 4 of the human heart 5.

Figure 2 B shows another electrode lead configuration of the dual chamber pacemaker 10 of Figure 2A. Instead of a right ventricular electrode (cf. Figure 2A), a His bundle electrode 8 is connected to the first electrode lead port 2. This His bundle electrode 8 is implanted at the His bundle 9 of the human heart 5. The second electrode lead port 20 is connected to the right atrial electrode 3 that is implanted in the atrium 4 of the human heart 5. In this configuration the dual chamber pacemaker 10 can be used for treating bradycardia and/or cardiac resynchronization therapy.

Figure 3A shows an electrode lead configuration of another pacemaker, namely a triple chamber pacemaker 100 having a first electrode lead port 2, a second electrode lead port 20 and a third electrode lead port 200. A right ventricular electrode 6 is connected to the first electrode lead port 2. A right atrial electrode lead 3 is connected to the second electrode lead port 20. Furthermore, a left ventricular electrode 11 is connected to the third electrode lead port 200. The right ventricular electrode 6 is implanted in an apical region of the right ventricle 7 of the human heart 5. The right atrial electrode 3 is implanted in the atrium 4 of the human heart 5. The left ventricular electrode 11 is implanted on an outside of the left ventricle 12, in particular in the coronary sinus system, of the human heart 5. Such electrode configuration is particularly appropriate for conventional cardiac resynchronization therapy.

Figure 3B shows another electrode lead configuration that can be selected and applied for the triple chamber pacemaker 100. Here, only two electrodes are connected to the triple chamber pacemaker 100, namely a His bundle electrode 8 to the first electrode lead port 2 and a right ventricular electrode 6 to the third electrode lead port 200. The third electrode lead port 200 generally serves for receiving a left ventricular electrode (cf. Figure 3A), as indicated by the label "LV". Furthermore, it serves for receiving a RV-backup (as indicated by the label "Bckp") employed in form of the right ventricular electrode 6. The second electrode lead port 20 is left empty and closed up. This electrode lead configuration is particularly appropriate for physiologic His bundle pacing in case of atrioventricular node ablation scenarios.

Figure 3C shows another electrode lead configuration that can be selected for the triple chamber pacemaker 100. Here, all three electrode lead ports 2, 20, 200 are occupied by a corresponding electrode. To be more precise, a His bundle electrode 8 is connected to the first electrode lead port 2, a right atrial electrode 3 is connected to the second electrode lead port 20 and a right ventricular electrode lead 6 is connected as RV-backup to the third electrode lead port 200. Such an electrode lead configuration of the triple chamber pacemaker 100 is particularly appropriate for physiologic His bundle pacing with right ventricular backup pacing.

Figure 3D shows another electrode lead configuration of the triple chamber pacemaker 100. In this electrode lead configuration, the His bundle electrode 8 is connected to the first electrode lead port 2. The right atrial electrode 3 is connected to the second electrode lead port 20. Furthermore, a left ventricular electrode 11 is connected to the third electrode lead port 200. Such an electrode lead configuration of the triple chamber pacemaker 100 is particularly appropriate for physiologic His bundle pacing applied for cardiac resynchronization therapy (a called His-Optimized Cardiac Resynchronization Therapy (HOT-CRT)).

Figure 4A shows a second triple chamber pacemaker 1000 serving as implantable medical device. This triple chamber pacemaker 1000 comprises also a first electrode lead port 2, a second electrode lead port 20 and a third electrode lead port 200. However, the second

electrode lead port 2 and the third electrode lead port 200 bear different labels and are configured for the connection of different electrodes.

The first electrode lead port 2 is configured to receive a right ventricular electrode or a His bundle electrode. In the embodiment of Figure 4A, a right ventricular electrode 6 is connected to the first electrode lead port 2.

The second electrode lead port 20 is configured to receive a left ventricular quadripolar electrode 11. Consequently, such a left ventricular electrode 11 is also connected to the second electrode lead port 20. As explained above, such left ventricular electrode 11 is implanted on an outside of the left ventricle 12 in particular in the coronary sinus system, of the human heart 5 to be stimulated.

The third electrode lead port 200 is configured to receive and to operate a right atrial electrode. Consequently, a right atrial electrode 3 is connected to the third electrode lead port 200.

Such an electrode configuration of the triple chamber pacemaker 1000 is particularly appropriate for physiologic His bundle pacing for cardiac resynchronisation therapy using a left ventricular quadrupolar electrode.

All electrode lead configurations depicted in Figures 1A to 4B are intended to be selectable in a programming device for programming an implantable medical device. In doing so, the number and/or kind of selectable electrode configurations can be limited to the needs or technical possibilities of the respective cardiac pacemaker. E.g., if a single chamber pacemaker is used, only those electrode configurations for single chamber pacemakers are to be applied or to be selectable. If triple chamber pacemakers are used, only those configurations are to be selectable which comply with a specific configuration of the individual electrode lead port of the pacemaker. Then, a programming of the according pacemaker is made particularly simple.

Claims

1. An implantable medical device for stimulating a human or animal heart, comprising:
a first processor,
a first memory unit, a stimulation unit configured to stimulate a cardiac region of a human or animal heart,
a detection unit configured to detect an electrical signal at the cardiac region of the same heart, and
a first electrode lead port for receiving an electrode lead, wherein the first electrode lead port comprises a first marking element and a second marking element,
wherein the first marking element indicates a first possible kind of electrode lead that can be received by the first electrode lead port and for an operation of which the first electrode lead port is designed to be configured, wherein the first possible kind of electrode lead is a His bundle electrode lead, and
wherein the second marking element indicates a second possible kind of electrode lead that can be received by the first electrode lead port and for an operation of which the first electrode lead port is designed to be configured, wherein the second possible kind of electrode lead is chosen from the group consisting of an atrial electrode lead, a right ventricular electrode lead, and a left ventricular electrode lead.

2. The implantable medical device according to claim 1, wherein the first memory unit comprises a first computer-readable program that causes the first processor to perform the following steps when executed on the first processor:
retrieving or receiving a dataset indicating whether an electrode lead of the first possible kind of electrode lead or an electrode lead of the second possible kind of electrode lead is connected to the first electrode lead port; and
operating the first electrode lead port with stimulation and/or sensing parameters being specifically adapted for His bundle pacing if an electrode lead of the first possible kind of electrode lead is connected to the first electrode lead port or operating the first electrode lead port with stimulation and/or sensing parameters being appropriate for

conventional cardiac pacing if an electrode lead of the second possible kind of electrode lead is connected to the first electrode lead port.

3. The implantable medical device according to claim 1 or 2, wherein the first electrode lead port further comprises a third marking element, wherein the third marking element indicates a third possible kind of electrode lead that can be received by the first electrode lead port and for an operation of which the first electrode lead port is designed to be configured, wherein the third possible kind of electrode lead is chosen from the group consisting of an atrial electrode lead, a right ventricular electrode lead, and a left ventricular electrode lead.

4. The implantable medical device according to claim 3, wherein the second possible kind of electrode lead is an atrial electrode lead and in that the third possible kind of electrode lead is a right ventricular electrode lead.

5. The implantable medical device according to any of the preceding claims 1 to 3, wherein the second possible kind of electrode lead is a right ventricular electrode lead.

6. The implantable medical device according to claim 5, wherein the implantable medical device comprises a second electrode lead port, wherein the second electrode lead port comprises a fourth marking element, wherein the fourth marking element indicates a fourth possible kind of electrode lead that can be received by the second electrode lead port and for an operation of which the second electrode lead port is designed to be configured, wherein the fourth possible kind of electrode lead is an atrial electrode lead.

7. The implantable medical device according to claim 5 or 6, wherein the implantable medical device comprises a third electrode lead port, wherein the third electrode lead port comprises a fifth marking element, wherein the fifth marking element indicates a fifth possible kind of electrode lead that can be received by the third electrode lead port and for an operation of which the third electrode lead port is designed to be

configured, wherein the fifth possible kind of electrode lead is a left ventricular electrode lead.

8. The implantable medical device according to claim 7, wherein the third electrode lead port also comprises a sixth marking element, wherein the sixth marking element indicates a sixth possible kind of electrode lead that can be received by the third electrode lead port and for an operation of which the third electrode lead port is designed to be configured, wherein the sixth possible kind of electrode lead is a right ventricular backup electrode lead.

9. An arrangement comprising the implantable medical device according to any of the preceding claims and a programming device for programming the implantable medical device.

10. The arrangement according to claim 9, wherein the programming device comprises a second processor and a second memory unit, wherein the second memory unit comprises a second computer-readable program that causes the second processor to perform the following steps when executed on the second processor:
displaying to a user one of at least two electrode lead configurations of the implantable medical device, wherein the at least two electrode lead configurations comprise a first electrode lead configuration in which no His bundle electrode lead is connected to the implantable medical device and a second electrode lead configuration in which a His bundle electrode lead is connected to a first electrode lead port of the implantable medical device;
receiving a user selection of a desired electrode lead configuration; and
if the first electrode lead configuration is selected, setting at least one sensing and/or stimulation parameter of the first electrode lead port to a value appropriate for conventional cardiac pacing; if the second electrode lead configuration is selected, setting at least one sensing and/or stimulation parameter of the first electrode lead port to a value appropriate for His bundle pacing and differing from a value of the same sensing and/or stimulation parameter appropriate for conventional cardiac pacing.

11. The arrangement according to claim 9, wherein the programming device comprises a second processor and a second memory unit, wherein the second memory unit comprises a second computer-readable program that causes the second processor to perform the following steps when executed on the second processor:
displaying to a user one of at least two electrode lead configurations of the implantable medical device, wherein the at least two electrode lead configurations comprise a first electrode lead configuration in which no His bundle electrode lead is connected to the implantable medical device and a second electrode configuration in which a His bundle electrode lead is connected to a first electrode port of the implantable medical device;
receiving a user selection of a desired electrode lead configuration; and
transmitting a dataset to the implantable medical device, the dataset indicating whether the first electrode lead configuration or the second electrode lead configuration is selected.

12. The arrangement according to any of claims 10 to 11, wherein the second electrode lead configuration comprises the following setting:
the implantable medical device comprises a single electrode lead port, namely the first electrode lead port; and
a His bundle electrode lead is connected to the first electrode lead port.

13. The arrangement according to any of claims 10 to 11, wherein the second electrode lead configuration comprises the following setting:
the implantable medical device further comprising exactly two electrode lead ports, namely the first electrode lead port and a second electrode lead port; and
a His bundle electrode lead is connected to the first electrode lead port and a right atrial electrode lead is connected to the second electrode lead port.

14. The arrangement according to any of claims 10 to 11, wherein the second electrode lead configuration comprises one of the following settings:
the implantable medical device further comprising exactly three electrode lead ports, namely the first electrode lead port, a second electrode lead port, and a third electrode lead port; and

a His bundle electrode lead is connected to the first electrode lead port, no electrode lead is connected to the second electrode lead port, and a right ventricular electrode lead is connected to the third electrode lead port; or

a His bundle electrode lead is connected to the first electrode lead port, a right atrial electrode lead is connected to the second electrode lead port, and a right ventricular electrode lead is connected to the third electrode lead port; or

a His bundle electrode lead is connected to the first electrode lead port, a right atrial electrode lead is connected to the second electrode lead port, and a left ventricular electrode lead is connected to the third electrode lead port.

15. A method for programming the implantable medical device with a programming device, wherein the implantable medical device comprises a first data communication unit, and wherein the programming device comprises a second data communication unit, the method comprising:

selecting, with the programming device, one of at least two electrode lead configurations of the implantable medical device, wherein the at least two electrode lead configurations comprise a first electrode lead configuration in which no His bundle electrode lead is connected to the implantable medical device and a second electrode configuration in which a His bundle electrode lead is connected to a first electrode port of the implantable medical device;

generating, with the programming device, a dataset for an electrode lead configuration selected on the programming device comprising one or more of:

an appropriate sensing parameter and/or stimulation parameter,

appropriate pacing time settings for treating brachycardia, parameters to provide a well-matched device feature set, and

parameters to ensure a proper and safe patient support in all possible device operating modes and conditions;

transmitting, with the second data communication unit, the dataset to the implantable medical device;

receiving, with the first data communication unit, the dataset; and

setting a sensing parameter of the detection unit and/or a stimulation parameter of the stimulation unit by using the received dataset.