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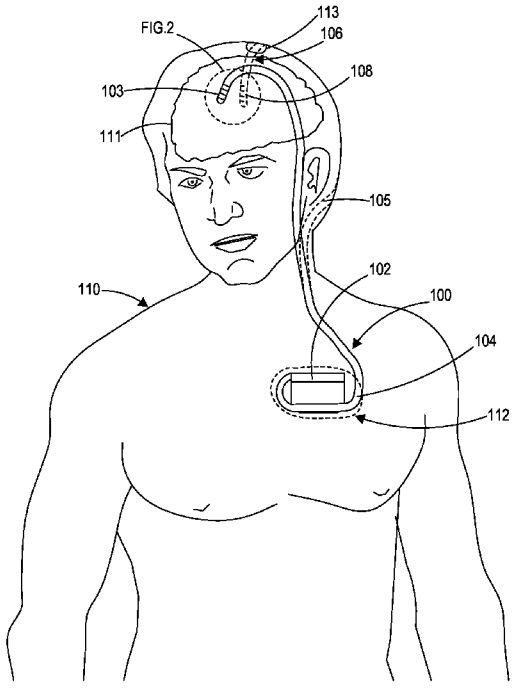

FIG. 1

(57) **Abstract:** Neurostimulation is provided by implanting an endovascular lead with a distal tip in proximity to a target area within a brain of a patient. The neurostimulation therapy provided during a trial period using the endovascular lead may be compared to a target threshold. Both stimulation and sensing may be compared to target thresholds for purposes of determining efficacy of the neurostimulation therapy. A decision may be made as to whether to implant a non-endovascular lead such as a deep brain stimulation lead for purposes of continuing the neurostimulation therapy.

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NEUROSTIMULATION THERAPY TRIALING USING AN ENDOVASCULAR LEAD

[0001] This application claims priority from U.S. Provisional Patent Application 63/591,932 filed 20 October 2023, the entire content of which is incorporated herein by reference.

[0002] Embodiments relate to neurostimulation therapy and more particularly to neurostimulation therapy trialing using an endovascular lead.

BACKGROUND

[0003] Patients suffering from one or more neurological conditions may benefit from neurostimulation therapy including deep brain stimulation (hereinafter DBS). To provide DBS therapy, a distal end of a lead is implanted into the brain of the patient at a target location. The proximal end of the lead is coupled to a neurostimulator that produces electrical stimulation signals that are delivered by one or more electrodes of the lead to the brain and/or that senses physiological signals captured by the one or more electrodes of the lead within the brain.

[0004] Implanting the neurostimulator within the body of the patient is an invasive procedure. Therefore, it is typically best to provide a trial period of neurostimulation prior to permanently implanting the neurostimulator to confirm that the neurostimulation therapy provides an adequate therapeutic effect. An external neurostimulator may provide the stimulation and/or sensing during the trial period. However, the distal tip of the lead must be present at the target location within the brain. Therefore, conventional trialing requires that the lead be implanted via the invasive procedure where holes are created through the skull for routing the lead into the brain and is therefore uncommon practice with a conventional DBS system.

SUMMARY

[0005] Embodiments address issues such as these and others by providing neurostimulation therapy trialing, including for DBS therapy, by using an endovascular lead

for trialing rather than a conventional DBS lead. The endovascular lead is implanted in a less invasive manner by being inserted into a blood vessel that extends into the brain and in proximity to the target location. The distal tip of the endovascular lead is advanced through the blood vessel to be in proximity to the target location. The neurostimulation therapy is then provided by the endovascular lead from within the blood vessel to the target location during the trial period. At the conclusion of the trial period, where it is determined that the neurostimulation therapy can provide a therapeutic effect, the neurostimulation therapy may be provided by a subsequently implanted non-endovascular lead such as a conventional DBS lead, and neurostimulation therapy may be provided by the endovascular lead, the conventional DBS lead, or some combination of the two.

[0006] Embodiments provide a method of providing neurostimulation therapy. The method involves implanting an endovascular lead within a blood vessel of a brain of the patient. The method involves providing the neurostimulation therapy using the endovascular lead during a trial period. The method further involves determining an efficacy of the neurostimulation therapy during the trial period and if the efficacy of the neurostimulation therapy meets a threshold, then continuing the neurostimulation therapy.

[0007] Embodiments also provide an implantable medical system. The system includes an endovascular lead having a distal end with at least one electrode positioned within a blood vessel at a first location within the brain of the patient. The system includes a non-endovascular lead having a distal end with at least one electrode positioned outside of blood vessels at a second location within the brain of the patient. The system further includes a neurostimulator coupled to the endovascular lead and the non-endovascular lead. The neurostimulator provides the neurostimulation therapy using the endovascular lead during a trial period prior to the non-endovascular lead being coupled to the neurostimulator and the neurostimulator continues to provide the neurostimulation therapy using the endovascular lead and/or the non-endovascular lead after the trial period when the non-endovascular lead becomes coupled to the neurostimulator.

DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 shows an example of a patient having an implantable medical system for trialing of neurostimulation therapy.

[0009] FIG. 2 shows an example of a relationship between an endovascular lead being used for trialing and a hypothetical DBS lead positioned at the target location.

[0010] FIG. 3 shows an example of components of an external device that communicates with the neurostimulation device.

[0011] FIG. 4 shows an example of components of a neurostimulation device that may couple to the endovascular lead to provide the neurostimulation related stimulation signals and/or to receive the sensed physiological signals.

[0012] FIGS. 5A and 5B show an example of a workflow to provide the trialing using the endovascular lead.

DETAILED DESCRIPTION

[0013] Embodiments provide an implantable medical system that allows a trial period of neurostimulation therapy without requiring an invasive procedure necessary for implanting a non-endovascular lead such as a DBS lead. Rather than implant the DBS lead for trialing, an endovascular lead is implanted via a blood vessel to an area within the brain of the patient that is in proximity to the target area. The endovascular lead is coupled to a neurostimulator to allow the neurostimulation therapy to be provided during the trial period by the electrodes of the endovascular lead located in proximity to the target area within the brain. An assessment of the efficacy of the neurostimulation therapy during the trial period may be made and subsequent neurostimulation therapy may be conducted thereafter when appropriate, such as by continuing to provide therapy via the endovascular lead, by implanting a DBS lead that is used for the neurostimulation therapy, and/or providing the neurostimulation therapy via a combination of both the endovascular lead and the DBS lead.

[0014] This disclosure describes example techniques to confirm the efficacy of forms of neurostimulation therapy. The example techniques are described with respect to DBS, but the example techniques are not so limited and may be applied to other types of therapies and/or other anatomical locations. Neurostimulation therapy, and DBS in particular, may provide relief for many different patient conditions such as movement disorders, epilepsy, obsessive compulsive disorder (OCD), depression, and others. Patients afflicted with movement disorders or other neurodegenerative impairment, whether by disease or trauma, may experience muscle control and movement problems, such as rigidity, bradykinesia (i.e.,

slow physical movement), rhythmic hyperkinesia (e.g., tremor), nonrhythmic hyperkinesia (e.g., tics) or akinesia (i.e., a loss of physical movement). Movement disorders may be found in patients with Parkinson's disease, multiple sclerosis, and cerebral palsy, among other conditions. Delivery of electrical stimulation by a medical device to one or more sites in a patient, such as within the brain, may help alleviate, and in some cases, eliminate symptoms associated with these movement disorders and other conditions.

[0015] FIG. 1 shows a typical environment for an implantable medical system 100 being used to provide neurostimulation therapy such as DBS therapy for a trial period. In this example, the implantable medical system 100 is installed onto a body 110 of a patient. The implantable medical system 100 of this example includes a neurostimulator 102 that has either been installed externally on the patient or has been implanted into a subcutaneous or subfascial pocket 112. At least one endovascular medical lead 104, or endovascular lead and extension combination, is routed between a target stimulation site within the brain 111 of the patient and the neurostimulator 102. The endovascular lead 104 has a distal end 103 and distal electrodes thereon positioned within the brain 111 in proximity to the target location for the stimulation and/or sensing to be applied.

[0016] The endovascular lead 104 is implanted in a less invasive way relative to a DBS lead by being introduced into a blood vessel that travels into the brain 111 and branches into the location that is in proximity to the target location. By using the endovascular lead 104 during the trial period when the efficacy of the neurostimulation therapy is being assessed, this eliminates the need to perform the more invasive implantation of a DBS lead in advance of the trial period.

[0017] FIG. 1 also shows a location and related aspects of a hypothetical DBS lead 105 to demonstrate the different approach to including an endovascular lead 104 a DBS lead 105. The hypothetical DBS lead 105, shown in phantom lines to indicate the hypothetical nature of the DBS lead 105, is considered to extend from the neurostimulator 102 in the conventional manner, beneath the skin, and to a location on the skull of the patient where a hole 113 is created to allow the DBS lead 105 to pass through the skull enter the brain 111 in area 106 beneath the hole 113. The hypothetical DBS lead 105 can then be routed in a non-endovascular way outside of any blood vessel to the target location within the brain 111 where a distal end 108 with electrodes is positioned. The consideration of such a

hypothetical DBS lead 105 may also serve an additional purpose during the determination of the efficacy of the neurostimulation therapy as discussed in more detail below in relation to FIGS. 5A and 5B.

[0018] FIG. 2 shows a more detailed view of the target area 208 within the brain 111 where the distal end 103 of the endovascular lead 104 is located and where the distal end 108 of the hypothetical DBS lead 105 is considered to be located. As can be seen, the endovascular lead including the distal end 103 with electrodes 204 is present within a blood vessel 202 that passes in proximity to the target area 208 of the brain 111. Thus, the endovascular lead is capable of providing neurostimulation therapy in the form of electrical neurostimulation signals from one or more electrodes 202 into the brain 111 in proximity to the target area 208 and/or sensing electrical physiological signals from the area in proximity to the target area 208. This allows trialing of the neurostimulation therapy at the target area 208 using only the endovascular lead 104.

[0019] The hypothetical DBS lead 105 is considered as having a typical DBS lead position relative to the target 208. As discussed below in relation to FIG. 5, the hypothetical DBS lead 105 may be considered for a simulation at the position by the target area 208 and with a predicted field of stimulation activation and/or sensing for purposes of comparing to efficacy information for neurostimulation via the endovascular lead 104 obtained during the trial period.

[0020] FIG. 3 shows an example of the components of an external device 114 that communicates with the neurostimulator 102 to provide programming the controls the neurostimulation therapy including stimulation and/or sensing functions and to obtain information collected by the neurostimulator 102. The external device 114 may take various forms, such as a handheld tablet, a personal computer, and the like. The several components of the external device 114 include a processor 302 as well as a communication circuitry 304 and an input/output circuitry 310. The processor 302 interacts with the communication circuitry 304 and input/output circuitry 310 to provide the operations of the implantable medical device 102. A power supply, not shown in FIG. 3, such as a battery or a utility power interface may also be included to provide electrical power to the various components.

[0021] The processor 302 performs various logical operations when interacting with the other components. These operations may involve utilizing the communication circuitry 304

to exchange data with the implantable medical device 102 and to produce relevant displays of information and receive relevant input from a user, such as a clinician or patient, viewing the displays. Examples of these logical operations in combination with logical operations performed by the neurostimulator 102 are discussed below in relation to FIGS. 5A and 5B. The processor 302 may be of various forms such as a general purpose programmable processor, application specific processor, hardwired digital logic, and/or various combinations. The processor 302 may utilize operational memory that is internal, external (not shown), or a combination of the two and may also utilize a storage device to retain data and programming in a long-term, non-volatile fashion.

[0022] The communication circuitry 304 includes both a transmitter circuit 306 and a receiver circuit 308 for sending and receiving wireless signals. The communication circuitry 304 is either wirelessly tethered or tethered by wire to the intermediary device 116 over the communication link 120. As previously discussed, the communication link may utilize a wireless protocol such as the Bluetooth® protocol. Alternatively, the communication link 120 may be wired and rely upon telemetry where the intermediary device 116 is a telemetry head held in very close proximity to the implantable medical device 102. As another alternative, any link with a sufficiently short latency to allow the clinician to react to changes in the patient may also be used, including remote/internet connected management.

[0023] The input/output circuitry 310 allows the external device 114 to interact with users, including clinicians or the patient, or other devices. The input/output circuitry 310 may provide outputs such as a visual display on a screen, audio, and the like. The input/output circuitry 310 may provide inputs such as a keyboard or keypad, a mouse and/or touch screen, and the like. The input/output circuitry 310 allows users to enter information such as programming details, stimulation parameters, and other information to be provided from the external device 114 to the neurostimulator 102 as well as review information such as physiological data sent from the neurostimulator 102 to the external device 114.

[0024] FIG. 4 shows an example of the neurostimulator 102. The components of the neurostimulator 102 are contained within a housing that isolates and protects the components from the surrounding environment. Typically, the housing is a biocompatible material that forms a hermetically sealed container. The components of the neurostimulator 102 include a processor 402 as well as a communication circuitry 404. A stimulation circuitry 410 is also

present to generate the stimulation signals used to provide the stimulation therapy, and sensing circuitry 412 is present to sense the physiological signals relevant to the stimulation therapy, such as the local field potential signals. The processor 402 interacts with the communication circuitry 404, stimulation circuitry 410, and sensing circuitry 412 to provide the operations of the neurostimulator 102. Although not shown, the implantable medical device 102 also includes a power source, such as an on-board battery, to provide electrical power to these components.

[0025] The processor 402 performs various logical operations when interacting with the other components to provide the stimulation and/or sensing functions of the neurostimulation therapy. Thus, examples of the logical operations of the neurostimulator 102 and processor 402 in combination with those of the external device 114 and processor 302 are shown in FIGS. 5A and 5B. The processor 402 may be of various forms such as a general purpose programmable processor, application specific processor, hardwired digital logic, and/or various combinations.

[0026] The communication circuitry 404 includes both a transmitter circuit 406 and a receiver circuit 408 for sending and receiving wireless signals. This allows the processor 402 to receive information such as programming, stimulation parameters and the like from the external device 114. This also allows the processor 402 to send information such as sensed physiological data to the external device 114.

[0027] The stimulation circuitry 410 in the example shown allows the implantable medical device 102 to interact with the brain tissue of the patient 110. The stimulation circuitry 410 may produce a stimulation signal that includes stimulation pulses of a given amplitude, such as a given electrical current amplitude. In accordance with the stimulation therapy algorithm being performed by the processor 402, the stimulation circuitry 410 may alter the stimulation amplitude of the stimulation therapy as requested by the processor 402 to provide effective stimulation therapy, such as effective adaptive deep brain stimulation.

[0028] One manner of providing effective stimulation therapy may utilize feedback in the form of sensed physiological signals. Sensing circuitry 412 senses these physiological signals such as local field potential signals and provides the sensed signal to the processor 402. For instance, with adaptive deep brain stimulation, the sensing circuitry 412 may be used to sense local field potential signals during the ongoing application of stimulation

signals. The sensed local field potential signals are analyzed by the processor 402 in order to then request stimulation amplitude changes by the stimulation circuitry 410. The processor 402 compares the sensed local field potential signal power to the physiological thresholds to determine whether to alter the stimulation amplitude.

[0029] As shown in FIG. 4, a proximal end of the endovascular lead 104 including electrical connectors 404 may be coupled to the neurostimulator 102. The neurostimulator may then configure the stimulation circuitry 410 and sensing circuitry 412 so that stimulation outputs 114 may be electrically coupled to one or more of the electrical connectors 404 when providing stimulation signals while sensing inputs 413 may be electrically coupled to one or more of the electrical connectors 404 when sensing physiological signals.

[0030] FIGS. 5A and 5B shows an example 500 of logical operations that may be performed between the external device 114 and the neurostimulator 102 and related actions by users such as the clinician or patient to provide the neurostimulation therapy including stimulation and/or sensing during the trial period. The operations begin at operation 502 by the clinician implanting the endovascular lead 104 via an appropriate blood vessel that positions the distal end 103 of the endovascular lead 104 in proximity to the target location 208. Examples of the blood vessels that may channel the distal end to the target area 208 include the Thalamostriate vein, the internal cerebral vein, the basal vein of Rosenthal, the internal sagittal sinus, any other vessel determined by patient specific anatomy, and the like.

[0031] The clinician then couples the proximal end 404 of the endovascular lead 104 to the neurostimulator 102, or couples the proximal end to an extension and couples the proximal end of the extension to the neurostimulator 102, at the operation 504. The clinician then programs the neurostimulator 102 to begin providing the trial period neurostimulation therapy using the external device 114 to send the programming information to the neurostimulator 102 at the operation 506.

[0032] Initial conditions due to the complications of implantation can affect the therapeutic effects of the neurostimulation therapy. Therefore, a waiting period may be employed to allow the conditions to become more typical and conducive to effective therapy. For instance, edema may be resolved within the waiting period. Likewise, lead stabilization may occur, and appropriate stimulation settings may be discoverable at that point. A query operation 508 may implement the waiting period by keeping track of the amount of time that

has elapsed since the neurostimulation therapy began and determining whether the elapsed time exceeds a waiting period. If not, the waiting period continues at the query operation 508. This waiting period may be implemented either at the neurostimulation device 102 when monitoring the therapeutic effect in terms of sensed signals and/or at the external device 114 when receiving the sensed signals, patient feedback, and the like that can be considered.

[0033] Once the waiting period has ended, the efficacy of the neurostimulation therapy in terms of maximum therapy effectiveness and tolerability may then be assessed at an operation 510. The assessment may be performed by the neurostimulation device 102 based on sensed signals and/or at the external device based on receiving the sensed signals, input from the clinician, feedback from the patient, and so forth. Furthermore, the efficacy of stimulation may be considered separately from the efficacy of sensing.

[0034] In relation to stimulation, the determination of efficacy may involve several tasks. The external device 114 may communicate with the neurostimulator 102 to obtain sensed physiological data such as local field potentials in association with stimulation that has been provided to monitor the therapeutic effect of the stimulation. This provides objective information regarding the efficacy. Likewise, the external device 114 may obtain patient feedback to provide subjective information regarding the efficacy. Such objective and subjective information, and combinations of the two, may be compared to a target stimulation threshold. For instance, the objective information may include determining if the patient meets their target therapeutic threshold. This threshold may be patient specific. Subjective and objective information may include whether there are one or more indicated side effects resulting from the therapy that are acceptable, such as the percentage of reduction in clinical scores for the neurological condition. Indicated side effects for consideration further include but are not limited to: Paresthesias, Muscle contractions, Dysarthria, Contralateral Gaze Deviation, Diplopia, Deviation of ipsilateral eye, Dizziness, ALO, Personality/impulsivity changes, Depression, Sweating, Nausea, Extreme discomfort, Warm sensations, Possible impact on dyskinesias and/or tremor, Possible mood changes, Akinesias, Phosphenes , and Ataxia. A specific example of a threshold for stimulation efficacy is at least a 30% reduction in the clinical scores for the given condition.

[0035] In relation to sensing, the determination of efficacy may also involve similar tasks. The external device 114 may again communicate with the neurostimulator 102 to obtain sensed physiological data such as local field potentials. This provides objective information regarding the efficacy of the sensing in terms of the maximum viability of signal biomarkers. For instance, the sensed signal may provide an indication of whether there are any signal limiting circumstances, such as device interferences. Additionally, this allows a determination of an appropriate signal response in terms of concluding that there is a sufficient neural substrate to elicit an evoked response to stimulation captured by the sensed signal. Such information may be compared to a target sensing threshold. For instance, the objective information may include determining if a chraracteristic of the sensed signal such as the magnitude of the local field potential meets the target sensing threshold. This sensing threshold may also be patient specific and may include a subject component based on patient feedback relative to the measured local field potential amplitude. A specific example of a threshold for sensing efficacy is at least a 0.8uV/rtHz resolution of the beta range local field potential.

[0036] Query operation 512 determines if the efficacy of the neurostimulation therapy, such as the stimulation and/or the sensing, meets the target threshold based on the considerations previously discussed. If the efficacy threshold is met, then the external device 114 may provide an indication to implant the DBS lead 105 and/or continue with neurostimulation with the endovascular lead 104. In one example, if the endovascular lead has produced a therapeutic effect, such as being effective in both the objective and subjective facets for both stimulation and sensing, the indication may be that the neurostimulation therapy may continue with only the endovascular lead 104 and the DBS lead implantation may be delayed or cancelled altogether. In another example, if some facet of stimulation or sensing with the endovascular lead 104 is questionable, then the indication may be that the DBS lead 105 may be implanted to supplement the therapy being provided via endovascular lead 104. Longer term neurostimulation therapy is then continued in a manner as deemed appropriate by these considerations above at an operation 516.

[0037] Returning to the query operation 512, if the efficacy of the neurostimulation therapy is determined to not meet the target threshold, then a simulated position and predicted field of activation and sensing of the hypothetical DBS lead 105 is computed by an

external device 114 at an operation 518. This information for the hypothetical DBS lead 105 is then compared to the results of the position and field of activation and sensing of the endovascular lead 104 at an operation 520. This information is used to determine if the patient could benefit from DBS lead placement. Query operation 522 determines the result of this comparison to find whether the hypothetical DBS lead is predicted to produce superior results to the endovascular lead. If so, then operation 514 provides the indication to implant the DBS lead 105 and proceed with neurostimulation therapy either with the implanted DBS lead 105 alone or in combination with the endovascular lead 104. If the hypothetical DBS lead 105 does not produce superior results, then the external device 114 may indicate that no implantation of the DBS lead 105 is necessary and no further therapy is to be provided or that therapy should proceed with the endovascular lead 104.

[0038] From the discussion above, it can be seen that insight into whether the more invasive procedure of implanting a DBS lead 105 is worthwhile on the basis of trialing of neurostimulation therapy using the endovascular lead 104 placed in the less invasive manner. Thus, trialing of the neurostimulation therapy can be a less burdensome procedure for the patient, and the need for DBS lead placement can be a determination based on the trialing rather than a requirement to perform the trialing.

[0039] The invention may further be described by reference to the following numbered paragraphs:

[0040] Example 1: A method of providing neurostimulation therapy, comprising: implanting an endovascular lead within a blood vessel of a brain of the patient providing the neurostimulation therapy using the endovascular lead during a trial period; determining an efficacy of the neurostimulation therapy during the trial period;
if the efficacy of the neurostimulation therapy meets a threshold, then continuing the neurostimulation therapy

[0040] Example 2: The method of example 1, wherein continuing the neurostimulation therapy comprises: implanting a non-endovascular lead not within blood vessels of the brain of the patient; and continuing the neurostimulation therapy using at least the non-endovascular lead.

[0041] Example 3: The method of example 2, wherein continuing the neurostimulation therapy comprises using at least the endovascular lead and the non-endovascular lead.

[0042] Example 4: The method of example 1, wherein continuing the neurostimulation therapy comprises continuing the neurostimulation therapy using the endovascular lead.

[0043] Example 5: The method of example 1, wherein providing the neurostimulation therapy comprises providing electrical stimulation signals into the brain.

[0044] Example 6 The method of example 5, wherein determining the efficacy of the neurostimulation therapy comprises monitoring therapeutic response to the electrical stimulation signals to determine whether the patient response to the electrical stimulation signals meets a target therapeutic threshold.

[0045] Example 7: The method of example 6, wherein the target therapeutic threshold comprises at least a 30 percent reduction in clinical scores.

[0046] Example 8: The method of examples 6 or 7, wherein upon determining that the patient response to the electrical stimulation signals does not meet the target therapeutic threshold, then comparing field activation and blood vessel location of the electrical stimulation signals of the endovascular lead to a simulated position and predicted field of activation of a hypothetical non-endovascular lead to estimate a therapeutic effect of the hypothetical non-endovascular lead, and when the comparison indicates that the therapeutic effect of the hypothetical non-endovascular lead is greater than the therapeutic effect of the endovascular lead, then implanting the non-endovascular lead and continuing neurostimulation therapy using the non-endovascular lead.

[0047] Example 9: The method of any of examples 5-8, wherein determining the efficacy of the neurostimulation therapy comprises confirming whether the patient has one or more indicated side effects.

[0048] Example 10: The method of any of examples 1-9, wherein providing the neurostimulation therapy comprises sensing physiological signals occurring within the brain.

[0049] Example 11: The method of example 10, wherein determining the efficacy of the neurostimulation therapy comprises comparing a characteristic of the sensed physiological signal to a target sensing threshold.

[0050] Example 12: The method of example 11, wherein the target sensing threshold comprises at least a 0.8uV/rtHz resolution of beta range local field potential.

[0051] Example 13: The method of any of example 11 or 12, wherein upon determining that the characteristic of the sensed physiological signals does not meet the target sensing threshold, then comparing a field of sensing and blood vessel location of the endovascular lead to a simulated position and predicted field of sensing of a hypothetical non-endovascular lead to estimate a sensing ability of the hypothetical non-endovascular lead, and when the comparison indicates that the sensing ability of the hypothetical non-endovascular lead is greater than the sensing ability of the endovascular lead, then implanting the non-endovascular lead and continuing neurostimulation therapy using the non-endovascular lead.

[0052] Example 14: The method of any of examples 1-13, wherein the blood vessel is a thalamostriate vein, an internal cerebral vein, a basal vein of Rosenthal, or an interior sagittal sinus.

[0053] Example 15: The method of any of examples 1-14, wherein the trial period occurs after a waiting period that occurs from a time of implanting the endovascular lead to the beginning of the trial period wherein during the waiting period edema is resolved and/or the endovascular lead becomes stabilized.

[0054] Example 16: An implantable medical system, comprising:
an endovascular lead having a distal end with at least one electrode positioned within a blood vessel at a first location within the brain of the patient;
a non-endovascular lead having a distal end with at least one electrode positioned outside of blood vessels at a second location within the brain of the patient; and

a neurostimulator coupled to the endovascular lead and the non-endovascular lead, the neurostimulator providing the neurostimulation therapy using the endovascular lead during a trial period prior to the non-endovascular lead being coupled to the neurostimulator and the neurostimulator continuing to provide the neurostimulation therapy using the endovascular lead and/or the non-endovascular lead after the trial period when the non-endovascular lead becomes coupled to the neurostimulator.

[0055] Example 17: The implantable medical system of example 16, wherein the neurostimulator continuing to provide the neurostimulation therapy comprises the neurostimulator providing the neurostimulation therapy using at least the non-endovascular lead.

[0056] Example 18: The implantable medical system of example 17, wherein the neurostimulator continuing to provide the neurostimulation therapy comprises the neurostimulator providing the neurostimulation therapy using at least the endovascular lead and the non-endovascular lead.

[0057] Example 19: The implantable medical system of example 16, wherein the neurostimulator continuing to provide the neurostimulation therapy comprises the neurostimulator continuing to provide the neurostimulation therapy using at least the endovascular lead.

[0058] Example 20: The implantable medical system of example 16, wherein the neurostimulator providing the neurostimulation therapy comprises the neurostimulator providing electrical stimulation signals into the brain.

[0059] Example 21: The implantable medical system of example 20, further comprising an external device that communicates with the neurostimulator to determine the efficacy of the neurostimulation therapy by monitoring therapeutic response to the electrical stimulation signals to determine whether the therapeutic response to the electrical stimulation signals meets a target therapeutic threshold.

[0060] Example 22: The implantable medical system of example 21, wherein the target therapeutic threshold comprises at least a 30 percent reduction in clinical scores.

[0061] Example 22: The implantable medical system of any of examples 21 and 22, wherein upon the external device determining that the patient response to the electrical stimulation signals does not meet the target therapeutic threshold, then the external device compares field activation and blood vessel location of the electrical stimulation signals of the endovascular lead to a simulated position and predicted field of activation of a hypothetical non-endovascular lead to estimate a therapeutic effect of the hypothetical non-endovascular lead, and when the comparison indicates that the therapeutic effect of the hypothetical non-endovascular lead is greater than the therapeutic effect of the endovascular lead, then providing an instruction to implant the non-endovascular lead and to continue providing neurostimulation therapy using the non-endovascular lead.

[0062] Example 23: The implantable medical system of any of examples 20-23, further comprising an external device that communicates with the neurostimulator to determine the efficacy of the neurostimulation therapy comprises confirming whether the patient has one or more indicated side effects.

[0063] Example 24: The implantable medical system of any of examples 18-24, wherein the neurostimulator providing the neurostimulation therapy comprises the neurostimulator sensing physiological signals occurring within the brain.

[0064] Example 25: The implantable medical system of example 25, wherein an external device communicates with the implantable medical device to compare a characteristic of the sensed physiological signal to a target sensing threshold.

[0065] Example 26: The implantable medical device of example 26, wherein the target sensing threshold comprises at least a 0.8uV/rtHz resolution of beta range local field potential.

[0066] Example 27: The implantable medical device of any of example 26 and 27, wherein upon the external device determining that the characteristic of the sensed physiological signals does not meet the target sensing threshold, then the external device compares a field of sensing and blood vessel location of the endovascular lead to a simulated position and predicted field of sensing of a hypothetical non-endovascular lead to estimate a sensing ability of the hypothetical non-endovascular lead, and when the comparison indicates that the sensing ability of the hypothetical non-endovascular lead is greater than the sensing ability of the endovascular lead, then upon the implanting of the non-endovascular lead, continuing neurostimulation therapy using the non-endovascular lead.

[0067] Example 28: The method of any of examples 16-28, wherein the blood vessel is a thalamostriate vein, an internal cerebral vein, a basal vein of Rosenthal, or an interior sagittal sinus.

[0068] Example 29: The method of any of examples 16-29, wherein the trial period occurs after a waiting period that occurs from a time of implanting the endovascular lead to the beginning of the trial period wherein during the waiting period edema is resolved and/or the endovascular lead becomes stabilized.

[0069] While embodiments have been particularly shown and described, it will be understood by those skilled in the art that various other changes in the form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A method (500) of configuring a system (100) capable of providing neurostimulation therapy, comprising:

configuring an endovascular lead (104) for implantation within a blood vessel of a brain of a patient (502);

configuring a system including the endovascular lead to provide the neurostimulation therapy using the endovascular lead during a trial period (506);

determining an efficacy of the neurostimulation therapy during the trial period (510);

if the efficacy of the neurostimulation therapy meets a threshold, then continuing to configure the system to provide the neurostimulation therapy (516).

2. The method of claim 1, wherein continuing to configure the system to provide the neurostimulation therapy comprises: configuring a non-endovascular lead for implantation not within blood vessels of the brain of the patient (514); and

continuing to configure the system to provide the neurostimulation therapy using at least the non-endovascular lead (516).

3. The method of claim 2, wherein continuing to configure the system to provide the neurostimulation therapy comprises using (516) at least the endovascular lead and the non-endovascular lead.

4. The method of claim 1, wherein continuing to configure the system to provide the neurostimulation therapy comprises configuring the system to provide the neurostimulation therapy using the endovascular lead (516).

5. The method of claim 1, wherein configuring the system to provide the neurostimulation therapy comprises providing electrical stimulation signals into the brain (516).

6. The method of claim 5, wherein determining the efficacy of the neurostimulation therapy comprises monitoring therapeutic response to the electrical stimulation signals to determine

whether the patient response to the electrical stimulation signals meets a target therapeutic threshold (510).

7. The method of claim 6, wherein the target therapeutic threshold comprises a 30 percent reduction in clinical scores.

8. An implantable medical system, comprising:

an endovascular lead (104) having a distal end (103) with at least one electrode (204) positioned within a blood vessel (202) at a first location within a brain of a patient;

a non-endovascular lead (105) having a distal end (103) with at least one electrode (206) positioned outside of blood vessels at a second location within the brain of the patient; and

a neurostimulator (102) coupled to the endovascular lead and the non-endovascular lead, the neurostimulator providing the neurostimulation therapy using the endovascular lead during a trial period prior to the non-endovascular lead being coupled to the neurostimulator and the neurostimulator continuing to provide the neurostimulation therapy using the endovascular lead and/or the non-endovascular lead after the trial period when the non-endovascular lead becomes coupled to the neurostimulator.

9. The implantable medical system of claim 8, wherein the neurostimulator (102) providing the neurostimulation therapy comprises the neurostimulator sensing physiological signals occurring within the brain.

10. The implantable medical system of claim 9, wherein an external device (114) communicates with the implantable medical device to determine a maximum viability of signal biomarkers within the physiological signals.

11. The implantable medical system of claim 10, wherein the external device (114) determines the maximum viability of signal biomarkers by comparing a characteristic of the sensed physiological signal to a target sensing threshold.

12. The implantable medical system of claim 11, wherein the sensing threshold comprises 0.8uV/rtHz resolution of beta range local field potential.

13. The implantable medical system of any of claims 11 and 12, wherein upon the external device (114) determining that the characteristic of the sensed physiological signals does not meet the target sensing threshold, then the external device compares a field of sensing and blood vessel location of the endovascular lead (104) to a simulated position and predicted field of sensing of a hypothetical non-endovascular lead to estimate a sensing ability of the hypothetical non-endovascular lead (105), and when the comparison indicates that the sensing ability of the hypothetical non-endovascular lead is greater than the sensing ability of the endovascular lead, then upon the implanting of the non-endovascular lead, continuing neurostimulation therapy using the non-endovascular lead.

14. The implantable medical system of any of claims 8-13, wherein the blood vessel (202) is a thalamostriate vein, an internal cerebral vein, a basal vein of Rosenthal, or an interior sagittal sinus.

15. The implantable medical system of any of claims 8-14, wherein the trial period occurs after a waiting period that occurs from a time of implanting the endovascular lead (104) to the beginning of the trial period wherein during the waiting period edema is resolved and/or the endovascular lead becomes stabilized.

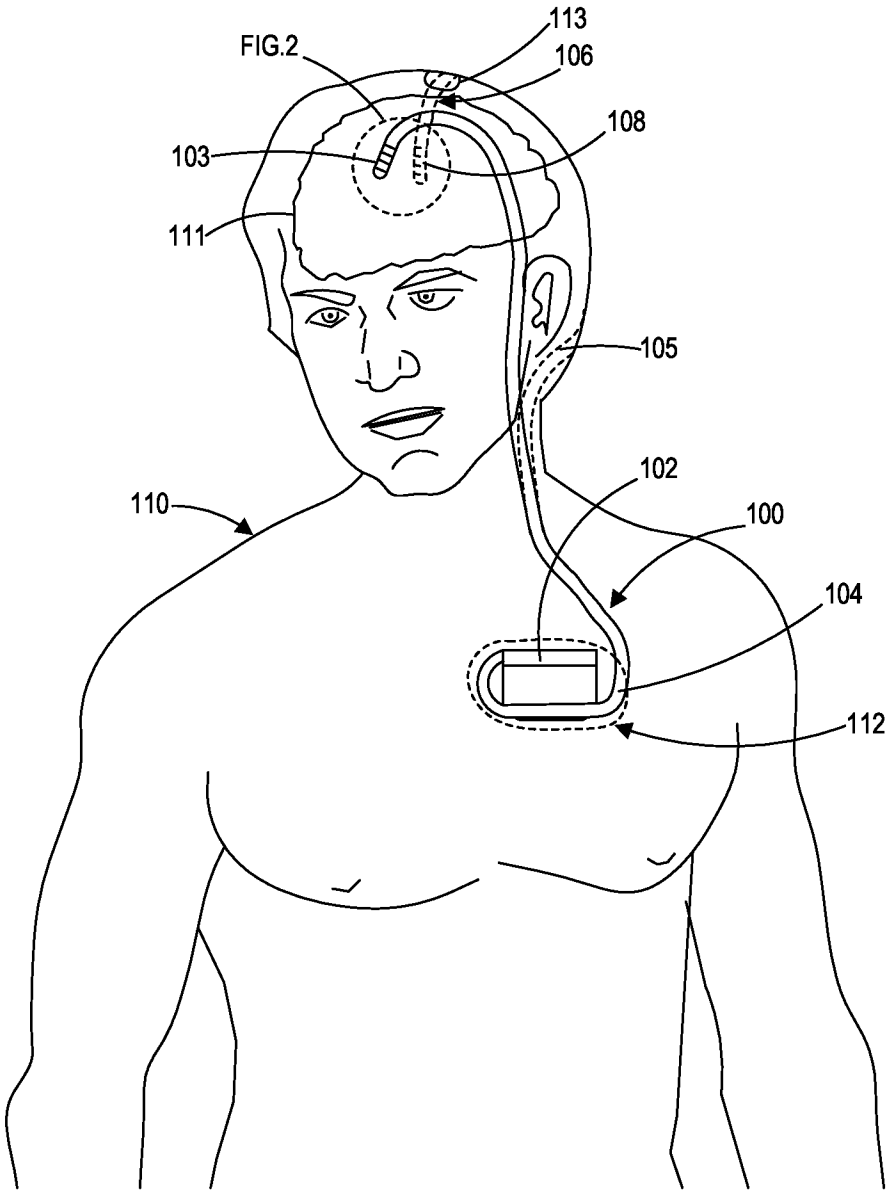

FIG. 1

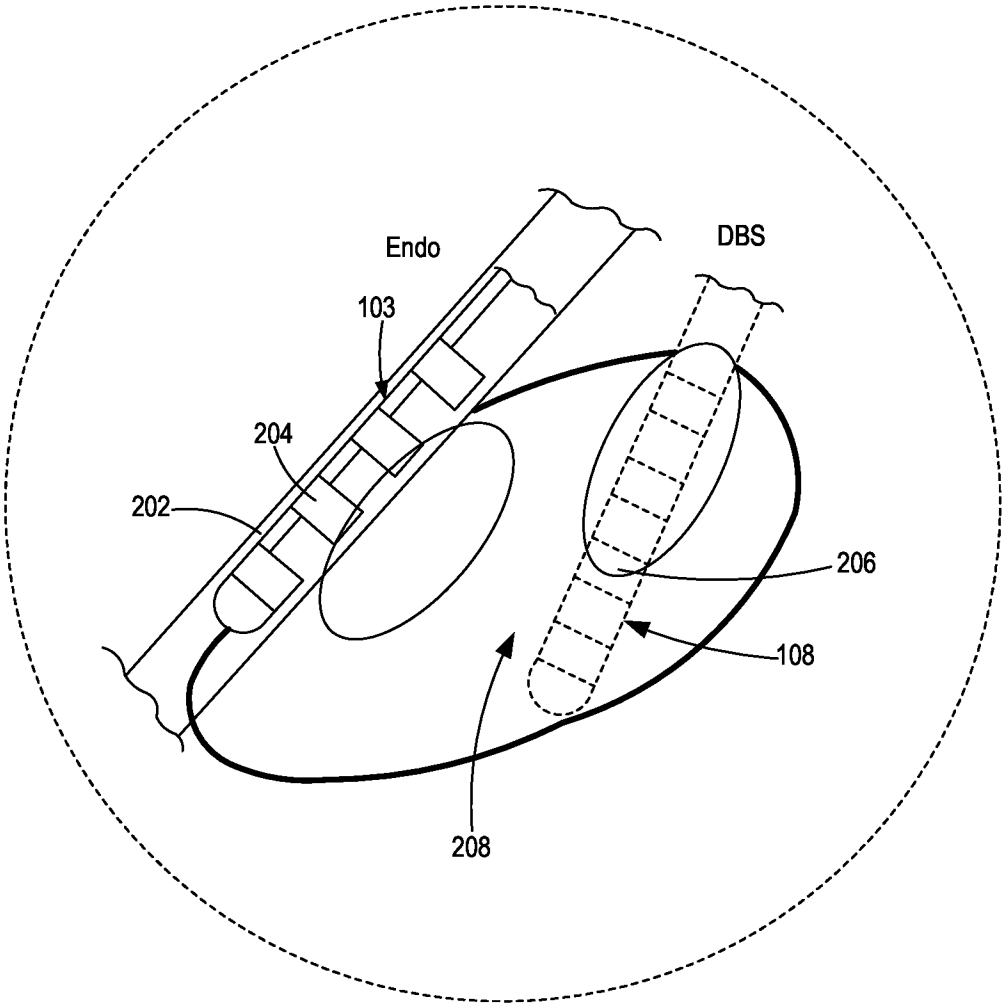

FIG. 2

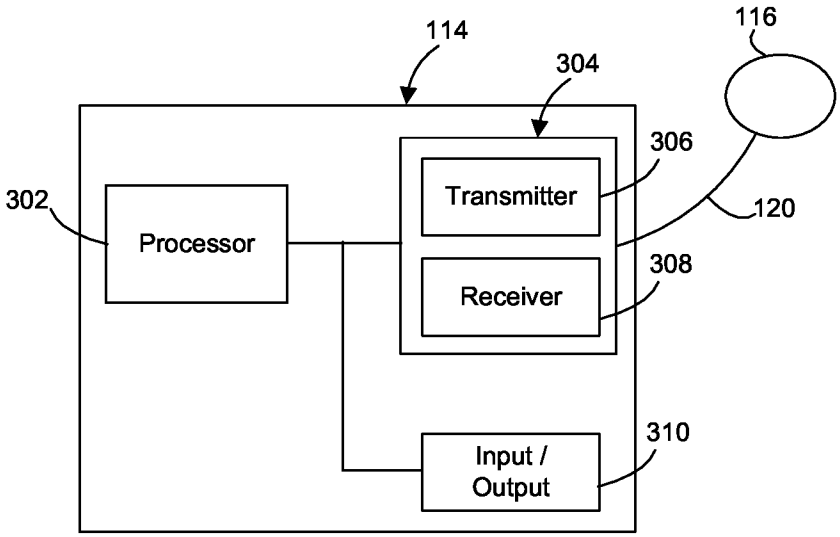
114
304
116
306
302
Processor
Transmitter
120
Receiver
308
310
Input /
Output

FIG.3

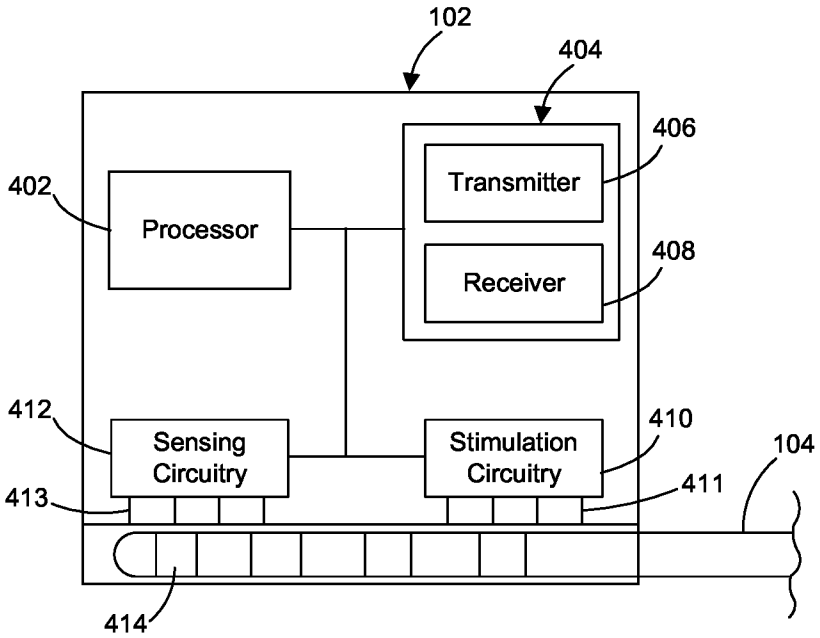
102
404
406
402
Processor
Transmitter
Receiver
408
412
410
Sensing
Circuitry
Stimulation
Circuitry
104
411
413
414

FIG.4

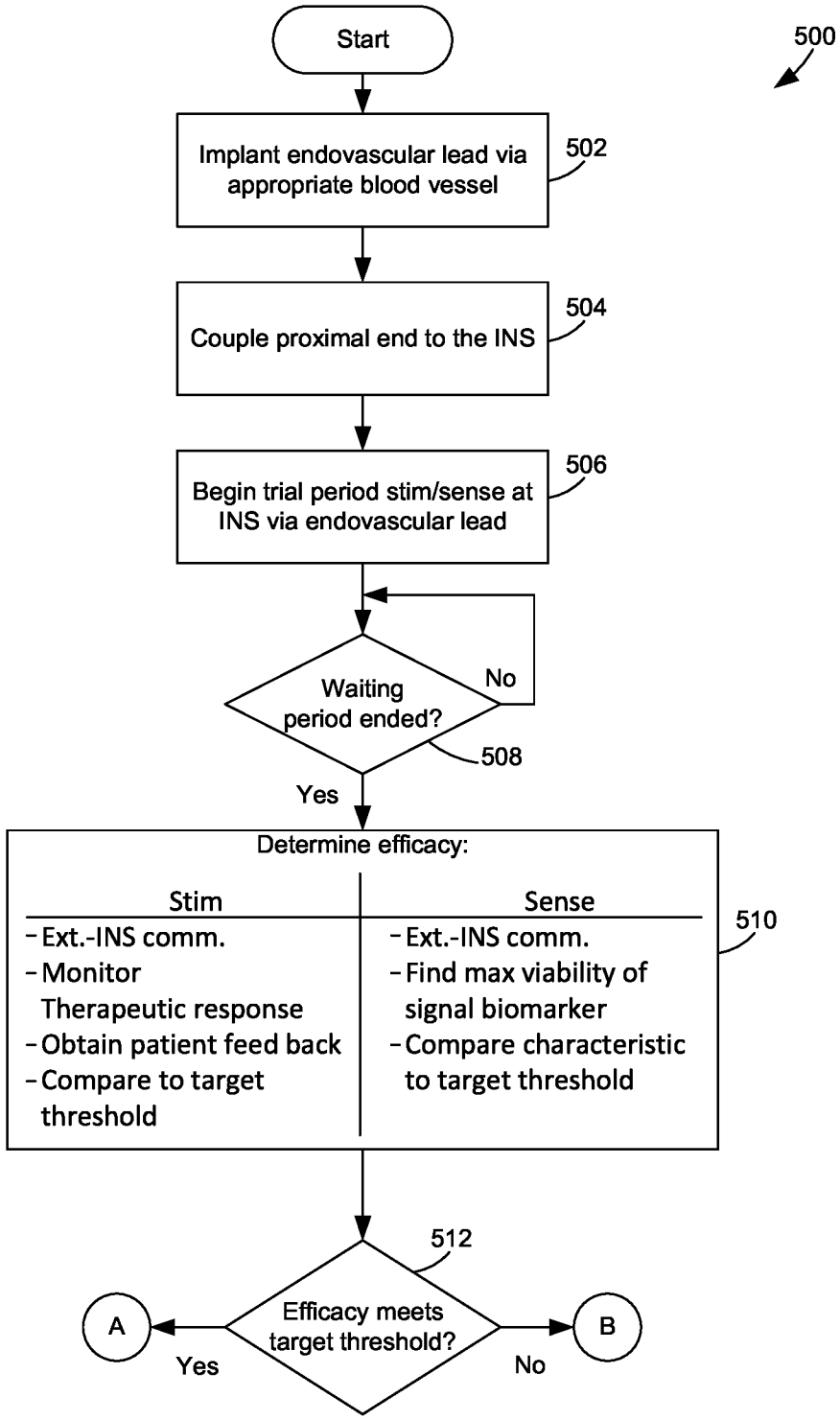
Start
500
Implant endovascular lead via appropriate blood vessel
502
Couple proximal end to the INS
504
Begin trial period stim/sense at INS via endovascular lead
506
Waiting period ended?
No
508
Yes
Determine efficacy:
Stim
- Ext.-INS comm.
- Monitor Therapeutic response
- Obtain patient feed back
- Compare to target threshold
Sense
- Ext.-INS comm.
- Find max viability of signal biomarker
- Compare characteristic to target threshold
510
512
Efficacy meets target threshold?
A
Yes
B
No

FIG.5A

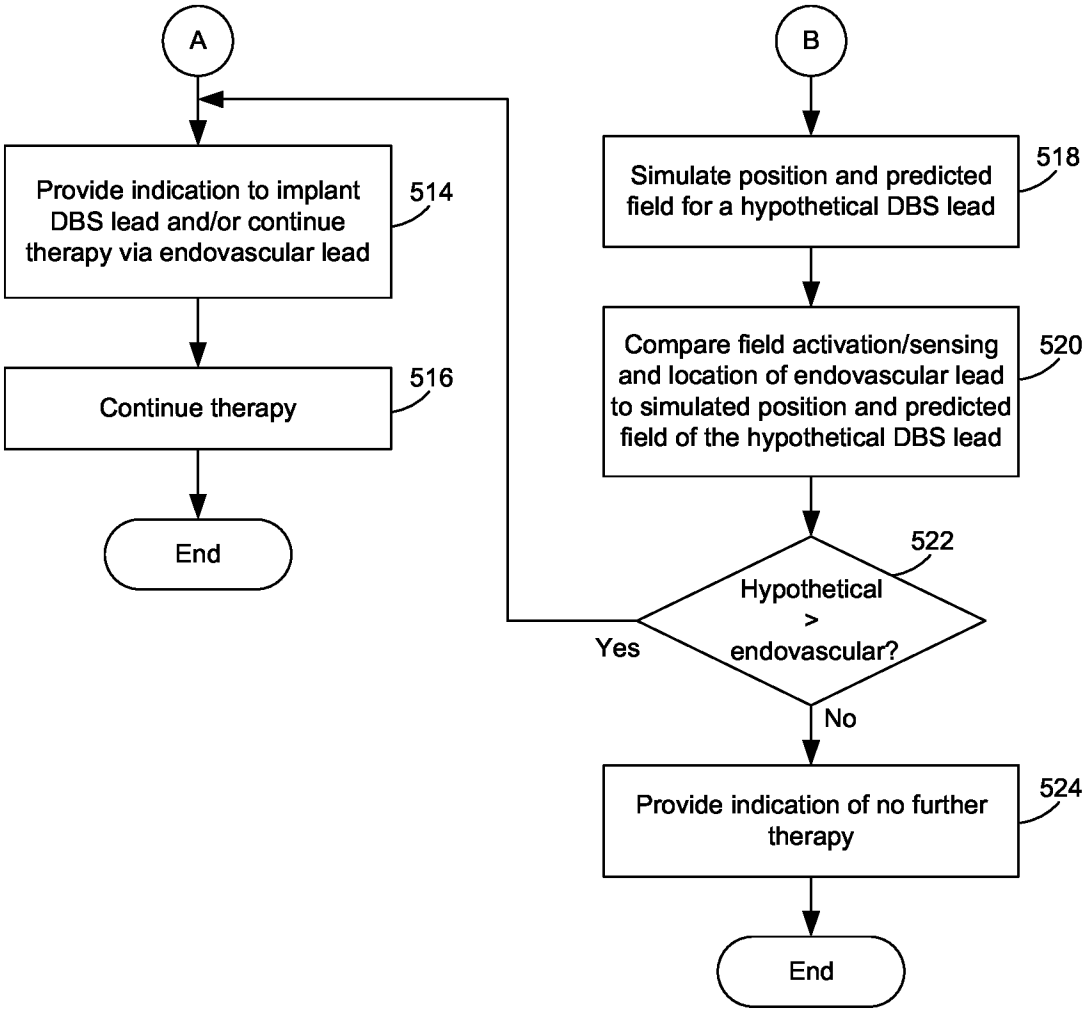
A
Provide indication to implant DBS lead and/or continue therapy via endovascular lead
514
Continue therapy
516
End
B
Simulate position and predicted field for a hypothetical DBS lead
518
Compare field activation/sensing and location of endovascular lead to simulated position and predicted field of the hypothetical DBS lead
520
522
Hypothetical > endovascular?
Yes
No
Provide indication of no further therapy
524
End

FIG.5B

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2024/059602

A. CLASSIFICATION OF SUBJECT MATTER

INV. A61N1/05 A61B5/369 A61N1/36
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61N A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2005/187589 A1 (WALLACE MICHAEL P [US] ET AL) 25 August 2005 (2005-08-25) paragraphs [0017] - [0037]; figures 1, 3	8-15
A	US 2011/264165 A1 (MOLNAR GABRIELA C [US] ET AL) 27 October 2011 (2011-10-27) the whole document	8-15
A	US 2022/323241 A1 (JOHN SAM EMMANUEL [AU] ET AL) 13 October 2022 (2022-10-13) the whole document	8-15
A	US 2022/202486 A1 (MORALES JOSE MIGUEL [US]) 30 June 2022 (2022-06-30) the whole document	8-15
A	US 2023/256238 A1 (MORALES JOSE MIGUEL [US]) 17 August 2023 (2023-08-17) the whole document	8-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 January 2025	24/01/2025

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Smit, Josephus

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2024/059602

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.: 1-7
because they relate to subject matter not required to be searched by this Authority, namely:
see FURTHER INFORMATION sheet PCT/ISA/210

2. [ ] Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims;; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

[ ] The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

[ ] No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.1

Claims Nos.: 1-7

Claims 1-7 relate to subject-matter considered by this Authority to be covered by the provisions of Rule 39.1(iv) / 67.1(iv) PCT - Method for treatment of the human or animal body by therapy. In particular, claims 1-7 relate to a method of configuring a system capable of providing neurostimulation therapy, comprising the step of providing neurostimulation therapy using an endovascular lead.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2024/059602

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		US 2024198090 A1	20-06-2024
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