A METHOD FOR THE TREATMENT OF ANEURYSM

Abstract: An apparatus for controlling a flow of blood in a lumen formed by a tissue wall of a patient's blood vessel comprises an implantable constricting device for gently constricting (i.e. without substantially hampering the blood circulation in the tissue wall) at least one portion of the tissue wall to influence the flow in the lumen, and a stimulation device for stimulating the wall portion of the tissue wall. A control device controls the stimulation device to stimulate the wall portion, as the constricting device constricts the wall portion, to cause contraction of the wall portion constricted by the constricting device to further influence the flow in the lumen. The apparatus can be used for stabilizing, treating or controlling an aneurysm, with a low risk of side-effects, such as injuring the blood vessel or causing embolism.
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TECHNICAL FIELD

[0001] The present invention relates to controlling the flow of blood in a blood vessel, for prophylactic and therapeutic purposes, and in particular to a method for treating a vascular aneurysm of a human or mammal patient.

BACKGROUND

[0002] An aneurysm (or aneurism) is a localized, blood-filled dilation (balloon-like bulge) of a blood vessel caused by disease or weakening of the vessel wall. Aneurysms most commonly occur in arteries at the base of the brain (the circle of Willis) and in the aorta (the main artery coming out of the heart), a so-called aortic aneurysm. The bulge in a blood vessel can burst and lead to severe internal hemorrhage and death at any time. The larger an aneurysm becomes, the more likely it is to burst and since aneurysms naturally grow, given enough time they will inevitably reach the bursting point if undetected.

[0003] Given the severe consequences of an aneurysm, screening is now commonly performed in order to early detect the presence of an aneurysm. In case of an aortic aneurysm the blood-filled dilation is commonly located in the abdomen close to the Y-bifurcation extending to the legs. At this location the aorta is typically about 2.5 centimeters wide, which can be measured for example using ultra-sonic or X-ray based measuring devices.

[0004] Existing treatment when detecting an aortic aneurysm includes implantation of a stent around the vessel using open surgery. An alternative surgical procedure is to implant a tube from the groin and guide the stent via arteria femoralis into position where the blood flow can by-pass the aortic aneurysm via the tube. The latter treatment has the drawback that an embolism is easily formed when alien material is introduced into the bloodstream.
Hence, there exists a need for a treatment of aortic aneurysm that is more robust and which brings about fewer complications.

SUMMARY

It is an object of the present invention to overcome or at least reduce some of the problems associated with existing treatments of aneurysm.

These objects and others are obtained by the method as set out in the appended claims.

According to this object of the present invention, a method for treating an aneurysmic bulge in a blood vessel in a human or mammal patient, the method comprising:

a) gently constricting at least one portion of the tissue wall of a blood vessel extending along the aneurysm to constrict the bulge of the blood vessel,

or

b) stimulating said wall portion to cause contraction of the wall portion to further increasing tonus of the wall portion, to prevent expansion of the bulge of the blood vessel.

In accordance with the preferred object of the invention is provided, a method for treating an aneurysmic bulge in a blood vessel in a human or mammal patient, the method comprising:

a) gently constricting at least one portion of the tissue wall of a blood vessel extending along the aneurysm to constrict the bulge of the blood vessel,

and

b) stimulating said wall portion to cause contraction of the wall portion to further increasing tonus of the wall portion, to prevent expansion of the bulge of the blood vessel.
In accordance with another object of the present invention, there is provided a method for treating an aneurysmic bulge in a blood vessel in a human or mammal patient, the method comprising:

[0009]

a) gently constricting at least one portion of the tissue wall of the aneurysm, or
b) stimulating at least one portion of the tissue wall of the aneurysm to cause contraction of the wall portion to further reduce the bulge of the blood vessel.

In accordance with a most beneficial embodiment of the invention, a method for treating an aneurysmic bulge in a blood vessel in a human or mammal patient, the method comprising:

a) gently constricting the tissue wall portion, and
b) stimulating the constricted wall portion to cause contraction of the wall portion to reduce the bulge of the blood vessel.

[0010] It should be understood that any embodiment or part of embodiment disclosed in this application related to a constriction device to constrict and a stimulation device to stimulate used in a combination, or in general terms a method for constriction and stimulation used in a combination, could both also be used for a separate constriction method or separate stimulation method or the constriction device as stand alone device or the stimulation device as a stand alone device, where applicable.

[0011] The present invention also provides an advantageous combination of constriction and stimulation devices, which results in a two-stage influence on the aneurysm. Thus, the constriction device may gently constrict the tissue wall by applying a relatively weak force against the wall portion, and the stimulation device may stimulate the constricted wall portion to achieve the desired final influence on the aneurysm, as well as stabilizing, treating, and monitoring the condition of the blood vessel. The phrase "gently constricting a portion of the tissue wall" is to be understood as constricting the wall portion without injuring the blood vessel tissue.

[0012]
[0013] Preferably, the stimulation performed in a fashion adapted to stimulate different areas of the wall portion as the constriction device constricts the wall portion, and preferably the control device controls the stimulation device to intermittently and individually stimulate the areas of the wall portion. This intermittent and individual stimulation of different areas of the wall portion of the blood vessel, e.g. a blood vessel, allows tissue of the wall portion to maintain substantially normal blood circulation during the operation of the apparatus of the invention.

[0014] For the treatment of aneurysms, it is particularly preferred that the method supports and preferably also strengthens the blood vessel. A combination of stimulation and constriction is applied to stimulate the healing of the vessel, preferably resulting in the reduction or disappearance of the aneurysm.

[0015] In some applications using the present invention, there will be daily adjustments of the implanted constriction device. Therefore, in a preferred embodiment of the invention, the constriction device is adjustable to enable adjustment of the constriction of the wall portion as desired, wherein the control device controls the constriction device to adjust the constriction of the wall portion. In a method according to an embodiment of the invention, the control device may control the constriction and stimulation devices independently of each other, and simultaneously. Optionally, the control device may control the stimulation device to stimulate, or to not stimulate the wall portion while the control device controls the constriction device to change the constriction of the wall portion.

[0016] Initially, the constriction device may be calibrated by using the control device to control the stimulation device to stimulate the wall portion, while controlling the constriction device to adjust the constriction of the wall portion until the desired restriction of the aneurysm is obtained, alternatively the desired support or treatment of the vessel, e.g. in the case of an aneurysm.

[0017] In a method according to an embodiment of the invention, the control device may control the stimulation device to change the stimulation of the wall portion in response to a sensed physical parameter of the patient or functional parameter of the apparatus. For example, the control device may control the stimulation device to increase the intensity of the stimulation of the wall portion in response to a sensed
pressure increase or reduction in the lumen, such that the flow in the lumen remains stopped, for example in an acute situation, i.e. a rupture of the aneurysm. Any sensor for sensing a physical parameter of the patient, such as a pressure in the patient's body that relates to the pressure in the lumen may be provided, wherein the control device controls the stimulation device in response to signals from the sensor. Such a sensor may for example sense the pressure in the patient's abdomen, the pressure against the implanted constriction device or the pressure on the tissue wall of the bodily blood vessel.

[0018] For example, a pressure sensor may be applied where the present invention is used for monitoring, and react to variations in the systolic or diastolic pressure of the patient. In the stabilization, treatment and monitoring of an aneurysm, it is conceived that a pressure sensor is provided to account for the variations in pressure and thereby provide a more gentle and physiological support and treatment. It is also conceived that a sensor is provided to follow the healing or worsening of the condition, as well as for alerting when pathological changes occur, and preferably indicate any changes in that direction.

[0019] In accordance with a fourth flow restriction option, the control device controls the constriction device to constrict the wall portion, to cease the constriction of the wall portion. In this case, the control device only controls the stimulation device to stimulate the wall portion when needed. A sensor for sensing a physical parameter of the patient's body that relates to the pressure in the lumen may be provided, wherein the control device controls the stimulation device in response to signals from the sensor. Such a physical parameter may be a pressure in the patient's abdomen and the sensor may be a pressure sensor.

[0020] In a particular embodiment of a method for treating an aneurysm, the sensor is a pressure sensor capable of detecting a sudden reduction of pressure indicative of a brusting aneurysm, where such sudden pressure reduction elicits a signal to the device, and the method includes a step of stopping the blood flow in response to such signal. A complete stop of the blood flow to a part of the body, e.g. the lower limbs in the case of an aneurysm on the Y-bifurcation extending to the legs, is of course only an acute measure, preventing death from internal haemorrhage.
[0021] In another embodiment of a method for treating and monitoring an aneurysm, the sensor is a sensor capable of detecting a change in a parameter indicative of a pathological change in the aneurysm, e.g. a change in pressure, temperature, conductivity, pH or other parameter, indicating a worsening condition or an imminent burst of the aneurysm.

[0022] In the above embodiment, the device comprises, in addition to said sensor, also a device for transmitting an alarm signal when the measured value of the above parameter deviates for a set range or threshold value.

[0023] The constriction device may include a plurality of separate constriction elements adapted to constrict any wall portions of a series of wall portions of the blood vessel’s tissue wall, respectively. The control device may control the constriction device to activate the constriction elements in random or in accordance with a predetermined sequence. In this case, the stimulation device includes stimulation elements positioned on the constriction elements, wherein the control device controls the stimulation device to activate the stimulation elements to stimulate any wall portions of the series of wall portions constricted by said constriction elements to contract the blood vessel to support or stimulate the walls of a blood vessel, or in acute situations even close the it’s lumen.

[0024] Alternatively, in a method according to an embodiment of the invention, the control device controls the constriction device to activate the constriction elements to constrict all of the wall portions of the series of wall portions, and controls the stimulation device to activate the stimulation elements to stimulate any constricted wall portions in random or in accordance with a predetermined sequence. The design of the constriction device in the form of a plurality of separate constriction elements makes possible to counteract growth of hard fibrosis where the constriction device is implanted.

**Stimulation**

[0025] When stimulating neural or muscular tissue there is a risk of injuring or deteriorating the tissue over time, if the stimulation is not properly performed. The method of the present invention is designed to reduce or even eliminate that risk. Thus, in accordance with an embodiment of the method according to the present
invention, the control device controls the stimulation device to intermittently stimulate different areas of the wall portion of the blood vessel, such that at least two of the areas are stimulated at different points of time that is, the stimulation is shifted from one area to another area over time. In addition, the control device controls the stimulation device, such that an area of the different areas that currently is not stimulated has time to restore substantially normal blood circulation before the stimulation device stimulates the area again. Furthermore, the control device controls the stimulation device to stimulate each area during successive time periods, wherein each time period is short enough to maintain satisfactory blood circulation in the area until the lapse of the time period. This gives the advantage that the apparatus of the present invention enables continuous stimulation of the wall portion of the blood vessel to achieve the desired flow control, while essentially maintaining over time the natural physical properties of the blood vessel without risking injuring the blood vessel.

[0026] Also, by physically changing the places of stimulation on the blood vessel over time as described above it is possible to create an advantageous changing stimulation pattern on the blood vessel, in order to achieve a desired flow control and preferably a positive influence on the health an regeneration of tissue.

[0027] In a method according to an embodiment of the invention, the control device may control the stimulation device to stimulate one or more of the areas of the wall portion at a time, for example by sequentially stimulating the different areas. Furthermore, the control device may control the stimulation device to cyclically propagate the stimulation of the areas along the wall portion, preferably in accordance with a determined stimulation pattern. To achieve the desired reaction of the tissue wall during the stimulation thereof, the control device may control the stimulation device to, preferably cyclically, vary the intensity of the stimulation of the wall portion.

[0028] In a preferred embodiment of the invention, the control device controls the stimulation device to intermittently stimulate the areas of the wall portion with pulses that preferably form pulse trains. At least a first area and a second area of the areas of the wall portion may be repeatedly stimulated with a first pulse train and a second pulse train, respectively, such that the first and second pulse trains over time are
shifted relative to each other. For example, the first area may be stimulated with the first pulse train, while the second area is not stimulated with said second pulse train, and vice versa. Alternatively, the first and second pulse trains may be shifted relative to each other, such that the first and second pulse trains at least partially overlap each other.

[0029] The pulse trains can be configured in many different ways. Thus, the control device may control the stimulation device to vary the amplitudes of the pulses of the pulse trains, the duty cycle of the individual pulses of each pulse train, the width of each pulse of the pulse trains, the length of each pulse train, the repetition frequency of the pulses of the pulse trains, the repetition frequency of the pulse trains, the number of pulses of each pulse train, and/or the off time periods between the pulse trains. Several pulse trains of different configurations may be employed to achieve the desired effect.

[0030] In case the control device controls the stimulation device to vary the off time periods between pulse trains that stimulate the respective area of the wall portion, it is also possible to control each off time period between pulse trains to last long enough to restore substantially normal blood circulation in the area when the latter is not stimulated during the off time periods.

**Electric Stimulation**

[0031] In accordance with a preferred embodiment of the method according to the invention, the stimulation device is an electrically powered stimulation device that electrically stimulates the tissue wall portion of the patient's blood vessel, preferably with electric pulses. This embodiment is particularly suited for applications in which the wall portion includes muscle fibers that react to electrical stimuli. In this embodiment, the control device controls the stimulation device to stimulate the wall portion with electric pulses preferably in the form of electric pulse trains, when the wall portion is in the constricted state, to cause contraction of the wall portion. Of course, the configuration of the electric pulse trains may be similar to the above described pulse trains and the control device may control the stimulation device to electrically stimulate the different areas of the wall of the blood vessel in the same manner as described above.
[0032] In a method according to an embodiment of the invention, the electric stimulation device suitably comprises at least one, preferably a plurality of electrical elements, such as electrodes, for engaging and stimulating the wall portion with electric pulses. Optionally, the electrical elements may be placed in a fixed orientation relative to one another. The control device controls the electric stimulation device to electrically energize the electrical elements, one at a time, or groups of electrical elements at a time. Preferably, the control device controls the electric stimulation device to cyclically energize each element with electric pulses. Optionally, the control device may control the stimulation device to energize the electrical elements, such that the electrical elements are energized one at a time in sequence, or such that a number or groups of the electrical elements are energized at the same time. Also, groups of electrical elements may be sequentially energized, either randomly or in accordance with a predetermined pattern.

[0033] The electrical elements may form any pattern of electrical elements. Preferably, the electrical elements form an elongate pattern of electrical elements, wherein the electrical elements are applicable on the patient's wall of the blood vessel, such that the elongate pattern of electrical elements extends lengthwise along the wall of the blood vessel, and the elements abut the respective areas of the wall portion. The elongate pattern of electrical elements may include one or more rows of electrical elements extending lengthwise along the wall of the blood vessel. Each row of electrical elements may form a straight, helical or zig-zag path of electrical elements, or any form of path. The control device may control the stimulation device to successively energize the electrical elements longitudinally along the elongate pattern of electrical elements in a direction opposite to, or in the same direction as that of, the flow in the lumen of a blood vessel.

[0034] Optionally, the method may comprise steps where the control device controls the stimulation device to successively energize the electrical elements from a position substantially at the center of the constricted wall portion towards both ends of the elongate pattern of electrical elements. Where the lumen of the blood vessel, for example a blood vessel in the case of a rupture, is to be kept closed for a relatively long time, the control device may control the stimulation device to energize the electrical elements, such that energized electrical elements form two waves of
energized electrical elements that simultaneously advance from the center of the constricted wall portion in two opposite directions towards both ends of the elongate pattern of electrical elements. Such waves of energized electrical elements can be repeated over and over again without harming the blood vessel and without moving blood in any direction in the lumen of the blood vessel.

[0035] In a method according to an embodiment of the invention, the control device suitably controls the stimulation device to energize the electrical elements, such that the electrical elements currently energized form at least one group of adjacent energized electrical elements. In accordance with a first alternative, the elements in the group of energized electrical elements form one path of energized electrical elements. The path of energized electrical elements may extend at least in part around the patient's blood vessel. In a second alternative, the elements of the group of energized electrical elements may form two paths of energized electrical elements extending on mutual sides of the patient's blood vessel, preferably substantially transverse to the flow direction in the blood vessel. In a third alternative, the elements of the group of energized electrical elements may form more than two paths of energized electrical elements extending on different sides of the patient's blood vessel, preferably substantially transverse to the flow direction.

[0036] In accordance with a preferred embodiment of the invention, the electrical elements form a plurality of groups of elements, wherein the groups form a series of groups extending along the blood vessel in the direction of flow. The electrical elements of each group of electrical elements may form a path of elements extending at least in part around the patient's blood vessel. In a first alternative, the electrical elements of each group of electrical elements may form more than two paths of elements extending on different sides of the blood vessel, preferably substantially transverse to the flow direction said vessel. The control device may control the stimulation device to energize the groups of electrical elements in the series of groups in random, or in accordance with a predetermined pattern. Alternatively, the control device may control the stimulation device to successively energize the groups of electrical elements in the series of groups in a direction opposite to, or in the same direction as that of, the flow in the blood vessel, or in both said directions starting from a position substantially at the center of the constricted
wall portion. For example, groups of energized electrical elements may form advancing waves of energized electrical elements, as described above; that is, the control device may control the stimulation device to energize the groups of electrical elements, such that energized electrical elements form two waves of energized electrical elements that simultaneously advance from the center of the constricted wall portion in two opposite directions towards both ends of the elongate pattern of electrical elements.

[0037]

Constriction and Stimulation Devices

[0004] Generally, the method of the invention comprises providing a constriction device that constricts the wall portion, a stimulation device that stimulates the constricted wall portion and a control device that controls the constriction device and/or the stimulation device. The method comprises operating the control device from outside the patient's body, specially for programming the device.

[0005] In an embodiment of the invention, the control device comprises a programmable internal control unit, such as a microprocessor, and the method comprises implanting in the patient the internal control unit and controlling by the internal control unit the constriction device and/or stimulation device. The control device may also comprise an external control unit outside the patient's body. In this case, the method comprises controlling by the external control unit the constriction device and/or stimulation device and, optionally, using the external control unit to program the implanted internal control unit. The internal control unit may be programmable for controlling the constriction device and/or stimulation device over time, for example in accordance with an activity schedule program.

[0006] The constriction of the wall portion can be calibrated by using the control device to control the stimulation device to stimulate the wall portion while controlling the constriction device to adjust the constriction of the wall portion until the desired restriction is obtained.

[0038] A structure may be provided for holding the electrical elements in a fixed orientation. Although the structure may be separate from the constriction device, it is
preferable that the structure is integrated in the constriction device, which is a practical design and facilitates implantation of the constriction and stimulation devices. Where the electrical elements form an elongate pattern of electrical elements, the structure may be applicable on the patient's blood vessel such that the elongate pattern of electrical elements extends along the blood vessel in the same direction as that of the flow in blood vessel and the elements abut the respective areas of the wall portion of the blood vessel.

**Thermal stimulation**

[0039] In another embodiment of the invention, the stimulation device thermally stimulates the wall portion of the blood vessel. Thus, the control device may control the stimulation device to cool the wall portion, when the wall portion is constricted, to cause contraction of the wall portion. Alternatively, the control device may control the stimulation device to heat the wall portion, when the wall portion is constricted and contracted, to cause expansion of the wall portion. The control device may control the stimulation device to cool the blood vessel to cause contraction thereof, or heat the blood vessel to cause expansion thereof. Where applicable, thermal stimulation may be practised in any of the embodiments of the present invention, and the thermal stimulation may be controlled in response to various sensors, for example strain, motion or pressure sensors.

**Sensor Controlled Constriction and/or Stimulation**

[0040] In an embodiment of the invention, the method comprises implanting at least one sensor and controlling by the control device the constriction device and/or the stimulation device in response to signals from the sensor. As mentioned above, the method may comprise the use of at least one implantable sensor, wherein the control device controls the constriction device and/or the stimulation device in response to signals from the sensor. Generally, the sensor directly or indirectly senses at least one physical parameter of the patient, or at least one functional
parameter of the apparatus, or at least one functional parameter of a medical implant in the patient.

[0041] Many different kinds of sensor for sensing physical parameters may be used. For example pressure sensors for sensing pressure in the blood vessel, strain sensors for sensing strain of the blood vessel, flow sensors for sensing fluid flow in the lumen of the blood vessel, spectro-photometrical sensors, Ph-sensors for sensing acidity or alkalinity of the fluid in the blood vessel, oxygen-sensors sensors for sensing the oxygen content of the blood in the blood vessel or walls thereof, or sensors for sensing the distribution of the stimulation on the stimulated blood vessel. Any conceivable sensors for sensing any other kind of useful physical parameter may be used.

[0042] Many different kinds of sensors that sense functional parameters of the apparatus may also be used for the control of the constriction device and/or the stimulation device in methods according to the invention. For example sensors for sensing electric parameters of implanted electric components of the apparatus, or sensors for sensing the performance of implanted motors of the apparatus.

[0043] The sensor may comprise a pressure sensor for sensing as the physical parameter a pressure in the patient’s body that relates to the pressure in the blood vessel, wherein the control device controls the constriction device and/or stimulation device to change the constriction of the wall portion in response to the pressure sensor sensing a predetermined value of measured pressure.

[0044] Alternatively, or in combination with the pressure sensor, a position sensor may be provided for sensing as the physical parameter the orientation of the patient with respect to the horizontal. The position sensor may be a biocompatible version of what is shown in U.S. patents 4 942 668 and 5 900 909. For example, the control device may control the constriction device and/or stimulation device to change the constriction of the patient’s wall portion in response to the position sensor sensing that the patient has assumed a substantially horizontal orientation, i.e. that the patient is lying down.

[0045] The above described sensors may be used in any of the embodiments of the invention, where applicable.
[0046] In a method according to an embodiment of the invention, the control device may control the constriction device and/or stimulation device to change the constriction of the patient’s wall portion in response to the time of day. For that purpose the control device may include a clock mechanism for controlling the constriction device and/or stimulation device to change the constriction of the wall portion to increase or decrease the influence on aneurysmic bulge in the vessel during different time periods of the day. In case a sensor of any of the above-described types for sensing a physical or functional parameter is provided, either the clock mechanism is used for controlling the constriction device and/or stimulation device provided that the parameter sensed by the sensor does not override the clock mechanism, or the sensor is used for controlling the constriction device and/or stimulation device provided that the clock mechanism does not override the sensor. Suitably, the control device produces an indication, such as a sound signal or displayed information, in response to signals from the sensor.

[0047] The control device may comprise an implantable internal control unit that directly controls the constriction device and/or stimulation device in response to signals from the sensor. The control device may further comprise a wireless remote control adapted to set control parameters of the internal control unit from outside the patient without mechanically penetrating the patient. At least one of the control parameters, which is settable by the wireless remote control, is the physical or functional parameter. Suitably, the internal control unit includes the above mentioned clock mechanism, wherein the wireless remote control also is adapted to set the clock mechanism.

[0048] Alternatively, the control device may comprise an external control unit outside the patient’s body for controlling the constriction device and/or stimulation device in response to signals from the sensor.

Adjustable Constriction

[0007] Method step (a) may be performed in many different ways. Thus, step (a) may be performed by:

(1) - constricting the wall portion clamping the organ between at least two articulated clamping elements positioned on different sides of the organ.
In the above noted alternatives (1) to (6) of method step (a), the constriction of the wall portion of the organ may be changed either mechanically or hydraulically. For many applications of the present invention,

Where the constriction of the wall portion is hydraulically changed, the method of the invention may further comprise implanting in the patient a reservoir containing a predetermined amount of hydraulic fluid, and a constriction device engaging the wall portion and having an expandable/contractible cavity, wherein step (a) is performed by distributing hydraulic fluid from the reservoir to increase the volume of the cavity to constrict the wall portion, and by distributing hydraulic fluid from the cavity to the reservoir to decrease the volume of the cavity to release the wall portion. The cavity may be defined by a balloon of the constriction device that abuts the tissue wall portion of the patient's organ, so that the patient's wall portion is constricted upon expansion of the cavity and released upon contraction of the cavity.

Alternatively, the cavity may be defined by a bellows that displaces a relatively large contraction element of the constriction device, for example a large balloon that abuts the wall portion, so that the patient's wall portion is constricted upon contraction of the bellows and released upon expansion of the bellows. Thus, a relatively small addition of hydraulic fluid to the bellows causes a relatively large increase in the constriction of the wall portion. Such a bellows may also be replaced by a suitably designed piston/cylinder mechanism.

Where the hydraulic means comprises a cavity in the constriction device, the following embodiments of the invention are conceivable.

1) The reservoir comprises first and second wall portions, and step (a) is performed by displacing the first and second wall portions relative to each other to change the volume of the reservoir, so that fluid is distributed from the reservoir to the cavity, or from the cavity to the reservoir.

1a) At least one of a magnetic device, a hydraulic device or an' electric control device displaces the first and second wall portions of the reservoir.

2) A pump is provided for pumping fluid between the reservoir and the cavity.

2a) The pump comprises a first activation member for activating the pump to pump fluid from the reservoir to the cavity and a second activation member for activating the pump to pump fluid from the cavity to the reservoir.
[0069] At least one of the activation members operates when subjected to an external predetermined pressure.

[0070] 2a3) At least one of the first and second activating members is operable by magnetic means, hydraulic means, or electric control means.

[0071] 2b) A fluid conduit between the pump and the cavity is provided, wherein the reservoir forms part of the conduit. The conduit and pump are devoid of any non-return valve. The reservoir forms a fluid chamber with a variable volume, and the pump distributes fluid from the chamber to the cavity by a reduction in the volume of the chamber and withdraws fluid from the cavity by an expansion of the volume of the chamber. A motor is provided for driving the pump, wherein the pump comprises a movable wall of the reservoir for changing the volume of the chamber.

[0072] In all of the above noted embodiments 1 to 2b where the hydraulic means comprises an expandable cavity in the constriction device, the cavity can be exchanged by a cylinder/piston mechanism for adjusting the constriction device. In this case, hydraulic fluid is distributed between the reservoir and the cylinder/piston. In accordance with a second alternative, there is provided an implantable main reservoir containing a predetermined amount of hydraulic fluid, wherein the reverse servo is operated to distribute hydraulic fluid between the main reservoir and the hydraulic means to adjust the constriction device. More specifically, the main reservoir is provided with first and second wall portions operatively connected to the first and second wall portions of the expandable servo reservoir, so that the volume of the main reservoir is changed when the volume of the expandable servo reservoir is changed. Thus, when the reverse servo distributes servo fluid between the fluid supply reservoir and the expandable servo reservoir to change the volume of the main reservoir, hydraulic fluid is distributed from the main reservoir to the hydraulic means, or from the hydraulic means to the main reservoir. Advantageously, the method comprises dimensioning the servo and main reservoirs, so that when the volume of the servo reservoir is changed by a relatively small amount of servo fluid, the volume of the main reservoir is changed by a relatively large amount of hydraulic fluid.

[0073] In both of the above-described alternatives, the fluid supply reservoir may have first and second wall portions, which are displaceable relative to each other to change the volume of the fluid supply reservoir to distribute servo fluid between the fluid supply reservoir and the expandable servo reservoir. The first and
second wall portions of the fluid supply reservoir may be displaced relative to each other by manual manipulation, a magnetic device, a hydraulic device, or an electric control device to change the volume of the fluid supply reservoir to distribute servo fluid between the fluid supply reservoir and the expandable servo reservoir.

[0049] In several alternative embodiments of the invention, the degree of constriction is adjustable. In these embodiments, there is an operation device for operating the adjustable constriction device to change the constriction of the patient's tissue wall portion, and the constriction and stimulation devices form a constriction/stimulation unit.

[0050] Preferably, the constriction and stimulation devices of the constriction/stimulation unit are integrated in a single piece suitable for implantation. The constriction device of the unit comprises contact surfaces dimensioned to contact a length of a tissue wall portion of a patient's blood vessel, and the stimulation device of the unit comprises a plurality of stimulation elements provided on and distributed along the contact surfaces. When the control device controls the stimulation device to stimulate the wall portion, the stimulation elements stimulate different areas of the wall portion along the length of the wall portion. The stimulation elements preferably comprise electric elements, as described above, for stimulating the wall portion with electric pulses. However, in most applications of the present invention, other kinds of stimulations, such as thermal stimulation, could be suitable to employ.

[0051] The operation device operates the adjustable constriction device of the constriction/stimulation unit in a manner that depends on the design of the constriction device, as will be explained by the following examples of embodiments.

[0052] 1) The constriction device comprises at least two elongated clamping elements having the contact surfaces and extending along the wall portion on different sides of the blood vessel, and the operation device operates the clamping elements to clamp the wall portion between the clamping elements to constrict the wall portion of the blood vessel.

[0053] 2) The constriction device comprises one elongate clamping element having the contact surfaces and extending along the wall portion on one side of the
blood vessel, and the operation device operates the clamping element to clamp the wall portion between the clamping element and the bone or tissue of the patient to constrict the wall portion.

[0054] 3) The constriction device comprises at least two engagement elements having the contact surfaces and positioned on different sides of the blood vessel, and the operation device rotates the engagement elements, such that the engagement elements engage and constrict the wall portion of the blood vessel.

[0055] 4) The constriction device comprises at least two articulated clamping elements having the contact surfaces and positioned on different sides of the blood vessel, and the operation device moves the clamping elements towards each other to clamp the wall portion of the blood vessel between the clamping elements, to constrict the wall portion.

[0056] 5) The constriction device comprises at least two separate clamping elements having the contact surfaces, at least one of the clamping elements being pivoted, such that it may turn in a plane in which the loop of the constriction member extends, and the operation device turns the pivoted clamping element to change the size of the constriction opening.

[0057] 6) The constriction device comprises at least one elongated constriction member having the contact surfaces, and forming means for forming the constriction member into at least a substantially closed loop around the blood vessel, wherein the loop defines a constriction opening. The operation device operates the constriction member in the loop to change the size of the constriction opening.

[0058] 6a) The elongated constriction member comprises a belt having the contact surfaces, and the operation device operates the belt to change the longitudinal extension of the belt in the loop to change the size of the constriction opening. The forming means may form the constriction member or belt into a loop having at least one predetermined size.

[0059] 6b) The elongated constriction member is operable to change the size of the constriction opening, such that the outer circumferential confinement surface of the constriction device is changed, or, alternatively, is unchanged.
6c) The elongated constriction member is elastic and varies in thickness as seen in a cross-section there through, and is operable to turn around the longitudinal extension of the constriction member.

6d) The elongated constriction member comprises two substantially or partly semi-circular frame elements having the contact surfaces and hinged together, such that the semi-circular elements are swingable relative to each other from a fully open state in which they substantially or partly form a circle to a fully folded state in which they substantially form a semi-circle.

In the above noted embodiments (1) to (6d), it is important that the constriction device is designed to constrict said length of the tissue wall portion of the patient’s blood vessel. For this purpose, the constriction device may include two or more of the described constriction elements/members to be applied in a row along said length of the wall portion, wherein said row extends in the direction of flow in the blood vessel. Preferably, such constriction elements/members are non-inflatable and mechanically operable or adjustable. An example of a non-inflatable constriction element is a cylinder, arranged around a blood vessel and supporting the same. Preferably said cylinder is elastic, and more preferably it is part of a device incorporating one or more of the functions of constriction, stimulation and monitoring described herein.

In the above noted embodiments (1) to (6d), the operation device may either mechanically or hydraulically adjust the constriction device of the constriction/stimulation unit. Also, the operation device may comprise an electrically powered operation device for operating the constriction device. For many applications of the present invention, the operation device suitably operates the constriction device, such that the through-flow area of the aneurysm assumes a size in the constricted state that enables the stimulation device to contract the wall portion such that the flow in the lumen is stopped, which may be a life-saving action in acute situations.

**Mechanical operation**

Where the operation device mechanically operates the constriction device of the constriction/stimulation unit, it may be non-inflatable. Furthermore, the operation
device may comprise a servo system, which may include a gearbox. The term "servo system" encompasses the normal definition of a servo mechanism, *i.e.*, an automatic device that controls large amounts of power by means of very small amounts of power, but may alternatively or additionally encompass the definition of a mechanism that transfers a weak force acting on a moving element having a long stroke into a strong force acting on another moving element having a short stroke. Preferably, the operation device operates the constriction device in a non-magnetic and/or non-manual manner. A motor may be operatively connected to the operation device. The operation device may be operable to perform at least one reversible function and the motor may be capable of reversing the function.

**Hydraulic Operation**

[0065] Where the operation device hydraulically operates the constriction device of the constriction/stimulation unit, it includes hydraulic means for adjusting the constriction device.

[0066] In an embodiment of the invention, the hydraulic means comprises a reservoir and an expandable/contractible cavity in the constriction device, wherein the operation device distributes hydraulic fluid from the reservoir to expand the cavity, and distributes hydraulic fluid from the cavity to the reservoir to contract the cavity. The cavity may be defined by a balloon of the constriction device that abuts the tissue wall portion of the patient's blood vessel, so that the patient's wall portion is constricted upon expansion of the cavity and released upon contraction of the cavity.

[0067] Alternatively, the cavity may be defined by a bellows that displaces a relatively large contraction element of the constriction device, for example a large balloon that abuts the wall portion, so that the patient's wall portion is constricted upon contraction of the bellows and released upon expansion of the bellows. Thus, a relatively small addition of hydraulic fluid to the bellows causes a relatively large increase in the constriction of the wall portion. Such a bellows may also be replaced by a suitably designed piston/cylinder mechanism.
[0068] Where the hydraulic means comprises a cavity in the constriction device, the apparatus of the invention can be designed in accordance with the options listed below.

[0069] 1) The reservoir comprises first and second wall portions, and the operation device displaces the first and second wall portions relative to each other to change the volume of the reservoir, such that fluid is distributed from the reservoir to the cavity, or from the cavity to the reservoir.

[0070] 1a) The first and second wall portions of the reservoir are displaceable relative to each other by at least one of a magnetic device, a hydraulic device or an electric control device.

[0071] 2) The operation device comprises a pump for pumping fluid between the reservoir and the cavity.

[0072] 2a) The pump comprises a first activation member for activating the pump to pump fluid from the reservoir to the cavity and a second activation member for activating the pump to pump fluid from the cavity to the reservoir.

[0073] 2a1) The first and second activation members are operable by manual manipulation thereof.

[0074] 2a2) At least one of the activation members operates when subjected to an external predetermined pressure.

[0075] 2a3) At least one of the first and second activating members is operable by magnetic means, hydraulic means, or electric control means.

[0076] 2b) The apparatus comprises a fluid conduit between the pump and the cavity, wherein the reservoir forms part of the conduit. The conduit and pump are devoid of any non-return valve. The reservoir forms a fluid chamber with a variable volume, and the pump distributes fluid from the chamber to the cavity by a reduction in the volume of the chamber and withdraws fluid from the cavity by an expansion of the volume of the chamber. The apparatus further comprises a motor for driving the pump, wherein the pump comprises a movable wall of the reservoir for changing the volume of the chamber.
[0077] In all of the above noted embodiments 1 to 2b where the hydraulic means comprises an expandable cavity in the constriction device, the cavity can be exchanged by a cylinder/piston mechanism for adjusting the constriction device. In this case, the operation device distributes hydraulic fluid between the reservoir and the cylinder/piston mechanism to adjust the constriction device.

[0078] In a special embodiment of the invention, the operation device comprises a reverse servo operatively connected to the hydraulic means. The term "reverse servo" is to be understood as a mechanism that transfers a strong force acting on a moving element having a short stroke into a weak force acting on another moving element having a long stroke; i.e., the reverse function of a normal servo mechanism. Thus, minor changes in the amount of fluid in a smaller reservoir could be transferred by the reverse servo into major changes in the amount of fluid in a larger reservoir. The reverse servo is particularly suited for manual operation thereof.

[0079] Preferably, the reverse servo comprises an expandable servo reservoir containing servo fluid and a fluid supply reservoir hydraulically connected to the servo reservoir to form a closed conduit system for the servo fluid. The expandable servo reservoir has first and second wall portions, which are displaceable relative to each other in response to a change in the volume of the expandable servo reservoir.

[0080] In accordance with a first alternative, the first and second wall portions of the servo reservoir are operatively connected to the hydraulic means. The reverse servo distributes fluid between the fluid supply reservoir and the expandable servo reservoir to change the volume of the servo reservoir, whereby the hydraulic means is operated to adjust the constriction device.

[0081] In accordance with a second alternative, there is provided an implantable main reservoir containing a predetermined amount of hydraulic fluid, wherein the reverse servo is operable to distribute hydraulic fluid between the main reservoir and the hydraulic means to adjust the constriction device. More specifically, the main reservoir is provided with first and second wall portions operatively connected to the first and second wall portions of the expandable servo reservoir, such that the volume of the main reservoir is changed when the volume of the expandable servo reservoir is changed. Thus, when the reverse servo distributes servo fluid between
the fluid supply reservoir and the expandable servo reservoir to change the volume of the main reservoir, hydraulic fluid is distributed from the main reservoir to the hydraulic means, or from the hydraulic means to the main reservoir. Advantageously, the servo and main reservoirs are dimensioned, such that when the volume of the servo reservoir is changed by a relatively small amount of servo fluid, the volume of the main reservoir is changed by a relatively large amount of hydraulic fluid.

[0082] In both of the above-described alternatives, the fluid supply reservoir may have first and second wall portions, which are displaceable relative to each other to change the volume of the fluid supply reservoir to distribute servo fluid between the fluid supply reservoir and the expandable servo reservoir. The first and second wall portions of the fluid supply reservoir may be displaceable relative to each other by manual manipulation, a magnetic device, a hydraulic device, or an electric control device to change the volume of the fluid supply reservoir to distribute servo fluid between the fluid supply reservoir and the expandable servo reservoir.

[0083] In all of the above noted embodiments 1 to 2b where the hydraulic means comprises an expandable cavity in the constriction device, or in embodiments where the hydraulic means comprises a hydraulically operable mechanical construction, the operation device may include the reverse servo described above. In a further embodiment of the invention, the hydraulic means include first and second hydraulically interconnected expandable/contractible reservoirs. The first reservoir is operatively connected to the constriction device, such that the constriction device changes the constriction of the patient's wall portion upon expansion or contraction of the first reservoir. By changing the volume of the second reservoir hydraulic fluid is distributed between the two reservoirs, so that the first reservoir is either expanded or contracted. This embodiment requires no non-return valve in the fluid communication conduits between the two reservoirs, which is beneficial to long-term operation of the hydraulic means.

[0084] Alternatively, the hydraulic means may include first and second hydraulically interconnected piston/cylinder mechanisms instead of the first and second reservoirs described above. The first piston/cylinder mechanism is operatively connected to the constriction device, such that the constriction device changes the constriction of the patient's wall portion upon operation of the first piston/cylinder mechanism. By
operating the second piston/cylinder mechanism hydraulic fluid is distributed between the two piston/cylinder mechanisms, so that the first piston/cylinder mechanism adjusts the constriction device.

[0085] Where the constriction device does not include an expandable/contractible cavity, the constriction device may comprise at least two elongated clamping elements having the above-mentioned contact surfaces and extending along the wall portion on different sides of the blood vessel. The hydraulic means, which may include the reverse servo described above, hydraulically moves the elongated clamping elements towards the wall portion to constrict the wall portion. For example, the constriction device may have hydraulic chambers in which the clamping elements slide back and forth. Further, the hydraulic means may also include a pump and an implantable reservoir containing hydraulic fluid. The pump distributes hydraulic fluid from the reservoir to the chambers to move the clamping elements against the wall portion, and distributes hydraulic fluid from the chambers to the reservoir to move the clamping elements away from the wall portion.

ENERGY SUPPLY

[0074] Generally, method step (a) is performed by using the constriction device and step (b) is performed by using the stimulation device, wherein the method further comprises forming the constriction and stimulation devices in an operable constriction/stimulation unit.

[0075] In a simple form of the invention, the method comprises implanting a source of energy, such as a battery, rechargeable battery or accumulator, releasing energy from the source of energy and using the released energy in connection with the operation of the constriction/stimulation unit.

[0076] In a more sophisticated form of the invention, which is preferable, the method comprises transmitting wireless energy from outside the patient's body to inside the patient's body and using the transmitted wireless energy in connection with the operation of the constriction/stimulation unit.

Design of the control device
[0086] In a method according to an embodiment of the invention, the control device suitably controls the constriction/stimulation unit from outside the patient's body. Preferably, the control device is operable by the patient. For example, the control device may comprise a manually operable switch for switching on and off the constriction/stimulation unit, wherein the switch is adapted for subcutaneous implantation in the patient to be manually or magnetically operated from outside the patient's body. Alternatively, the control device may comprise a hand-held wireless remote control, which is conveniently operable by the patient to switch on and off the constriction/stimulation unit. The wireless remote control may also be designed for application on the patient's body like a wristwatch. Such a wristwatch type of remote control may emit a control signal that follows the patient's body to implanted signal responsive means of the apparatus.

[0087] Where the control device wirelessly controls the constriction/stimulation unit from outside the patient's body, the wireless control function is preferably performed in a non-magnetic manner, i.e., the control device controls the constriction device of the constriction/stimulation unit in a non-magnetic manner. The patient may use the remote control to control the constriction/stimulation unit to adjust the stimulation intensity and/or adjust the constriction of the wall portion. The wireless remote control may comprise at least one external signal transmitter or transceiver and at least one internal signal receiver or transceiver implantable in the patient.

[0088] The wireless remote control preferably transmits at least one wireless control signal for controlling the constriction/stimulation unit. The control signal may comprise a frequency, amplitude, phase modulated signal or a combination thereof, and may be an analogue or a digital signal, or a combination of an analogue and digital signal. The remote control may transmit an electromagnetic carrier wave signal for carrying the digital or analogue control signal. Also the carrier signal may comprise digital, analogue or a combination of digital and analogue signals.

[0089] Any of the above control signals may comprise wave signals, for example a sound wave signal, an ultrasound wave signal, an electromagnetic wave signal, an infrared light signal, a visible light signal, an ultra violet light signal, a laser light signal, a microwave signal, a radio wave signal, an x-ray radiation signal or a gamma
radiation signal. Alternatively, the control signal may comprise an electric or magnetic field, or a combined electric and magnetic field.

[0090] As mentioned above, the control signal may follow the patient's body to implanted signal responsive means of the apparatus.

[0091] In a method according to an embodiment of the invention, the control device may include a programmable internal control unit, such as a microprocessor, implantable in the patient for controlling the constriction/stimulation unit. The control device may further include an external control unit intended to be outside the patient's body, wherein the internal control unit is programmable by the external control unit. For example, the internal control unit may be programmable for controlling the constriction/stimulation unit over time, suitably in accordance with an activity schedule program. The apparatus of the invention may comprise an external data communicator and an implantable internal data communicator communicating with the external data communicator, wherein the internal communicator feeds data related to the constriction/stimulation unit back to the external data communicator or the external data communicator feeds data to the internal data communicator.

Source of Energy

[0092] The present invention also presents a solution for supplying energy for use in connection with the operation of the constriction/stimulation unit. Thus, in a broad sense, the present invention provides an apparatus for treating a vascular aneurysm of a blood vessel, supporting the walls thereof, and stimulating the walls, wherein the apparatus comprises an implantable constriction device for gently constricting a portion of the tissue wall, a stimulation device for intermittently and individually stimulating different areas of the wall portion, as the constriction device constricts the wall portion, to cause contraction of the wall portion to further strengthen the blood vessel, wherein the constriction and stimulation devices form an operable constriction/stimulation unit, a source of energy, and a control device operable from outside the patient's body to control the source of energy to release energy for use in connection with the operation of the constriction/stimulation unit. In a simple form of the invention, the source of energy, such as a battery or accumulator, is implantable in the patient's body.
Transmission of Wireless Energy

[0093] In a more sophisticated form of the invention, which is preferable, the source of energy is external to the patient's body and the control device controls the external source of energy to release wireless energy. In this sophisticated form of the invention, the apparatus comprises an energy-transmission device that transmits the released wireless energy from outside the patient's body to inside the patient's body. Among many things the wireless energy may comprise electromagnetic energy, an electric field, an electromagnetic field or a magnetic field, or a combination thereof, or electromagnetic waves. The energy-transmission device may transmit wireless energy for direct use in connection with the operation of the constriction/stimulation unit, as the wireless energy is being transmitted. For example, where an electric motor or pump operates the constriction device, wireless energy in the form of a magnetic or an electromagnetic field may be used for direct power of the motor or pump.

[0094] Thus, the motor or pump is running directly during transmission of the wireless energy. This may be achieved in two different ways: a) using a transforming device implanted in the patient to transform the wireless energy into energy of a different form, preferably electric energy, and powering the motor or pump with the transformed energy, or b) using the wirelessly transmitted energy to directly power the motor or pump. Preferably wireless energy in the form of an electromagnetic or magnetic field is used to directly influence specific components of the motor or pump to create kinetic energy for driving the motor or pump. Such components may include coils integrated in the motor or pump, or materials influenced by magnetic fields, or permanent magnets, wherein the magnetic or electromagnetic field influences the coils to generate a current for driving the motor or pump, or influences the material or permanent magnets to create kinetic energy for driving the motor or pump.

[0095] Preferably, the energy-transmission device transmits energy by at least one wireless signal, suitably a wave signal. The wave signal may comprise an electromagnetic wave signal including one of an infrared light signal, a visible light signal, an ultra violet light signal, a laser signal, a microwave signal, a radio wave signal, an x-ray radiation signal, and a gamma radiation signal. Alternatively, the
wave signal may comprise a sound or ultrasound wave signal. The wireless signal may be a digital or analogue signal, or a combination of a digital and analogue signal.

Transforming Wireless Energy

[0096] In accordance with a particular embodiment of the invention, an implantable energy-transforming device is provided for transforming wireless energy of a first form transmitted by the energy-transmission device into energy of a second form, which typically is different from the energy of the first form. The constriction/stimulation unit is operable in response to the energy of the second form. For example, the wireless energy of the first form may comprise sound waves, whereas the energy of the second form may comprise electric energy. In this case, the energy-transforming device may include a piezo-electric element for transforming the sound waves into electric energy. Optionally, one of the energy of the first form and the energy of the second form may comprise magnetic energy, kinetic energy, sound energy, chemical energy, radiant energy, electromagnetic energy, photo energy, nuclear energy or thermal energy. Preferably, one of the energy of the first form and the energy of the second form is non-magnetic, non-kinetic, non-chemical, non-sonic, non-nuclear or non-thermal.

[0097] The energy-transforming device may function differently from or similar to the energy-transmission device. In a special embodiment, the energy-transforming device comprises at least one element, such as at least one semiconductor, having a positive region and a negative region, when exposed to the energy of the first form transmitted by the energy-transmission device, wherein the element is capable of creating an energy field between the positive and negative regions, and the energy field produces the energy of the second form. More specifically, the element may comprise an electrical junction element, which is capable of inducing an electric field between the positive and negative regions when exposed to the energy of the first form transmitted by the energy-transmission device, whereby the energy of the second form comprises electric energy.

[0098] The energy-transforming device may transform the energy of the first form directly or indirectly into the energy of the second form. An implantable motor or
pump for operating the constriction device of the constriction/stimulation unit may be provided, wherein the motor or pump is powered by the energy of the second form. The constriction device may be operable to perform at least one reversible function and the motor may be capable of reversing the function. For example, the control device may shift polarity of the energy of the second form to reverse the motor.

[0099] The energy-transforming device may directly power the motor or pump with the transformed energy, as the energy of the second form is being transformed from the energy of the first form. Preferably, the energy-transforming device directly operates the constriction/stimulation unit with the energy of the second form in a non-magnetic, non-thermal or non-mechanical manner.

[00100] Normally, the constriction/stimulation unit comprises electric components that are energized with electrical energy. Other implantable electric components of the apparatus may be at least one voltage level guard or at least one constant current guard. Therefore, the energy-transforming device may transform the energy of the first form into a direct current or pulsating direct current, or a combination of a direct current and pulsating direct current. Alternatively, the energy-transforming device may transform the energy of the first form into an alternating current or a combination of a direct and alternating current.

[00101] In a method according to an embodiment of the invention, the apparatus of the invention may comprise an internal source of energy implantable in the patient for supplying energy for the operation of the constriction/stimulation unit. The apparatus may further comprise an implantable switch operable to switch from an "off" mode, in which the internal source of energy is not in use, to an "on" mode, in which the internal source of energy supplies energy for the operation of the constriction/stimulation unit, and/or for energizing implanted electronic components of the apparatus. The switch may be operable by the energy of the first form transmitted by the energy-transmission device or by the energy of the second form supplied by the energy-transforming device. The described switch arrangement reduces power consumption of the apparatus between operations.

[00102] The internal source of energy may store the energy of the second form supplied by the energy-transforming device. In this case, the internal source of
energy suitably comprises an accumulator, such as at least one capacitor or at least one rechargeable battery, or a combination of at least one capacitor and at least one rechargeable battery. Where the internal source of energy is a rechargeable battery it may be charged only at times convenient for the patient, for example when the patient is sleeping. Alternatively, the internal source of energy may supply energy for the operation of the constriction/stimulation unit but not be used for storing the energy of the second form. In this alternative, the internal source of energy may be a battery and the switch described above may or may not be provided.

[00103] Suitably, the apparatus of the invention comprises an implantable stabilizer for stabilizing the energy of the second form. Where the energy of the second form is electric energy the stabilizer suitably comprises at least one capacitor.

[00104] The energy-transforming device may be designed for implantation subcutaneously in the abdomen, thorax or cephalic region of the patient. Alternatively, it may be designed for implantation in an orifice of the patient's body and under the mucosa or intramuscularly outside the mucosa of the orifice.

[00105] Although the constriction/stimulation unit in the embodiments described above is designed as a single piece, which is most practical for implantation, it should be noted that as an alternative the constriction device and stimulation device could be designed as separate pieces. Any one of the constriction and stimulation units described above may alternatively be replaced by two or more separate constriction/stimulation elements, which are controlled independently of one another.

[00106] The above-described methods according to various embodiments of the invention are suited for treating dysfunctions of an blood vessel of a human being or animal.

[00107] In a method according to an embodiment of the invention, where an apparatus is used for controlling the blood flow in a blood vessel of a patient, the apparatus comprises an implantable constriction device for gently constricting at least one portion of the tissue wall of the blood vessel to influence the blood flow in the blood vessel, a stimulation device for stimulating the tissue wall portion, and a control device for controlling said stimulation device to stimulate the tissue wall portion as said constriction device constricts the tissue wall portion to cause
contraction of the tissue wall portion to further influence the blood flow in the blood vessel.

[00108] Method including laparoscopic method

A prefered method for controlling expansion of a bulge in a blood vessel of a patient, the method comprising:

a) gently constricting at least one portion of the tissue wall of the patient's blood vessel to constrict the bulge in the blood vessel, and

b) stimulating the constricted tissue wall portion to cause contraction thereof to further prevent bulge expansion in the blood vessel.

A prefered operation method for controlling an expansion of an aneurysmic bulge in a blood vessel, having a lumen formed by a tissue wall of a patient's blood vessel, the method comprising the steps of:

inserting a needle like tube into a cavity of the patients body,

using the needle like tube to fill the cavity with gas thereby expanding the abdominal or thoraxial cavity,

placing at least two laparoscopic trocars in the patient's body,

inserting a camera through one of the trocars into the cavity,

inserting a dissecting tool through any of the trocar and dissecting an area of at least one portion of the tissue wall of the aneurysmic bulge in the blood vessel,

placing a constriction device and a stimulation device in the dissected area in operative engagement with the blood vessel,
using the constriction device to gently constrict the wall portion of the blood vessel to constrict the bulge, and

using the stimulation device to stimulate the constricted wall portion to cause contraction of the wall portion to further influence the tonus in the wall portion, thus preventing expansion of the bulge in the blood vessel.

Alternative embodiments of the laparoscopic method comprising:

A first operation method for controlling a expansion of an aneurysmic bulge in a blood vessel having a lumen formed by a tissue wall of a patient's blood vessel, the method comprising the steps of:

inserting a needle like tube into a cavity of the patient's body,

using the needle like tube to fill the cavity with gas thereby expanding the cavity,

placing at least two laparoscopical trocars in the patient's body,

inserting a camera through one of the trocars into the cavity,

inserting a dissecting tool through any of the trocar and dissecting an area of at least one portion of the tissue wall of the blood vessel,

placing a stimulation device in the dissected area in operative engagement with the blood vessel, and

using the stimulation device to stimulate the wall portion to cause contraction of the wall portion, preventing expansion of the bulge in the blood vessel.

A second operation method for controlling a expansion of an aneurysmic bulge in a blood vessel, having a lumen formed by a tissue wall of a patient's blood vessel, the method comprising the steps of:

inserting a needle like tube into a cavity of the patient's body,

using the needle like tube to fill the cavity with gas thereby expanding the cavity,

placing at least two laparoscopical trocars in the patient's body,

inserting a camera through one of the trocars into the cavity,

inserting a dissecting tool through any of the trocar and dissecting an area of at least one portion of the tissue wall of the blood vessel,
placing a constriction device in the dissected area in operative engagement with the blood vessel,
using the constriction device to constrict the wall, preventing expansion of the bulge in the blood vessel.

A third operation method for controlling an expansion of an aneurysmic bulge in a blood vessel, having a lumen formed by a tissue wall of a patient's blood vessel, the method comprising the steps of:
cutting the skin of the patient, inserting a dissecting tool and dissecting an area of at least one portion of the tissue wall of the blood vessel, a constriction device and a stimulation device in the dissected area in operative engagement with the blood vessel, using the constriction device to gently constrict the wall portion of the blood vessel to influence the flow in the lumen, and using the stimulation device to stimulate the constricted wall portion, preventing expansion of the bulge in the blood vessel.

A fourth method for controlling an expansion of an aneurysmic bulge in a blood vessel, having a lumen formed by a tissue wall of a patient's blood vessel, the method comprising the steps of:
cutting the skin of the patient, inserting a dissecting tool and dissecting an area of at least one portion of the tissue wall of the blood vessel, placing a stimulation device in the dissected area in operative engagement with the blood vessel, and using the stimulation device to stimulate the wall portion to cause contraction of the wall portion, preventing expansion of the bulge in the blood vessel.

A fifth operation method for controlling an expansion of an aneurysmic bulge in a blood vessel, having a lumen formed by a tissue wall of a patient's blood vessel, the method comprising the steps of:
cutting the skin of the patient,
inserting a dissecting tool and dissecting an area of at least one portion of the tissue wall of the blood vessel,
placing a constriction device in the dissected area in operative engagement with the blood vessel, and
using the constriction device to constrict the wall portion, preventing expansion of the bulge in the blood vessel.

Both the preferred and the five alternative laparoscopic methods disclosed above, but not limited to these, further comprise:
A method, wherein the cavity comprising; at least one of an abdominal cavity, a cavity in the pelvic region, a thoraxial cavity, a cavity in a limb, a cavity in human soft tissue such as muscle, fat and fibrotic tissue.

Further additional method embodiments comprising:
A method, further comprising implanting a powered operation device for operating the constriction device.
A method, wherein the operation device comprises a powered hydraulic operation device.
A method, wherein the operation device comprises an electrically powered operation device.
A method, wherein the operation device comprises an electric motor.
A method, further comprising transmitting wireless energy for powering the operation device, and when desired to influence the flow in the patient's blood vessel, powering the operation device with the transmitted energy to operate the constriction device.
A method, further comprising implanting a source of energy in the patient, providing an external source of energy, controlling the external source of energy to release wireless energy, transforming the wireless energy into storable energy, non-invasively charging the implanted source of energy with the transformed energy, and
controlling the implanted source of energy from outside the patient's body to release energy for use in connection with the operation of the constriction device and/or stimulation device.

A method, wherein the wireless energy is transformed into a storable energy different from the wireless energy

A method, wherein step (b) is performed by stimulating any constricted wall portions of a series of wall portions.

A, wherein the wall portions of the series of wall portions are constricted by the stimulation device in random or in accordance with a predetermined sequence.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[00109] The invention will be described in closer detail below, in the detailed description, non-limiting examples and claims, with reference to the drawings in which:

[00110] FIGURES 1A, 1B, 1C, 1D and 1E schematically illustrate different states of operation of a general embodiment of an apparatus used for practicing the method according to the present invention.

[00111] FIGURES 1F, 1G and 1H illustrate different states of operation of a modification of the general embodiment.

[00112] FIGURES 1I, 1K and 1L illustrate an alternative mode of operation of the modification of the general embodiment.

[00113] FIGURE 2 is a longitudinal cross-section of a preferred embodiment of the apparatus for use in a method according to an embodiment of the invention including a constriction device and an electric stimulation device.

[00114] FIGURE 3 is a cross-section along line III-III in FIGURE 2.

[00115] FIGURE 4 is the same cross-section shown in FIGURE 3, but with the apparatus in a different state of operation.
FIGURES 5A, 5B and 5C are cross-sections of the embodiment of FIGURE 2 showing different states of operations with the apparatus applied on a tissue wall of a patient's organ.

FIGURES 6A, 6B and 6C are cross-sections of a modification of the embodiment of FIGURE 2 showing different states of operations with the apparatus applied on a tissue wall of a patient's organ.

FIGURES 7A and 7B show different steps of an electric stimulation mode performed by the apparatus of FIGURE 2 while the apparatus is constricting a tissue wall of a patient's organ.

FIGURE 8A is a pulse/time diagram showing electric stimulation pulses generated by the apparatus for use in a method according to an embodiment of the invention for stimulating a tissue wall of a patient's blood vessel.

FIGURE 8B is pulse/time diagram showing a modification of the electric stimulation shown in FIGURE 8A, in which pulses of mixed frequencies and/or amplitudes are employed.

FIGURES 9A and 9B show two pulse/time diagrams, respectively, representing electric stimulation of two different areas of the tissue wall with pulses forming pulse trains.

FIGURES 10A and 10B show the pulse/time diagrams of FIGURES 9A and 9B with modified pulse trains.

FIGURE 11A is a longitudinal cross-section of an embodiment of an apparatus used for practicing the method of the invention, where the apparatus includes a thermal stimulation device and the apparatus is constricting a tissue wall of a patient's organ.

FIGURE 11B is the same embodiment of FIGURE 11A with the thermal stimulation device activated.

FIGURE 12A is a schematic view of hydraulic operation means suited for operating the constriction device of the embodiments of FIGURES 2-11.
FIGURE 12B shows the embodiment of FIGURE 12A with the constriction device constricting a tissue wall of a patient's blood vessel.

FIGURE 13 is a schematic general view of a human being having a cuff implanted for treating an aneurysm located on the aorta in the abdomen close to the Y-bifurcation extending to the legs.

FIGURE 14A shows a schematic detail of the apparatus indicated in FIGURE 13.

FIGURE 14B shows a detail of the cuff when placed on the Y-bifurcation.

FIGURE 14C shows a cross-sectional view of the cuff in FIGURE 14B.

FIGURE 15 is a schematic sectional view of a mechanically operable non-inflatable constriction device for use in accordance with the invention.

FIGURES 16 and 17 are cross-sectional views taken along the lines XVI-XVI and XVII-XVII, respectively, of FIGURE 15.

FIGURE 18 schematically shows an alternative design of the embodiment of FIGURE 15;

FIGURE 19 schematically illustrates a motor arrangement for the design according to FIGURE 18;

FIGURES 20 and 21 are schematic sectional views of two alternative designs of non-inflatable constriction devices for use in a method according to an embodiment of the invention.

FIGURES 22 and 23 illustrate a fully open and a reduced constriction opening, respectively, of the embodiment of FIGURE 21;

FIGURE 24 is a schematic view of a further alternative design of a non-inflatable constriction device for use in a method according to an embodiment of the invention.
FIGURES 25 and 26 illustrate a fully open and a reduced constriction opening, respectively, of the embodiment of FIGURE 24;

FIGURE 27 is a schematic view of another alternative design of a non-inflatable constriction device for use in a method according to an embodiment of the invention.

FIGURES 28 and 29 are schematic sectional views, respectively, of yet another alternative design of a non-inflatable constriction device for use in a method according to an embodiment of the invention.

FIGURE 30A is a schematic view of a hydraulically operable inflatable constriction device for use in accordance with the invention.

FIGURE 30B is the same embodiment shown in FIGURE 30A with the constriction device inflated.

FIGURES 31A, 31B, 31C and 31D are block diagrams illustrating four different principles for hydraulic operation of the constriction device shown in FIGURE 30A.

FIGURE 32 is a cross-sectional view of a reservoir having a variable volume controlled by a remote control motor.

FIGURES 33A and 33B are perspective views of a reverse servo in accordance with a particular embodiment of the hydraulic operation principle shown in FIGURE 31C.

FIGURE 34 is a schematic view of another hydraulically operable constriction device for use in accordance with the invention.

FIGURE 35A illustrates the constriction device of FIGURE 34 in a constricted state.

FIGURE 35B illustrates the constriction device of FIGURE 34 in a released state.

FIGURES 36A - 36E schematically illustrate different operation stages of an embodiment of the invention, in which a constriction device and a
stimulation device used for practicing the method of the invention co-operate to move the fluid and/or other bodily matter in the lumen of a patient's organ.

[00150] FIGURE 37 is a schematic block diagram illustrating a general embodiment of the apparatus for use in a method according to an embodiment of the invention, in which energy is transferred to energy consuming components of the apparatus implanted in the patient.

[00151] FIGURES 38 to 49 are schematic block diagrams illustrating twelve embodiments, respectively, based on the general embodiment shown in FIGURE 37, wherein wireless energy is transmitted from outside a patient's body to energy consuming components of the apparatus implanted in the patient.

[00152] FIGURE 50 illustrates an energy-transforming device in the form of an electrical junction element for use in a method according to an embodiment of the present invention.

[00153] FIGURE 51 is a block diagram illustrating control components for use in a method according to an embodiment of the invention.

[00154] FIGURE 52 is a schematic view of exemplary circuitry for use in a method according to an embodiment of the invention, in which wireless energy is transformed into a current.

[00155] Fig. 53 illustrates a system for treating, stabilizing or monitoring an aneurysm, wherein the system includes an apparatus for use in a method according to an embodiment of the invention implanted in a patient.

[00156] Figs. 54-67 schematically show various embodiments of the system for wirelessly powering the apparatus shown in Fig. 53.

[00157] Fig. 68 is a schematic block diagram illustrating an arrangement for supplying an accurate amount of energy used for the operation of the apparatus shown in Fig. 53.

[00158] Fig. 69 schematically shows an embodiment of the system, in which the apparatus is operated with wire-bound energy.
Fig. 70 is a more detailed block diagram of an arrangement for controlling the transmission of wireless energy used for the operation of the apparatus shown in Fig. 53.

Fig. 71 is a circuit for the arrangement shown in Fig. 70, according to a possible implementation example.

DETAILED DESCRIPTION

Referring to the drawing figures, like reference numerals designate identical or corresponding elements throughout several figures.

FIGURES 1A-1L only disclose the principle of how a constriction may be combined with stimulation for further restriction.

FIGURES 1A, 1B and 1C schematically illustrate different states of operation of a generally designed apparatus used for practicing the method of the present invention, when the apparatus is applied on a wall portion of a bodily organ designated BO. The apparatus includes a constriction device and a stimulation device, which are designated CSD, and a control device designated CD for controlling the constriction and stimulation devices CSD. FIGURE 1A shows the apparatus in an inactivation state, in which the constriction device does not constrict the organ BO and the stimulation device does not stimulate the organ BO. FIGURE 1B shows the apparatus in a constriction state, in which the control device CD controls the constriction device to gently constrict the wall portion of the organ BO to a constricted state, in which the blood circulation in the constricted wall portion is substantially unrestricted and the flow in the lumen of the wall portion is restricted. FIGURE 1C shows the apparatus in a stimulation state, in which the control device CD controls the stimulation device to stimulate different areas of the constricted wall portion, so that the wall portion of the organ BO contracts (thickens) and closes the lumen.

FIGURES 1D and 1E show how the stimulation of the constricted wall portion can be cyclically varied between a first stimulation mode, in which the left area of the wall portion (see FIGURE 1D) is stimulated while the right area of the...
wall portion is not stimulated, and a second stimulation mode, in which the right area of the wall portion (see FIGURE 1E) is stimulated while the left area of the wall portion is not stimulated, in order to maintain over time satisfactory blood circulation in the constricted wall portion.

[00164] It should be noted that the stimulation modes shown in FIGURES 1D and 1E only constitute a principle example of how the constricted wall portion of the organ BO may be stimulated. Thus, more than two different areas of the constricted wall portion may be simultaneously stimulated in cycles or successively stimulated. Also, groups of different areas of the constricted wall portion may be successively stimulated.

[00165] FIGURES 1F, 1G and 1H illustrate different states of operation of a modification of the general embodiment shown in FIGURES 1A-1E, wherein the constriction and stimulation devices CSD include several separate constriction/stimulation elements, here three elements CSDE1, CSDE2 and CSDE3. FIGURE 1F shows how the element CSDE1 in a first state of operation is activated to both constrict and stimulate the organ BO, so that the lumen of the organ BO is closed, whereas the other two elements CSDE2 and CSDE3 are inactivated. FIGURE 1G shows how the element CSDE2 in a second following state of operation is activated, so that the lumen of the organ BO is closed, whereas the other two elements CSDE1 and CSDE3 are inactivated. FIGURE 1H shows how the element CSDE3 in a following third state of operation is activated, so that the lumen of the organ BO is closed, whereas the other two elements CSDE1 and CSDE2 are inactivated. By shifting between the first, second and third states of operation, either randomly or in accordance with a predetermined sequence, different portions of the organ can by temporarily constricted and stimulated while maintaining the lumen of the organ closed, whereby the risk of injuring the organ is minimized. It is also possible to activate the elements CSDE1-CSDE3 successively along the lumen of the organ to move fluids and/or other bodily matter in the lumen.

[00166] FIGURES 1I, 1K and 1L illustrate an alternative mode of operation of the modification of the general embodiment. Thus, FIGURE 1I shows how the element CSDE1 in a first state of operation is activated to both constrict and stimulate the organ BO, so that the lumen of the organ BO is closed, whereas the other two elements CSDE2 and CSDE3 are activated to constrict but not stimulate the organ BO, so that the lumen of the organ BO is not completely closed where the
elements CSDE2 and CSDE3 engage the organ BO. FIGURE 1K shows how the element CSDE2 in a second following state of operation is activated to both constrict and stimulate the organ BO, so that the lumen of the organ BO is closed, whereas the other two elements CSDE1 and CSDE3 are activated to constrict but not stimulate the organ BO, so that the lumen of the organ BO is not completely closed where the elements CSDE1 and CSDE3 engage the organ BO. FIGURE 1L shows how the element CSDE3 in a following third state of operation is activated to both constrict and stimulate the organ BO, so that the lumen of the organ BO is closed, whereas the other two elements CSDE1 and CSDE2 are activated to constrict but not stimulate the organ BO, so that the lumen of the organ BO is not completely closed where the elements CSDE1 and CSDE2 engage the organ BO. By shifting between the first, second and third states of operation, either randomly or in accordance with a predetermined sequence, different portions of the organ can by temporarily stimulated while maintaining the lumen of the organ closed, whereby the risk of injuring the organ is reduced. It is also possible to activate the stimulation of the elements CSDE1-CSDE3 successively along the lumen of the organ BO to move fluids and/or other bodily matter in the lumen.

[00167] FIGURES 2-4 show basic components of an embodiment of the apparatus according to the invention for controlling a flow of fluid in a lumen formed by a tissue wall of a patient's blood vessel. The apparatus comprises a tubular housing 1 with open ends, a constriction device 2 arranged in the housing 1, a stimulation device 3 integrated in the constriction device 2, and a control device 4 (indicated in FIGURE 4) for controlling the constriction and stimulation devices 2 and 3. The constriction device 2 has two elongate clamping elements 5, 6, which are radially movable in the tubular housing 1 towards and away from each other between retracted positions, see FIGURE 3, and clamping positions, see FIGURE 4. The stimulation device 3 includes a multiplicity of electrical elements 7 positioned on the clamping elements 5, 6, so that the electrical elements 7 on one of the clamping elements 5, 6 face the electrical elements 7 on the other clamping element. Thus, in this embodiment the constriction and stimulation devices form a constriction/stimulation unit, in which the constriction and stimulation devices are integrated in a single piece.
[00168] The constriction and stimulation devices may also be separate from each other. In this case, a structure may be provided for holding the electrical elements 7 in a fixed orientation relative to one another. Alternatively, the electrical elements 7 may include electrodes that are separately attached to the wall portion of the patient’s blood vessel.

[00169] When the apparatus is in its stimulation state, it is important to stimulate the different areas of the wall portion 8 in a manner so that they essentially maintains their natural physical properties over time to prevent the areas from being injured. Consequently, the control device 4 controls the stimulation device 3 to intermittently stimulate each area of the wall portion 8 during successive time periods, wherein each time period is short enough to maintain over time satisfactory blood vessel condition in the area. Furthermore, the control device 4 controls the stimulation of the areas of the wall portion 8, so that each area that currently is not stimulated restores before it is stimulated again. To maintain over time the effect of stimulation, i.e., to keep the lumen closed by maintaining the wall portion 8 contracted, the control device 4 controls the stimulation device 3 to stimulate one or more of the areas at a time and to shift the stimulation from one area to another over time. The control device 4 may control the stimulation device 3 to cyclically propagate the stimulation of the areas along the tubular wall portion 8, for example, in accordance with a determined stimulation pattern. To achieve the desired reaction of the tissue wall during the stimulation thereof, the control device may control the stimulation device to, preferably cyclically, vary the intensity of the stimulation of the wall portion 8.

[00170] In the embodiment of FIGURES 2 - 4, the electrical elements 7 form a series of fourteen groups of electrical elements 7 extending longitudinally along each elongate clamping element 5 and 6, respectively, see FIGURE 2. The electrical elements 7 of each group of electrical elements 7 form a first path of four electrical elements 7 positioned in a row on clamping element 5 and extending tranverse thereto, and a second path of four electrical elements 7 positioned in a row on clamping element 6 and extending tranverse thereto. Thus, the two paths of electrical elements 7 extend on mutual sides of the patient's blood vessel. The control device 4 controls the stimulation device 3 to successively energize the groups of electrical elements 7 in the series of groups in a direction opposite to or,
alternatively, in the same direction as that of the flow in the lumen of the patient's blood vessel. Of course, the number of electrical elements 7 of each path of electrical elements 7 can be greater or smaller than four, and several parallel rows of electrical elements 7 can form each path of electrical elements 7.

[00171] The control device 4 controls the stimulation device 3 to energize the electrical elements 7 with electric biphasic pulses, i.e., combined positive and negative pulses. The desired stimulation effect is achieved by varying different pulse parameters. Thus, the control device 4 controls the stimulation device 3 to vary the pulse amplitude (voltage), the off time period between successive pulses, the pulse duration and the pulse repetition frequency. The pulse current should be between 1 to 30mA. For neural stimulation, a pulse current of about 5mA and a pulse duration of about 300µs are suitable, whereas a pulse current of about 20mA and a pulse duration of about 30µs are suitable for muscular stimulation. The pulse repetition frequency suitably is about 10Hz. For example, as illustrated in the Pulse/time diagram P/t of FIGURE 8A, a pulse combination including a negative pulse PS of short duration and high amplitude (voltage), and a positive pulse PL of long duration and low amplitude following the negative pulse may be cyclically repeated to form a pulse train of such pulse combinations. The energy content of the negative pulse PS should be substantially equal to the energy content of the positive pulse PL.

[00172] FIGURES 5A - 5C illustrate in principle the function of the apparatus of FIGURE 2 when the apparatus is applied on a portion 8 of a tubular tissue wall of a patient's organ. Thus, FIGURE 5A shows the apparatus in a non-clamping state, in which the clamping elements 5, 6 are in their retracted positions and the wall portion 8 extends through the open ends of the housing 1 without being constricted by the clamping elements 5, 6. FIGURE 5B shows the apparatus in a clamping state, in which the clamping elements 5, 6 have been moved from their retracted positions to their clamping positions, in which the clamping elements 5, 6 gently constrict the wall portion 8 to a constricted state, in which the blood circulation in the constricted wall portion 8 is substantially unrestricted and the flow in the lumen of the wall portion 8 is restricted. FIGURE 5C shows the apparatus in a stimulation state, in which the clamping elements 5, 6 constrict the wall portion 8 and the electrical elements 7 of the stimulation device 3 electrically stimulate different areas of the wall portion 8, so that the wall portion 8 contracts (thickens) and closes the lumen.
[00173] When the apparatus is in its stimulation state, it is important to stimulate the different areas of the wall portion 8 in a manner so that they essentially maintain their natural physical properties over time to prevent the areas from being injured. Consequently, the control device 4 controls the stimulation device 3 to intermittently stimulate each area of the wall portion 8 during successive time periods, wherein each time period is short enough to maintain over time satisfactory blood circulation in the area. Furthermore, the control device 4 controls the stimulation of the areas of the wall portion 8, so that each area that currently is not stimulated restores substantially normal blood circulation before it is stimulated again. To maintain over time the effect of stimulation, i.e., to keep the lumen closed by maintaining the wall portion 8 contracted, the control device 4 controls the stimulation device 3 to stimulate one or more of the areas at a time and to shift the stimulation from one area to another over time. The control device 4 may control the stimulation device 3 to cyclically propagate the stimulation of the areas along the tubular wall portion 8, for example in accordance with a determined stimulation pattern. To achieve the desired reaction of the tissue wall during the stimulation thereof, the control device may control the stimulation device to, preferably cyclically, vary the intensity of the stimulation of the wall portion 8.

[00174] In the embodiment of FIGURES 2 - 4, the electrical elements 7 form a series of fourteen groups of electrical elements 7 extending longitudinally along each elongate clamping element 5 and 6, respectively, see FIGURE 2. The electrical elements 7 of each group of electrical elements 7 form a first path of four electrical elements 7 positioned in a row on clamping element 5 and extending tranverse thereto and a second path of four electrical elements 7 positioned in a row on clamping element 6 and extending tranverse thereto. Thus, the two paths of electrical elements 7 extend on mutual sides of the patient's organ. The control device 4 controls the stimulation device 3 to successively energize the groups of electrical elements 7 in the series of groups in a direction opposite to or, alternatively, in the same direction as that of the flow in the patient's lumen. Of course, the number of electrical elements 7 of each path of electrical elements 7 can be greater or smaller than four, and several parallel rows electrical elements 7 can form each path of electrical elements 7.

[00175] FIGURES 6A - 6C show another embodiment of an apparatus used for practicing the method of the invention including a tubular housing 9 and three...
elongate clamping elements 10a, 10b, 10c, which are radially movable in the tubular housing 9 towards and away from a central axis thereof between retracted positions, see FIGURE 6A, and clamping positions, see FIGURE 6B. The three clamping elements 10a-10c are symmetrically disposed around the central axis of the housing 9. The stimulation device of this embodiment includes electrical elements 11a, 11b, 11c that form a series of groups of elements extending longitudinally along the elongate clamping elements 10a-10c, wherein the electrical elements 11a - 11c of each group of electrical elements form a path of three electrical elements 11a, 11b and 11c extending circumferentially around the central axis of the housing 9. The three electrical elements 11a - 11c of each group are positioned on the three clamping elements 10a-10c, respectively. Thus, the path of three electrical elements 11a-11c extends around the patient's organ. Of course, the number of electrical elements 11a-11c of each path of electrical elements can be greater than three, and several parallel rows electrical elements 11a-11c can form each path of electrical elements.

FIGURES 7A and 7B show different steps of an electric stimulation mode performed by the apparatus of FIGURE 2 while the clamping elements 5, 6 of the apparatus are constricting a portion of a tubular tissue wall of a patient's organ 12 to restrict the flow in the lumen 13 of the organ 12. For the sake of clarity only the clamping elements 5, 6 of the constriction device 2 are shown in FIGURES 7A, 7B. Thus, FIGURE 7A illustrates how energized electrical elements 7 of groups of electrical elements electrically stimulate a first portion 14 and a second portion 15 of the tubular wall to contract and close the lumen 13. FIGURE 7B illustrates how energized electrical elements 7 of other groups of electrical elements electrically stimulate a third portion 16 of the tubular wall different from the first and second portions to contract and close the lumen 13, while the electrical stimulation of the first and second portions 14, 15 of the tubular wall has been ceased, so that substantially normal blood circulation in the first and second portions is restored. In this manner, the electric stimulation of the constricted tubular wall is shifted over time from one portion of the tubular wall to another to insure recurrent restoration of blood circulation in the constricted tubular wall.

The control device 4 controls the stimulation device 3 to energize the electrical elements 7 with electric biphasic pulses, i.e., combined positive and negative pulses. The desired stimulation effect is achieved by varying different pulse
parameters. Thus, the control device 4 controls the stimulation device 3 to vary the pulse amplitude (voltage), the off time period between successive pulses, the pulse duration and the pulse repetition frequency. The pulse current should be between 1 to 30mA. For neural stimulation, a pulse current of about 5mA and a pulse duration of about 300µs are suitable, whereas a pulse current of about 20mA and a pulse duration of about 30µs are suitable for muscular stimulation. The pulse repetition frequency suitably is about 10Hz. For example, as illustrated in the Pulse/time diagram P/t of FIGURE 8A, a pulse combination including a negative pulse PS of short duration and high amplitude (voltage), and a positive pulse PL of long duration and low amplitude following the negative pulse may be cyclically repeated to form a pulse train of such pulse combinations. The energy content of the negative pulse PS should be substantially equal to the energy content of the positive pulse PL.

[00178] Figures 5 to 7 disclose principle only and the restriction may be exaggerated or used only in emergency situations to save life if an aneurysm bursts.

[00179] FIGURE 8B is a pulse/time diagram showing a modification of the electric stimulation shown in FIGURE 8A. Thus, the pulse combination of FIGURE 8A is mixed with a pulse train combination having a first relatively long pulse train PTL of high frequency/low amplitude pulses, appearing simultaneously with the positive pulse PL of the pulse combination of FIGURE 8A, and a second relatively short pulse train PTS of high frequency/low amplitude appearing simultaneously with the negative pulse PS of the pulse combination shown in FIGURE 8A. As a result, the high frequency/low amplitudes pulse trains PTL and PTS are superimposed on the positive and negative pulses PL and PS of FIGURE 8A, as illustrated in FIGURE 8B. The pulse configuration of FIGURE 8B, and variations thereof, is beneficial to use in connection with the stimulation of particular human blood vessels, in order to achieve the desired stimulation effect.

[00180] Preferably, the electric pulses form pulse trains, as illustrated in the Pulse/time diagrams P/t of FIGURES 9A, 9B, 9C and 9D. The Pulse/time diagram P/t of FIGURE 9A represents an individual area of the wall portion of the patient's tubular blood vessel which is stimulated with a pulse train 18A. The pulse train 18A includes three initial negative pulses, each of which is of short duration and high amplitude (voltage), and one positive pulse of long duration and low amplitude.
following the negative pulses. After a delay to enable the area of the blood vessel to restore substantially normal blood circulation, the pulse train 18A is repeated.

[00181] The Pulse/time diagram P/t of FIGURE 9B represents another individual area of the wall portion, which is stimulated with a pulse train 18B having the same configuration as the pulse train 18A. The pulse trains 18A and 18B are shifted relative to each other, so that they partially overlap one another to ensure that the constricted wall portion always is stimulated to contract as desired.

[00182] The pulse/time diagrams P/t of FIGURES 10A and 10B represent two different areas of the wall portion, which are stimulated with cyclically repeated pulse trains 18C and 18D, respectively, having the same configuration. Each pulse train 18C, 18D includes two initial negative pulses, each of which is of short duration and high amplitude (voltage), and one positive pulse of long duration and low amplitude following the two negative pulses. In this case, the pulse trains 18C and 18D are shifted relative to each other, so that they do not overlap each other. Thus, the off time period between adjacent pulse trains 18C is longer than the duration of pulse train 18D and the off time period between adjacent pulse trains 18D is longer than the duration of pulse train 18C.

[00183] The pulse trains 18A, 18B, 18C and 18D can be configured in many different ways. Thus, the control device 4 can control the stimulation device 2 to vary the length of each pulse train, the repetition frequency of the pulse trains, the number of pulses of each pulse train, and/or the off time periods between the pulse trains. Typically, the control device 4 controls each off time period between the pulse trains to last long enough to restore substantially normal blood circulation in the area that just has been stimulated before that area again is stimulated with electric pulses.

[00184] FIGURES 11A and 11B show another embodiment of an apparatus used for practicing the method of the invention that controls blood flow in a blood vessel 19. The apparatus of FIGURES 11A and 11B includes a constriction device with two clamping elements 20a and 20b, a stimulation device in the form of two thermal stimulation elements 21a and 21b integrated in the clamping elements 20a, 20b, respectively, and a control device 4 for controlling the clamping elements 20a, 20b and stimulation elements 21a, 21b. The clamping elements 20a and 20b are movable towards and away from each other in the same manner as described above.
in connection with the embodiment according to FIGURES 5A-5C. The thermal stimulation elements 21a and 21b, which may include Pertier elements, are positioned on the clamping elements 20a, 20b, so that the thermal elements 21a are facing the thermal elements 21b. FIGURE 11A shows how the clamping elements 20a, 20b constrict the blood vessel 19, so that the blood flow is restricted. FIGURE 11B shows how the control device 4 controls the thermal stimulation elements 21a, 21b to cool the wall of the blood vessel 19, so that the wall contracts and closes the blood vessel 19. To release the blood vessel 19, the control device 4 controls the thermal stimulation elements 21a, 21b to heat the wall of the blood vessel 19, so that the wall expands.

[00185] FIGURES 12A and 12B show hydraulic operation means suited for operating the constriction device of the embodiments described above. Specifically, FIGURES 12A and 12B show the apparatus of FIGURE 2 provided with such means for hydraulic operation of the constriction device 2. (The stimulation device is not shown.) Thus, the housing 1 forms two hydraulic chambers 22a and 22b, in which the two clamping elements 5, 6 are possible to slide back and forth relative to the tubular tissue wall portion 8 of a patient's blood vessel. The hydraulic operation means include an expandable reservoir 23, such as an elastic balloon, containing hydraulic fluid, conduits 24a and 24b between the reservoir 23 and the hydraulic chambers 22a, 22b, and a two-way pump 25 for pumping the hydraulic fluid in the conduits 24a, 24b. The control device 4 controls the pump 25 to pump hydraulic fluid from the reservoir 23 to the chambers 22a, 22b to move the clamping elements 5, 6 against the wall portion 8, whereby the tubular wall portion 8 is constricted, see FIGURE 12B, and to pump hydraulic fluid from the chambers 22a, 22b to the reservoir 23 to move the clamping elements 5, 6 away from the wall portion 8, whereby the tubular wall 8 is released, see FIGURE 12A.

[00186] Alternatively, the embodiment of FIGURES 12A and 12B may be manually operated by applying suitable manually operable hydraulic means for distributing the hydraulic fluid between the expandable reservoir 23 and the hydraulic chambers 22a, 22b. In this case the pump 25 is omitted.
[00187] FIGURE 13 shows a general view of a human 100 having a cuff 101 implanted for treating an aneurysm. In FIGURE 13 the treated aneurysm is located on the aorta in the abdomen close to the Y-bifurcation extending to the legs. The cuff 101 can be designed in various ways but is generally formed as an implantable member adapted to be placed in connection with a blood vessel having said vascular aneurysm, and adapted to exert a pressure on said aneurysm from the outside of said blood vessel. In particular the pressure exerted on the blood vessel is essentially uniform from all direction and adapted to hinder the blood vessel to expand in all directions thereby acting to prevent the blood vessel from bursting. The pressure can in accordance with one embodiment be essentially equal to or lower than the diastolic blood pressure of the treated patient. The cuff 101 can be made in any suitable material such as an elastic material adapted for implantation in a human or mammal body.

[00188] The cuff 101 can exercise the pressure in a number of different ways. In accordance with one embodiment of the present invention the pressure applied on the blood vessel can be mechanical and adjustable by means of an adjustable screw or a similar means in order to apply a pressure on the blood vessel. The cuff 101 can also be formed by a spring loaded member and operated in a suitable manner such as hydraulically or pneumatically.

[00189] In FIGURE 14A a cuff 101 in accordance with one embodiment of the present invention is shown in more detail. The cuff 101 comprises a number of segments 103 each adjustable and possible to tailor to fit a particular aneurysm 102 of a blood vessel 104 to be treated. Each segment 103 can be adjusted either as a whole or individually. The segments 103 can be controlled and adjusted mechanically by an adjustable screw or similar or adapted to be filled with a fluid. For example, the segments can be provided axially along the blood vessel and also radially along the blood vessel forming a matrix of sub-segments that constitutes the cuff 101. In particular one segment can be located above and one below the aneurysm along the blood vessel.

[00190] The adjustment can be controlled by an electronic control unit 105 adapted to receive and transmit signals from a transmitter/receiver 106 located outside the body of a treated patient. The electronic control unit can also comprise a chargeable
battery 111 chargeable from the outside by an external charger unit 112. The electronic control unit can comprise an electrical pulse generator 109 for generating electrical pulses as is described in more detail below.

[00191] The electronic control unit 105 can further be connected to or comprise a hydraulic pump 110 associated with a reservoir 115 containing of a fluid used to regulate the pressure of the cuff 101. The pump is thus adapted to pump the hydraulic fluid in or out from the cuff 101 in order to adjust the pressure applied in the aneurysm. The control mechanism used for keeping the pressure in the cuff 101 can comprise a pressure tank 117.

[00192] The cuff 101 can be shaped in any desirable form to enable treatment of an aneurysm wherever it is located. In accordance with one embodiment the cuff 101 is provided with at least one sensor 107 adapted to sense the pressure from the blood vessel that the cuff is surrounding.

[00193] The sensor(s) 107 used to generate a signal indicative of one or many parameters related to the aneurysm and the device 101 used for treating the aneurysm can for example be a gauge sensor. The sensor 107 can be adapted to generate sensor signals used for monitoring parameters including but not limited to the pressure in a hydraulic cuff, the pressure of a mechanical cuff, the pressure of a pneumatic cuff, the pressure in a blood vessel, the shape of the blood vessel in particular a parameter related to the diameter of the aneurysm.

[00194] By sensing the pressure from the blood vessel the cuff can be controlled to apply a correct pressure on the blood vessel thereby keeping the form of the blood vessel essentially constant. For example the pressure may vary over time as a result of changes in the wall of the blood vessel of surrounding tissue. Also the pressure will change as a function of the phase in which the heart is working. In other words the pressure will be different in a systolic phase as compared to a diastolic phase. By using a pressure sensor the pressure applied by the cuff 101 can be adapted to react to changes in the sensed pressure and apply a corresponding counter pressure. The sensor signals generated by the sensor(s) 107 of the cuff can also be used to trigger an alarm in response to the sensor signal indicating an expansion of the aneurysm. In response to an alarm signal being generated the cuff can be
automatically controlled to exercise a counter pressure on the blood vessel to counter or limit the expansion of the aneurysm.

[00195] In yet another embodiment, electrodes 108 can be provided in the cuff. The electrodes can be connected to the electrical pulse generator, which is adapted to generate electrical pulses for stimulating the wall of the aneurysm. The purpose of the electrical stimulation is to increase the tonus of the wall of the aneurysm.

[00196] In accordance with one embodiment the electrical stimulation device used for treating a vascular aneurysm of a human or mammal patient is connected to electrodes adapted to stimulate the wall of the aneurysm at multiple stimulation points. The multiple stimulation groups may further be blood vesselized in different stimulation groups which can stimulated independently of each other. In accordance with one embodiment the electrical stimulation is performed with positive and or negative voltage stimulation pulses. In one embodiment the current used for stimulation of the aneurysm wall is kept essentially constant.

[00197] The sequence of electrical pulses used to stimulation the wall of the aneurysm can be applied with a predetermined periodicity having periods of no stimulation therein between during which periods without stimulation the wall of the aneurysm is allowed to rest. The electrical stimulation signal can also be Pulse Width Modulated to control the energy applied. In accordance with one embodiment the electrical stimulation is applied during the systolic phase to increase the tonus of the wall of the aneurysm. The systolic phase can be detected by the sensors 107 used to sense the pressure of the aneurysm as described above.

[00198] In accordance with one embodiment the stimulation can be controlled to be applied with a temporarily increased intensity and position during emergency situations when the aneurysm is detected to rapidly expands, to limit the expansion of said aneurysm.

[00199] The shape of the cuff 101 can as stated above be tailor made to suit the location where an aneurysm is to be treated. In FIGURE 14C, a cuff 101 is seen from above in a direction aligned with a treated blood vessel. As can be seen in FIGURE 14C each segment 3 can be sub-divided into a number of sub segments 103a, 103 b... together forming a closed loop around the treated aneurysm. In case
the aneurysm is located in the aorta bifurcation region the cuff 101 can be Y-shaped as is shown in Fig. 14B.

[00200] Of course, the constriction device 101 shown in FIGURES 14A - 14C may be replaced by any one of the constriction devices described in the various embodiments of the present invention, where applicable.

[00201] FIGURES 15-17 show a mechanically operable constriction device having an elongated constriction member in the form of a circular resilient core 37 with two overlapping end portions 38, 39. The core 37 defines a substantially circular restriction opening and is enclosed in an elastic soft hose 40 except at a releasable and lockable joint 41 of the core 37, which when released enables application of the core 37 with its hose 40 around a portion of a tubular tissue wall of a patient's blood vessel. The materials of all of these elements are bio-compatible so that the patient's body will not reject them. An operation device 42 for mechanically operating the longitudinal extension of the core 37 to change the size of the restriction opening comprises a drive wheel 43 in frictional engagement with the overlapping end portions 38, 39 of the core 37. The drive wheel 43 is journalled on a holder 44 placed in the hose 40 and provided with two counter pressure rollers 45, 46 pressing the respective end portions 38, 39 of the core 37 against the drive wheel 43 to increase the frictional engagement there between. An electric motor 47 of the operation device is connected to the drive wheel 43 via a long flexible drive shaft 48, and is moulded together with a remote controlled power supply unit 49 in a body 50 of silicone rubber. The length of the flexible drive shaft 48 is selected so that the body 50 can be placed in a desired position in the patient's body, suitably in the abdomen.

[00202] The power supply unit 49 can be controlled to power the electric motor 47 to turn the drive wheel 43 in one direction to reduce the diameter of the core 37, so that the wall portion is constricted, or to turn the drive wheel 43 in the opposite direction to increase the diameter of the core 37, so that the wall portion is released.

[00203] In accordance with a first alternative, a rack gear may be formed on one of the end portions 38, 39 of the core 37 and the drive wheel 43 may be replaced by a drive gear wheel connected to the other end portion of the core 37 and in mesh with the rack gear.
In accordance with a second alternative, the operation device 42 may be designed as a worm-driven hose clamp, i.e., one of the end portions 38, 39 of the core 37 may be provided with threads and the other end portion of the core 37 may be provided with a worm, the threads of which interacts with the threads of said one end portion of the core 37. The threads of such a worm may also interact with threads provided on both end portions 38, 39 of the core 37. In this alternative, the electric motor 47 turns the worm in one direction to reduce the diameter of the core 37, so that the wall portion is constricted, or turn the worm in the opposite direction to increase the diameter of the core 37, so that the wall portion is released in one direction to reduce the diameter of the core 37, so that the wall portion is constricted, or turns the clamping screw in the opposite direction to increase the diameter of the core 37, so that the wall portion is released.

FIGURE 18 shows a constriction device which is identical to the embodiment of FIGURES 15-17, except that the motor 47 is encapsulated in the hose 40 so that it is fixed to the core 37 and has a short drive shaft 51, and that the motor 47 is positioned relative to the core 37, such that the drive shaft 51 extends substantially tangentially to the circular core 37. There is an angular gearing 52 connecting the drive shaft 51 to the drive wheel 43.

FIGURE 19 shows a suitable alternative arrangement for the motor 47 in the embodiment of FIGURE 18, comprising a first clamping member 53 secured to one end portion of the core 37 and a second clamping member 54 secured to the other end portion 39 of the core 37. The motor 47 is secured to the first clamping member 53 and is operatively connected to a worm gear 55 via a gear transmission 56. The worm gear 55 is journalled at its opposite ends on holders 57 and 58, which are rigidly secured to the clamping member 53 and the motor 47, respectively. The second clamping member 54 has a pinion in mesh with the worm gear 55. When the motor 47 is powered, the worm gear 55 rotates, and will thereby pull the end portion 39 of the core 37 in one or the opposite longitudinal direction, so that the diameter of the substantially circular core 37 is either increased or decreased. The motor 47, worm gear 55, gear transmission 56 and second clamping member 54 constitute a servo system of the type that transfers a weak force acting on a moving element.
having a long stroke into a strong force acting on another moving element having a short stroke.

[00207] FIGURE 20 shows a constriction device including a plurality of arcuate lamellae 59 arranged like the conventional adjustable aperture mechanism of a camera. A motor 60 operates the lamellae 59 to change the size of a restriction opening defined by the lamellae 59.

[00208] FIGURE 21 shows a constriction device including two semi-circular elements 61 and 62, which are hinged together such that the semi-circular elements 61, 62 are possible to swing relative to each other between a fully open state in which they substantially form a circle, and an angular state, in which the size of the restriction opening defined by the semi-circular elements 61, 62 is reduced. A motor 63 operates the semi-circular elements 61, 62 to swing them relative to each other. Fig 21 and 22 show exaggerated movements.

[00209] FIGURES 24 show a constriction device including an elastic belt 64 forming a circle and having a substantially oval cross-section. A motor 67 operates the belt 64 to turn around the longitudinal extension thereof between a fully open state, in which the inner broader side of the belt 64 forms a substantially cylindrical surface, and a reduced open state, in which the inner broader side of the belt 64 forms a substantially conical surface.

[00210] FIGURES 25-26 show another embodiment of an apparatus used for practicing the method of the invention. The apparatus includes a constriction device having an elastic belt 64, which forms a circle and has a substantially oval cross-section. A motor 67 operates the belt 64 to turn around the longitudinal extension thereof between a fully open state, in which the inner broader side of the belt 64 forms a substantially cylindrical surface, illustrated in FIGURE 25, and a reduced open state, in which the inner broader side of the belt 64 forms a substantially conical surface, illustrated in FIGURE 26.

[00211]

[00212] FIGURE 27 shows a constriction device 68 having two rigid articulated clamping elements 69 positioned on opposite sides of a portion of a tubular tissue wall 70 of a patient's blood vessel. An operation device 71 turns the clamping
elements 69 toward each other to clamp the wall portion 70 between the clamping elements 69 to thereby contract the wall portion, and turns the clamping elements 69 away from each other to release the wall portion from the clamping elements 69.

[00213] FIGURES 28 and 29 show another embodiment of an apparatus used for practicing the method of the invention. The apparatus of FIGURES 28 and 29 include a constriction device 300 having three bending members 301, 302 and 303 displaced relative to one another in a row along a portion of a tubular tissue wall 304 of a patient's organ and positioned alternately on opposite sides of the tubular wall 304. (Alternatively, each member 301, 302 and 303 may take the shape of an hourglass.) An operation device (not shown) moves the two outer members 301, 303 laterally against the tubular wall 304 in one direction and the intermediate member 302 against the tubular wall 304 in the opposite direction to bend the tubular wall 304 to thereby constrict the tubular wall portion 304, see FIGURE 29. To release the wall portion 304 the operation device moves the members 301-303 away from the tubular wall portion 304 to the position shown in FIGURE 28.

[00214] FIGURES 30A and 30B show a hydraulically operable elongated constriction device in the form of a band 72 having an expandable/contractible cavity 73, which is in fluid communication with an adjustable reservoir 74 containing hydraulic fluid. FIGURE 30A illustrates when the band is in a non-constriction state, whereas FIGURE 30B illustrates when the band is in a constriction state, in which the cavity 73 is expanded by hydraulic fluid supplied by the reservoir 74.

[00215] FIGURES 31A, 31B, 31C and 31D are block diagrams of four differently operated hydraulic constriction devices. FIGURE 31A shows the band 72 of FIGURE 30A, the cavity 73 of which is in fluid communication with a reservoir 75. FIGURE 31B shows the embodiment of FIGURE 30A, in which the cavity 73 of the band 72 is in fluid communication with the reservoir 74 via an operation device in the form of a two-way pump 76. FIGURE 31C shows an operation device in the form of a reverse servo system with a first closed system controlling a second system. The reverse servo system comprises an adjustable fluid supply reservoir 77 and an adjustable servo reservoir 78. The servo reservoir 78 controls a larger adjustable reservoir 79 which in connection with the band 72 applied around a portion of tubular tissue wall.
of a patient's blood vessel varies the volume of the cavity 73 of the band 72, which in turn varies the constriction of the wall portion. FIGURE 31D shows an embodiment identical to the embodiment of FIGURE 31C, except that the larger reservoir 79 is omitted. Instead, the servo reservoir 78 is in fluid communication with the cavity of the band 72.

[00216] In all of the above embodiments according to FIGURES 12A through 3OB, stimulation devices may be provided to form constriction/stimulation units, in which the stimulation devices include a multiplicity of electrical elements 7 (indicated in FIGURES 12A - 15, 18, 20 - 23, 26 - 31B) positioned on the constriction devices.

[00217] FIGURE 32 is a cross-sectional view of a fluid supply device including a bellows reservoir 80 defining a chamber 81, the size of which is variable by an operation device comprising a remote controlled electric motor 82. The reservoir 80 and the motor 82 are placed in a housing 83. Moving a large wall 84 varies the chamber 81. The wall 84 is secured to a nut 85, which is threaded on a rotatable spindle 86. The spindle 86 is rotated by the motor 82. A battery 89 placed in the housing 83 powers the motor 82. A signal receiver 90 for controlling the motor 82 is also placed in the housing 83. Alternatively, the battery 89 and the signal receiver 90 may be mounted in a separate place. The motor 82 may also be powered with energy transferred from transmitted signals.

[00218] Where applicable, the fluid supply device of FIGURE 32 may be used for supplying hydraulic fluid for the operation of the constriction devices described in this specification. For example, the fluid supply device of FIGURE 32 may be substituted for the reservoir 74 in the embodiment according to FIGURE 30A.

[00219] FIGURES 33A and 33B show a reverse servo including a rectangular housing 91 and an intermediate wall 92, which is movable in the housing 91. A relatively large, substantially cylindrical bellows reservoir 93 is arranged in the housing 91 and is joined to the movable intermediate wall 92. Another cylindrical bellows reservoir 94, which is substantially smaller than reservoir 93, is arranged in the housing 91 at the other side of the intermediate wall 92 and is also joined to the wall 92. The small bellows reservoir 94 has a fluid supply pipe 95 and the large bellows reservoir 93 has a fluid supply pipe 96.
Referring to FIGURE 33A, when a small amount of hydraulic fluid is conducted through the supply pipe 95 into the small bellows reservoir 94, the small bellows reservoir 94 expands and pushes the movable intermediate wall 92 towards the large bellows reservoir 93. As a result, the large bellows reservoir 93 is contracted by the intermediate wall 92, whereby a large amount of hydraulic fluid is forced out of the large bellows reservoir 93 through the supply pipe 96, as shown in FIGURE 33B.

For example, the reverse servo of FIGURES 33A and 33B may be used in the embodiment of FIGURE 31C, wherein the small bellows reservoir 94 corresponds to the small servo reservoir 78 and the large bellows reservoir 93 corresponds to the large reservoir 79. Also, the reverse servo of FIGURES 33A and 33B may be used in the embodiment of FIGURE 3OA and 30B, wherein the small bellows reservoir 94 is connected to the adjustable reservoir 74, and the large bellows reservoir 93 is connected to the cavity 73 of the band 72.

FIGURE 34 schematically shows a hydraulically operable constriction device 97 of the apparatus of the invention, which is similar to the embodiment shown in FIGURE 3OA, except that the hydraulic system is designed differently. Thus, the constriction device 97 includes a relatively small inflatable cavity 98, which is in fluid communication with a reservoir 99 containing hydraulic fluid, and a relatively large cavity 100, which is displaceable by small cavity 98. Small cavity 98 is adapted to displace large cavity 100 to constrict the patient’s tubular wall portion when small cavity 98 is inflated and to displace large cavity 100 to release the wall portion when small cavity 98 is deflated. Thus, a relatively small addition of hydraulic fluid from reservoir 99 to small cavity 98 causes a relatively large increase in the constriction of the wall portion.

Large cavity 100 is defined by a contraction element in the form of a big balloon 101, which may be connected to an injection port (not shown) for calibration of the volume of large cavity 100. Adding fluid to or withdrawing fluid from the injection port with the aid of a syringe calibrates the volume of balloon 101. Small cavity 98 is defined by a small bellows 102 attached to an annular frame 103 of constriction device 97 and at the opposite end is attached to balloon 101.
FIGURES 35A and 35B schematically illustrate the operation of constriction device 97, when annular frame 103 is applied around the tubular wall portion of the patient’s organ. Referring to FIGURE 35A, when small cavity 98 is deflated bellows 102 pulls balloon 101 inwardly into annular frame 103, so that constriction device 97 constricts the wall portion. Referring to FIGURE 34B, when small cavity 98 is inflated bellows 102 pulls balloon 101 out of annular frame 103, so that constriction device 97 releases the wall portion.

As mentioned above, the constriction device and stimulation device can co-operate to actively move the fluid and/or other bodily matter in the lumen of a patient’s organ. This can be practised by use of the constriction/stimulation unit according to FIGURE 2. Thus, in accordance with a first cooperation option, the clamping elements 5, 6 of the constriction device constricts the wall portion 8 without completely closing the lumen, and the control device 4 controls the electrical elements 7 to progressively stimulate the constricted wall portion in the downstream or upstream direction of the lumen to cause progressive contraction of the wall portion 8 to move the fluid and/or other bodily matter in the lumen.

In accordance with a second cooperation option, the constriction device constricts the wall portion so that the flow in the lumen is restricted, and the control device 4 controls a few electrical elements 7 at one end of the elongate clamping elements 5, 6 to stimulate the constricted wall portion 8 to close the lumen either at an upstream end or a downstream end of the wall portion 8. With the lumen closed in this manner, the control device 4 controls the constriction device to increase the constriction of the wall portion, whereby the fluid and/or other bodily matter in the lumen is moved downstream or upstream of the wall portion 8.

Alternatively, the control device 4 controls the stimulation device to stimulate the constricted wall portion 8 while the constriction device varies the constriction of the different areas of the wall portion, so that the wall portion 8 is progressively constricted in the downstream or upstream direction of the lumen. FIGURES 36A - 36E show different operation stages of such an alternative embodiment. Thus, a constriction device 104 used for practicing the method of the invention includes two elongate constriction elements 105, 106 having convex surfaces 107, 108 that abut a length of the wall portion 8 on mutual sides thereof. A multiplicity of electrical elements 7 (such as electrodes) are positioned on the convex surfaces 107, 108. The control device 4 controls the electrical elements 7 during
operation of the constriction device 104 to stimulate the wall portion 8 and controls
the elongate constriction elements 105, 106 to move relative to the tubular wall
portion 8 so that the constriction elements 105, 106 progressively constrict the wall
portion 8, as appears from FIGURES 36A to 36D.

[00228] Thus, in an initial position of the constriction elements 105, 106 shown
in FIGURE 36A, the wall portion is not constricted by the constriction elements 105,
106 and the electrical elements 7 are not energized. Starting from this initial position,
the control device 4 controls the constriction elements 105, 106 to swing the left
ends of the constriction elements 105, 106 toward the wall portion (indicated by
arrows) to constrict the tubular wall portion 8, see FIGURE 36B, while energizing the
electrical elements 7, so that the electrical elements 7 that contact the wall portion 8
contract the latter. FIGURE 36 C shows how the lumen of the tubular wall portion 8
is completely closed by the thickened wall portion 8. Then, as shown in FIGURE
36C, the control device 4 controls the constriction elements 105, 106 to move so that
their right ends are moving towards each other (indicated by arrows), while the
convex surfaces 107, 108 of the constriction elements 105, 106 are rolling on each
other with the contracted wall portion 8 between them, see FIGURE 36D. As a result,
the bodily matter in the lumen of the organ is forced to the right (indicated by a white
arrow). When the constriction elements 105, 106 have rolled on each other to the
position shown in FIGURE 36E, the control device 4 controls the right ends of the
constriction elements 105, 106 to move away from each other (indicated by arrows in
FIGURE 36E) to the initial position shown in FIGURE 36A. The operation stages
described according to FIGURES 36A to 36E can be cyclically repeated a number of
times until the desired amount of bodily matter has been moved in the lumen of the
organ in a peristaltic manner.

[00229] Alternatively, only one of the constriction elements 105, 106 can be
provided with a convex surface, whereas the other constriction element has a plane
surface that abuts the wall portion. It is also possible to use a single constriction
element with a convex surface that presses the tubular portion 8 of the organ against
a bone of the patient.

[00230] In the embodiment according to FIGURES 36A to 36E, the control
device 4 may control the electrical elements 7 to progressively stimulate the
constricted wall portion 8 to cause progressive contraction thereof in harmony with
the movement of the elongate constriction elements 105, 106, as the convex surfaces 107, 108 of the constriction elements 105, 106 are rolling on each other.

[00231] FIGURES 35A and 35B schematically illustrate the operation of constriction device 97, when annular frame 103 is applied around the tubular wall portion of the patient's blood vessel. Referring to FIGURE 35A, when small cavity 98 is deflated bellows 102 pulls balloon 101 inwardly into annular frame 103, so that constriction device 97 constricts the wall portion. Referring to FIGURE 35B, when small cavity 98 is inflated bellows 102 pulls balloon 101 out of annular frame 103, so that constriction device 97 releases the wall portion.

[00232] FIGURE 37 schematically shows a general embodiment of the apparatus of the invention, in which energy is transferred to energy consuming components of the apparatus implanted in the patient. The apparatus of FIGURE 37 comprises an implanted constriction/stimulation unit 110, which is operable to gently constrict a portion of a tubular tissue wall of a patient's blood vessel and to stimulate different areas of the constricted portion to cause contraction of the wall portion. The constriction device of the constriction/stimulation unit 110 is capable of performing a reversible function, i.e., to constrict and release the wall portion, so that the constriction/stimulation unit 110 works, for example as an artificial sphincter.

[00233] A source of energy 111 is adapted to supply energy consuming components of the constriction/stimulation unit 110 with energy via a power supply line 112. A wireless remote control or a subcutaneously implanted switch operable by the patient to switch on or off the supply of energy from the source of energy may be provided. The source of energy may be an implantable permanent or rechargeable battery, or be included in an external energy-transmission device, which may be operable directly by the patient or be controlled by a remote control operable by the patient to transmit wireless energy to the energy consuming components of the constriction/stimulation unit. Alternatively, the source of energy may comprise a combination of an implantable rechargeable battery, an external energy-transmission device and an implantable energy-transforming device for transforming wireless energy transmitted by the external energy-transmission device into electric energy for the charge of the implantable rechargeable battery.
[00234] FIGURE 38 shows a special embodiment of the general embodiment of FIGURE 37 having some parts implanted in a patient and other parts located outside the patient's body. Thus, in FIGURE 38 all parts placed to the right of the patient's skin 109 are implanted and all parts placed to the left of the skin 109 are located outside the patient's body. An implanted energy-transforming device 111A of the apparatus is adapted to supply energy consuming components of the constriction/stimulation unit 110 with energy via the power supply line 112. An external energy-transmission device 113 of the apparatus includes a wireless remote control transmitting a wireless signal, which is received by a signal receiver incorporated in the implanted energy-transforming device 111A. The implanted energy-transforming device 111A transforms energy from the signal into electric energy, which is supplied via the power supply line 112 to the constriction/stimulation unit 110.

[00235] The apparatus of FIGURE 38 may also include an implanted rechargeable battery for energizing energy consuming implanted components of the apparatus. In this case, the implanted energy-transforming device 111A also charges the battery with electric energy, as the energy-transforming device transforms energy from the signal into the electric energy.

[00236] A reversing device in the form of an electric switch 114, such as a microprocessor, is implanted in the patient for reversing the constriction device of the constriction/stimulation unit 110. The wireless remote control of the external energy-transmission device 113 transmits a wireless signal that carries energy and the implanted energy-transforming device 111A transforms the wireless energy into a current for operating the switch 114. When the polarity of the current is shifted by the energy-transforming-device 111A the switch 114 reverses the function performed by the constriction device of the constriction/stimulation unit 110.

[00237] FIGURE 39 shows an embodiment of the invention including the energy-transforming device 111A, the constriction/stimulation unit 110 and an implanted operation device in the form of a motor 115 for operating the constriction device of the constriction/stimulation unit 110. The motor 115 is powered with energy from the energy-transforming device 111A, as the remote control of the external energy-
transmission device 113 transmits a wireless signal to the receiver of the energy-transforming device 111A.

[00238] FIGURE 40 shows an embodiment of the invention including the energy-transforming device 111A, the constriction/stimulation unit 110 and an implanted assembly 116 including a motor/pump unit 117 and a fluid reservoir 118. In this case the constriction device of the constriction/stimulation unit 110 is hydraulically operated, i.e., hydraulic fluid is pumped by the motor/pump unit 117 from the reservoir 118 to the constriction/stimulation unit 110 to constrict the wall portion, and hydraulic fluid is pumped by the motor/pump unit 117 back from the constriction/stimulation unit 110 to the reservoir 118 to release the wall portion. The implanted energy-transforming device 111A transforms wireless energy into a current, for powering the motor/pump unit 117.

[00239] FIGURE 41 shows an embodiment of the invention comprising the external energy-transmission device 113 that controls the control unit 122 to reverse the motor 115 when needed, the constriction/stimulation unit 110, the constriction device of which is hydraulically operated, and the implanted energy-transforming device 111A, and further comprising an implanted hydraulic fluid reservoir 119, an implanted motor/pump unit 120, an implanted reversing device in the form of a hydraulic valve shifting device 121 and a separate external wireless remote control 111B. The motor of the motor/pump unit 120 is an electric motor. In response to a control signal from the wireless remote control of the external energy-transmission device 113, the implanted energy-transforming device 111A powers the motor/pump unit 120 with energy from the energy carried by the control signal, whereby the motor/pump unit 120 distributes hydraulic fluid between the reservoir 119 and the constriction device of the constriction/stimulation unit 110. The remote control 111B controls the shifting device 121 to shift the hydraulic fluid flow direction between one direction in which the fluid is pumped by the motor/pump unit 120 from the reservoir 119 to the constriction device of the constriction/stimulation unit 110 to constrict the wall portion, and another opposite direction in which the fluid is pumped by the motor/pump unit 120 back from the constriction device of the constriction/stimulation unit 110 to the reservoir 119 to release the wall portion.
[00240] FIGURE 42 shows an embodiment of the invention including the energy-transforming device 111A and the constriction/stimulation unit 110. A control unit 122, an accumulator 123 and a capacitor 124 are also implanted in the patient. A separate external wireless remote control 111B controls the control unit 122. The control unit 122 controls the energy-transforming device 111A to store electric energy in the accumulator 123, which supplies energy to the constriction/stimulation unit 110. In response to a control signal from the wireless remote control 111B, the control unit 122 either releases electric energy from the accumulator 123 and transfers the released energy via power lines, or directly transfers electric energy from the energy-transforming device 111A via the capacitor 124, which stabilises the electric current, for the operation of the constriction/stimulation unit 110.

[00241] In accordance with one alternative, the capacitor 124 in the embodiment of FIGURE 42 may be omitted. In accordance with another alternative, the accumulator 123 in this embodiment may be omitted.

[00242] FIGURE 43 shows an embodiment of the invention including the energy-transforming device 111A, the constriction/stimulation unit 110. A battery 125 for supplying energy for the operation of the constriction/stimulation unit 110 and an electric switch 126 for switching the operation of the constriction/stimulation unit 110 are also implanted in the patient. The switch 126 is operated by the energy supplied by the energy-transforming device 111A to switch from an off mode, in which the battery 125 is not in use, to an on mode, in which the battery 125 supplies energy for the operation of the constriction/stimulation unit 110.

[00243] FIGURE 44 shows an embodiment of the invention identical to that of FIGURE 43, except that a control unit 122 also is implanted in the patient. A separate external wireless remote control 111B controls the control unit 122. In this case, the switch 126 is operated by the energy supplied by the energy-transforming device 111A to switch from an off mode, in which the wireless remote control 111B is prevented from controlling the control unit 122 and the battery 125 is not in use, to a standby mode, in which the remote control 111B is permitted to control the control unit 122 to release electric energy from the battery 125 for the operation of the constriction/stimulation unit 110.
[00244] FIGURE 45 shows an embodiment of the invention identical to that of FIGURE 44, except that the accumulator 123 is substituted for the battery 125 and the implanted components are interconnected differently. In this case, the accumulator 123 stores energy from the energy-transforming device 111A. In response to a control signal from the wireless remote control 111B, the implanted control unit 122 controls the switch 126 to switch from an off mode, in which the accumulator 123 is not in use, to an on mode, in which the accumulator 123 supplies energy for the operation of the constriction/stimulation unit 110.

[00245] FIGURE 46 shows an embodiment of the invention identical to that of FIGURE 45, except that the battery 125 also is implanted in the patient, and the implanted components are interconnected differently. In response to a control signal from the wireless remote control 111B, the implanted control unit 122 controls the accumulator 123, which may be a capacitor, to deliver energy for operating the switch 126 to switch from an off mode, in which the battery 125 is not in use, to an on mode, in which the battery 125 supplies electric energy for the operation of the constriction/stimulation unit 110.

[00246] Alternatively, the switch 126 may be operated by energy supplied by the accumulator 123 to switch from an off mode, in which the wireless remote control 111B is prevented from controlling the battery 125 to supply electric energy and the battery 125 is not in use, to a standby mode, in which the wireless remote control 111B is permitted to control the battery 125 to supply electric energy for the operation of the constriction/stimulation unit 110.

[00247] FIGURE 47 shows an embodiment of the invention identical to that of FIGURE 43, except that a motor 115, a mechanical reversing device in the form of a gearbox 127 and a control unit 122 for controlling the gearbox 127 also are implanted in the patient. A separate external wireless remote control 111B controls the implanted control unit 122 to control the gearbox 127 to reverse the function performed by the constriction device (mechanically operated) of the constriction/stimulation unit 110.

[00248] FIGURE 48 shows an embodiment of the invention identical to that of FIGURE 46, except that the implanted components are interconnected differently.
Thus, in this case, the battery 125 powers the control unit 122 when the accumulator 123, suitably a capacitor, activates the switch 126 to switch to an on mode. When the switch 126 is in its on mode the control unit 122 is permitted to control the battery 125 to supply, or not supply, energy for the operation of the constriction/stimulation unit 110.

[00249] FIGURE 49 shows an embodiment of the invention identical to that of FIGURE 39, except that a gearbox 127 that connects the motor 115 to the constriction/stimulation unit 110, and a control unit 122 that controls the energy-transforming device 111A to power the motor 115 also are implanted in the patient. There is a separate external wireless remote control 111B that controls the control unit 122 to reverse the motor 115 when needed.

[00250] Optionally, the accumulator 123 shown in FIGURE 42 may be provided in the embodiment of FIGURE 49, wherein the implanted control unit 122 controls the energy-transforming device 111A to store the transformed energy in the accumulator 123. In response to a control signal from the wireless remote control 111B, the control unit 122 controls the accumulator 123 to supply energy for the operation of the constriction/stimulation unit 110.

[00251] Those skilled in the art will realise that the above various embodiments according to FIGURES 38-49 could be combined in many different ways. For example, the energy operated switch 114 could be incorporated in any of the embodiments of FIGURES 39, 42-49, the hydraulic shifting device 121 could be incorporated in the embodiment of FIGURE 40, and the gearbox 127 could be incorporated in the embodiment of FIGURE 39. The switch 114 may be of a type that includes electronic components, for example a microprocessor, or a FGPA (Field Programmable Gate Array) designed for switching. Alternatively, however, the energy operated switch 114 may be replaced by a subcutaneously implanted push button that is manually switched by the patient between "on" and 'Off'.

[00252] Alternatively, a permanent or rechargeable battery may be substituted for the energy-transforming devices 111A of the embodiments shown in FIGURES 38-49.
FIGURE 50 shows the energy-transforming device in the form of an electrical junction element 128 for use in any of the above embodiments according to FIGURES 37-49. The element 128 is a flat p-n junction element comprising a p-type semiconductor layer 129 and an n-type semiconductor layer 130 sandwiched together. A light bulb 131 is electrically connected to opposite sides of the element 128 to illustrate how the generated current is obtained. The output of current from such a p-n junction element 128 is correlated to the temperature. See the formula below.

\[ I = I_0 \left( \exp \left( \frac{qV}{kT} \right) - 1 \right) \]

Where
- \( I \) is the external current flow,
- \( I_0 \) is the reverse saturation current,
- \( q \) is the fundamental electronic charge of 1.602 x 10-19 coulombs,
- \( V \) is the applied voltage,
- \( k \) is the Boltzmann constant, and
- \( T \) is the absolute temperature.

Under large negative applied voltage (reverse bias), the exponential term becomes negligible compared to 1.0, and \( I \) is approximately \(-I_0\). \( I_0 \) is strongly dependent on the temperature of the junction and hence on the intrinsic-carrier concentration. \( I_0 \) is larger for materials with smaller bandgaps than for those with larger bandgaps. The rectifier action of the diode, that is, its restriction of current flow to only one direction, is in this particular embodiment the key to the operation of the p-n junction element 128.

The alternative way to design a p-n junction element is to deposit a thin layer of semiconductor onto a supporting material which does not absorb the kind of energy utilised in the respective embodiments. For use with wirelessly transmitted energy in terms of light waves, glass could be a suitable material. Various materials may be used in the semiconductor layers, such as, but not limited to, cadmium telluride, copper-indium-diselenide and silicon. It is also possible to use a multilayer structure with several layers of p and n-type materials to improve efficiency.
[00256] The electric energy generated by the p-n junction element 128 could be of the same type as generated by solar cells, in which the negative and positive fields create a direct current. Alternatively, the negative and positive semiconductor layers may change polarity following the transmitted waves, thereby generating the alternating current.

[00257] The p-n junction element 128 is designed to make it suited for implantation. Thus, all the external surfaces of the element 128 in contact with the human body are made of a biocompatible material. The p-n junction semiconductors are designed to operate optimally at a body temperature of 37°C because the current output, which should be more than 1 µA, is significantly dependent upon such temperature, as shown above. Since both the skin and subcutis absorb energy, the relation between the sensitivity or working area of the element 128 and the intensity or strength of the wireless energy-transmission is considered. The p-n junction element 128 preferably is designed flat and small. Alternatively, if the element 128 is made in larger sizes it should be flexible, in order to adapt to the patient's body movements. The volume of the element 128 should be kept less than 2000 cm³.

[00258] FIGURE 51 shows basic parts of a remote control of the apparatus of the invention for controlling the constriction/stimulation unit 110. In this case, the stimulation device of the constriction/stimulation unit stimulates the wall portion with electric pulses. The remote control is based on wireless transmission of electromagnetic wave signals, often of high frequencies in the order of 100 kHz - 1 GHz, through the skin 132 of the patient. In FIGURE 51, all parts placed to the left of the skin 132 are located outside the patient's body and all parts placed to the right of the skin 132 are implanted.

[00259] An external signal-transmission device 133 is to be positioned close to a signal-receiving device 134 implanted close to the skin 132. As an alternative, the signal-receiving device 134 may be placed for example inside the abdomen of the patient. The signal-receiving device 134 comprises a coil, approximately 1-100 mm, preferably 25 mm in diameter, wound with a very thin wire and tuned with a capacitor to a specific high frequency. A small coil is chosen if it is to be implanted under the skin of the patient and a large coil is chosen if it is to be implanted in the abdomen of the patient. The signal transmission device 133 comprises a coil having about the
same size as the coil of the signal-receiving device 134 but wound with a thick wire that can handle the larger currents that is necessary. The coil of the signal transmission device 133 is tuned to the same specific high frequency as the coil of the signal-receiving device 134.

[00260] The signal-transmission device 133 is adapted to send digital information via the power amplifier and signal-receiving device 134 to an implanted control unit 135. To avoid that accidental random high frequency fields trigger control commands, digital signal codes are used. A conventional keypad placed on the signal transmission device 133 is used to order the signal transmission device 133 to send digital signals for the control of the constriction/stimulation unit. The signal transmission device 133 starts a command by generating a high frequency signal. After a short time, when the signal has energized the implanted parts of the control system, commands are sent to operate the constriction device of the constriction/stimulation unit 110 in predefined steps. The commands are sent as digital packets in the form illustrated below.

<table>
<thead>
<tr>
<th>Start pattern, 8 bits</th>
<th>Command, 8 bits</th>
<th>Count, 8 bits</th>
<th>Checksum, 8 bits</th>
</tr>
</thead>
</table>

[00261] The commands are sent continuously during a rather long time period (e.g., about 30 seconds or more). When a new constriction or release step is desired, the Count byte is increased by one to allow the implanted control unit 135 to decode and understand that another step is demanded by the signal transmission device 133. If any part of the digital packet is erroneous, its content is simply ignored.

[00262] Through a line 136, an implanted energizer unit 137 draws energy from the high frequency electromagnetic wave signals received by the signal-receiving device 134. The energizer unit 137 stores the energy in a source of energy, such as a large capacitor, powers the control unit 135 and powers the constriction/stimulation unit 110 via a line 138.

[00263] The control unit 135 comprises a demodulator and a microprocessor. The demodulator demodulates digital signals sent from the signal transmission device 133. The microprocessor receives the digital packet, decodes it and sends a control signal via a signal line 139 to control the constriction device of the
constriction/stimulation unit 110 to either constrict or release the wall portion of the patient's blood vessel depending on the received command code.

[00264] FIGURE 52 shows a circuitry of an embodiment of the invention, in which wireless energy is transformed into a current. External components of the circuitry include a microprocessor 140, a signal generator 141 and a power amplifier 142 connected thereto. The microprocessor 140 is adapted to switch the signal generator 141 on/off and to modulate signals generated by the signal generator 141 with digital commands. The power amplifier 142 amplifies the signals and sends them to an external signal-transmitting antenna coil 143. The antenna coil 143 is connected in parallel with a capacitor 144 to form a resonant circuit tuned to the frequency generated by the signal generator 141.

[00265] Implanted components of the circuitry include a signal receiving antenna coil 145 and a capacitor 146 forming together a resonant circuit that is tuned to the same frequency as the transmitting antenna coil 143. The signal receiving antenna coil 145 induces a current from the received high frequency electromagnetic waves and a rectifying diode 147 rectifies the induced current, which charges a storage capacitor 148. The storage capacitor 148 powers a motor 149 for driving the constriction device of the constriction/stimulation unit 110. A coil 150 connected between the antenna coil 145 and the diode 147 prevents the capacitor 148 and the diode 147 from loading the circuit of the signal-receiving antenna 145 at higher frequencies. Thus, the coil 150 makes it possible to charge the capacitor 148 and to transmit digital information using amplitude modulation.

[00266] A capacitor 151 and a resistor 152 connected in parallel and a diode 153 form a detector used to detect amplitude modulated digital information. A filter circuit is formed by a resistor 154 connected in series with a resistor 155 connected in series with a capacitor 156 connected in series with the resistor 154 via ground, and a capacitor 157, one terminal of which is connected between the resistors 154,155 and the other terminal of which is connected between the diode 153 and the circuit formed by the capacitor 151 and resistor 152. The filter circuit is used to filter out undesired low and high frequencies. The detected and filtered signals are fed to an implanted microprocessor 158 that decodes the digital information and controls the
motor 149 via an H-bridge 159 comprising transistors 160, 161, 162 and 163. The motor 149 can be driven in two opposite directions by the H-bridge 159.

[00267] The microprocessor 158 also monitors the amount of stored energy in the storage capacitor 148. Before sending signals to activate the motor 149, the microprocessor 158 checks whether the energy stored in the storage capacitor 148 is enough. If the stored energy is not enough to perform the requested operation, the microprocessor 158 waits for the received signals to charge the storage capacitor 148 before activating the motor 149.

[00268] Alternatively, the energy stored in the storage capacitor 148 may only be used for powering a switch, and the energy for powering the motor 149 may be obtained from another implanted energy source of relatively high capacity, for example a battery. In this case the switch is adapted to connect the battery to the motor 149 in an on mode when the switch is powered by the storage capacitor 148 and to keep the battery disconnected from the motor 149 in a standby mode when the switch is not powered.

Wireless transmission of energy

[00269] Fig. 53 illustrates a system for treating a disease comprising an apparatus 301 of the present invention placed in the abdomen of a patient 300. An implanted energy-transforming device 302 is adapted to supply energy consuming components of the apparatus with energy via a power supply line 303. An external energy-transmission device 304 for non-invasively energizing the apparatus 301 transmits energy by at least one wireless energy signal. The implanted energy-transforming device 302 transforms energy from the wireless energy signal into electric energy which is supplied via the power supply line 303. The system may also include a transmitter/receiver 305 located outside the body of a treated patient. This transmitter/receiver communicates with an electronic control unit 306 adapted to receive and transmit signals from said transmitter/receiver 305. The system can also comprise a chargeable battery (not shown) chargeable from the outside by an external charger unit, same or different from the external energy-transmission device 304. The system can also comprise an electrical pulse generator (not shown) for generating electrical pulses as is described in more detail below.
[00270] The wireless energy signal may include a wave signal selected from the following: a sound wave signal, an ultrasound wave signal, an electromagnetic wave signal, an infrared light signal, a visible light signal, an ultra violet light signal, a laser light signal, a micro wave signal, a radio wave signal, an x-ray radiation signal and a gamma radiation signal. Alternatively, the wireless energy signal may include an electric or magnetic field, or a combined electric and magnetic field.

[00271] The wireless energy-transmission device 304 may transmit a carrier signal for carrying the wireless energy signal. Such a carrier signal may include digital, analogue or a combination of digital and analogue signals. In this case, the wireless energy signal includes an analogue or a digital signal, or a combination of an analogue and digital signal.

[00272] Generally speaking, the energy-transforming device 302 is provided for transforming wireless energy of a first form transmitted by the energy-transmission device 304 into energy of a second form, which typically is different from the energy of the first form. The implanted apparatus 301 is operable in response to the energy of the second form. The energy-transforming device 302 may directly power the apparatus with the second form energy, as the energy-transforming device 302 transforms the first form energy transmitted by the energy-transmission device 304 into the second form energy. The system may further include an implantable accumulator, wherein the second form energy is used at least partly to charge the accumulator.

[00273] Alternatively, the wireless energy transmitted by the energy-transmission device 304 may be used to directly power the apparatus, as the wireless energy is being transmitted by the energy-transmission device 304. Where the system comprises an operation device for operating the apparatus, as will be described below, the wireless energy transmitted by the energy-transmission device 304 may be used to directly power the operation device to create kinetic energy for the operation of the apparatus.

[00274] The wireless energy of the first form may comprise sound waves and the energy-transforming device 302 may include a piezo-electric element for transforming the sound waves into electric energy. The energy of the second form
may comprise electric energy in the form of a direct current or pulsating direct current, or a combination of a direct current and pulsating direct current, or an alternating current or a combination of a direct and alternating current. Normally, the apparatus comprises electric components that are energized with electrical energy. Other implantable electric components of the system may be at least one voltage level guard or at least one constant current guard connected with the electric components of the apparatus.

[00275] Optionally, one of the energy of the first form and the energy of the second form may comprise magnetic energy, kinetic energy, sound energy, chemical energy, radiant energy, electromagnetic energy, photo energy, nuclear energy or thermal energy. Preferably, one of the energy of the first form and the energy of the second form is non-magnetic, non-kinetic, non-chemical, non-sonic, non-nuclear or non-thermal.

[00276] The energy-transmission device may be controlled from outside the patient's body to release electromagnetic wireless energy, and the released electromagnetic wireless energy is used for operating the apparatus. Alternatively, the energy-transmission device is controlled from outside the patient's body to release non-magnetic wireless energy, and the released non-magnetic wireless energy is used for operating the apparatus.

[00277] The external energy-transmission device 304 also includes a wireless remote control having an external signal transmitter for transmitting a wireless control signal for non-invasively controlling the apparatus. The control signal is received by an implanted signal receiver which may be incorporated in the implanted energy-transforming device 302 or be separate there from.

[00278] The wireless control signal may include a frequency, amplitude, or phase modulated signal or a combination thereof. Alternatively, the wireless control signal includes an analogue or a digital signal, or a combination of an analogue and digital signal. Alternatively, the wireless control signal comprises an electric or magnetic field, or a combined electric and magnetic field.

[00279] The wireless remote control may transmit a carrier signal for carrying the wireless control signal. Such a carrier signal may include digital, analogue or a
combination of digital and analogue signals. Where the control signal includes an analogue or a digital signal, or a combination of an analogue and digital signal, the wireless remote control preferably transmits an electromagnetic carrier wave signal for carrying the digital or analogue control signals.

[00280] Fig. 54 illustrates the system of Fig. 53 in the form of a more generalized block diagram showing the apparatus 301, the energy-transforming device 302 powering the apparatus 301 via power supply line 303, and the external energy-transmission device 304, The patient's skin 305, generally shown by a vertical line, separates the interior of the patient to the right of the line from the exterior to the left of the line.

[00281] Fig. 55 shows an embodiment of the invention identical to that of Fig. 54, except that a reversing device in the form of an electric switch 306 operable for example by polarized energy also is implanted in the patient for reversing the apparatus 301. When the switch is operated by polarized energy the wireless remote control of the external energy-transmission device 304 transmits a wireless signal that carries polarized energy and the implanted energy-transforming device 302 transforms the wireless polarized energy into a polarized current for operating the electric switch 306. When the polarity of the current is shifted by the implanted energy-transforming device 302 the electric switch 306 reverses the function performed by the apparatus 301.

[00282] Fig. 56A shows an embodiment of the invention identical to that of Fig. 54, except that an operation device 307 implanted in the patient for operating the apparatus 301 is provided between the implanted energy-transforming device 302 and the apparatus 301. This operation device can be in the form of a motor 307, such as an electric servomotor. The motor 307 is powered with energy from the implanted energy-transforming device 302, as the remote control of the external energy-transmission device 304 transmits a wireless signal to the receiver of the implanted energy-transforming device 302.

[00283] Fig. 56B shows an embodiment of the invention identical to that of Fig. 54, except that it also comprises an operation device is in the form of an assembly 308 including a motor/pump unit 309 and a fluid reservoir 310 is implanted in the patient.
In this case the apparatus 301 is hydraulically operated, i.e. hydraulic fluid is pumped by the motor/pump unit 309 from the fluid reservoir 310 through a conduit 311 to the apparatus 301 to operate the apparatus, and hydraulic fluid is pumped by the motor/pump unit 309 back from the apparatus 301 to the fluid reservoir 310 to return the apparatus to a starting position. The implanted energy-transforming device 302 transforms wireless energy into a current, for example a polarized current, for powering the motor/pump unit 309 via an electric power supply line 312.

[00284] Instead of a hydraulically operated apparatus 301, it is also envisaged that the operation device comprises a pneumatic operation device. In this case, the hydraulic fluid can be pressurized air to be used for regulation and the fluid reservoir is replaced by an air chamber.

[00285] In all of these embodiments the energy-transforming device 302 may include a rechargeable accumulator like a battery or a capacitor to be charged by the wireless energy and supplies energy for any energy consuming part of the system.

[00286] As an alternative, the wireless remote control described above may be replaced by manual control of any implanted part to make contact with by the patient's hand most likely indirect, for example a press button placed under the skin.

[00287] Fig. 57 shows an embodiment of the invention comprising the external energy-transmission device 304 with its wireless remote control, the apparatus 301, in this case hydraulically operated, and the implanted energy-transforming device 302, and further comprising a hydraulic fluid reservoir 313, a motor/pump unit 309 and an reversing device in the form of a hydraulic valve shifting device 314, all implanted in the patient. Of course the hydraulic operation could easily be performed by just changing the pumping direction and the hydraulic valve may therefore be omitted. The remote control may be a device separated from the external energy-transmission device or included in the same. The motor of the motor/pump unit 309 is an electric motor. In response to a control signal from the wireless remote control of the external energy-transmission device 304, the implanted energy-transforming device 302 powers the motor/pump unit 309 with energy from the energy carried by the control signal, whereby the motor/pump unit 309 distributes hydraulic fluid between the hydraulic fluid reservoir 313 and the apparatus 301. The remote control
of the external energy-transmission device 304 controls the hydraulic valve shifting device 314 to shift the hydraulic fluid flow direction between one direction in which the fluid is pumped by the motor/pump unit 309 from the hydraulic fluid reservoir 313 to the apparatus 301 to operate the apparatus, and another opposite direction in which the fluid is pumped by the motor/pump unit 309 back from the apparatus 301 to the hydraulic fluid reservoir 313 to return the apparatus to a starting position.

[00288] Fig. 58 shows an embodiment of the invention comprising the external energy-transmission device 304 with its wireless remote control, the apparatus 301, the implanted energy-transforming device 302, an implanted internal control unit 315 controlled by the wireless remote control of the external energy-transmission device 304, an implanted accumulator 316 and an implanted capacitor 317. The internal control unit 315 arranges storage of electric energy received from the implanted energy-transforming device 302 in the accumulator 316, which supplies energy to the apparatus 301. In response to a control signal from the wireless remote control of the external energy-transmission device 304, the internal control unit 315 either releases electric energy from the accumulator 316 and transfers the released energy via power lines 318 and 319, or directly transfers electric energy from the implanted energy-transforming device 302 via a power line 320, the capacitor 317, which stabilizes the electric current, a power line 321 and the power line 319, for the operation of the apparatus 301.

[00289] The internal control unit is preferably programmable from outside the patient's body. In a preferred embodiment, the internal control unit is programmed to regulate the apparatus 301 according to a pre-programmed time-schedule or to input from any sensor sensing any possible physical parameter of the patient or any functional parameter of the system.

[00290] In accordance with an alternative, the capacitor 317 in the embodiment of Fig. 58 may be omitted. In accordance with another alternative, the accumulator 316 in this embodiment may be omitted.

[00291] Fig. 59 shows an embodiment of the invention identical to that of Fig. 54, except that a battery 322 for supplying energy for the operation of the apparatus 301 and an electric switch 323 for switching the operation of the apparatus 301 also are
implanted in the patient. The electric switch 323 may be controlled by the remote control and may also be operated by the energy supplied by the implanted energy-transforming device 302 to switch from an off mode, in which the battery 322 is not in use, to an on mode, in which the battery 322 supplies energy for the operation of the apparatus 301.

[00292] Fig. 60 shows an embodiment of the invention identical to that of Fig. 59, except that an internal control unit 315 controllable by the wireless remote control of the external energy-transmission device 304 also is implanted in the patient. In this case, the electric switch 323 is operated by the energy supplied by the implanted energy-transforming device 302 to switch from an off mode, in which the wireless remote control is prevented from controlling the internal control unit 315 and the battery is not in use, to a standby mode, in which the remote control is permitted to control the internal control unit 315 to release electric energy from the battery 322 for the operation of the apparatus 301.

[00293] Fig. 61 shows an embodiment of the invention identical to that of Fig. 60, except that an accumulator 316 is substituted for the battery 322 and the implanted components are interconnected differently. In this case, the accumulator 316 stores energy from the implanted energy-transforming device 302. In response to a control signal from the wireless remote control of the external energy-transmission device 304, the internal control unit 315 controls the electric switch 323 to switch from an off mode, in which the accumulator 316 is not in use, to an on mode, in which the accumulator 316 supplies energy for the operation of the apparatus 301. The accumulator may be combined with or replaced by a capacitor.

[00294] Fig. 62 shows an embodiment of the invention identical to that of Fig. 60, except that a battery 322 also is implanted in the patient and the implanted components are interconnected differently. In response to a control signal from the wireless remote control of the external energy-transmission device 304, the internal control unit 315 controls the accumulator 316 to deliver energy for operating the electric switch 323 to switch from an off mode, in which the battery 322 is not in use, to an on mode, in which the battery 322 supplies electric energy for the operation of the apparatus 301.
Alternatively, the electric switch 323 may be operated by energy supplied by the accumulator 316 to switch from an off mode, in which the wireless remote control is prevented from controlling the battery 322 to supply electric energy and is not in use, to a standby mode, in which the wireless remote control is permitted to control the battery 322 to supply electric energy for the operation of the apparatus 301.

It should be understood that the switch 323 and all other switches in this application should be interpreted in its broadest embodiment. This means a transistor, MCU, MCPU, ASIC, FPGA or a DA converter or any other electronic component or circuit that may switch the power on and off. Preferably the switch is controlled from outside the body, or alternatively by an implanted internal control unit.

Fig. 63 shows an embodiment of the invention identical to that of Fig. 59, except that a motor 307, a mechanical reversing device in the form of a gear box 324, and an internal control unit 315 for controlling the gear box 324 also are implanted in the patient. The internal control unit 315 controls the gear box 324 to reverse the function performed by the apparatus 301 (mechanically operated). Even simpler is to switch the direction of the motor electronically. The gear box interpreted in its broadest embodiment may stand for a servo arrangement saving force for the operation device in favour of longer stroke to act.

Fig. 64 shows an embodiment of the invention identical to that of Fig. 62 except that the implanted components are interconnected differently. Thus, in this case the internal control unit 315 is powered by the battery 322 when the accumulator 316, suitably a capacitor, activates the electric switch 323 to switch to an on mode. When the electric switch 323 is in its on mode the internal control unit 315 is permitted to control the battery 322 to supply, or not supply, energy for the operation of the apparatus 301.

Fig. 65 schematically shows conceivable combinations of implanted components of the apparatus for achieving various communication options. Basically, there are the apparatus 301, the internal control unit 315, motor or pump unit 309, and the external energy-transmission device 304 including the external
wireless remote control. As already described above the wireless remote control transmits a control signal which is received by the internal control unit 315, which in turn controls the various implanted components of the apparatus.

[00300] A feedback device, preferably comprising a sensor or measuring device 325, may be implanted in the patient for sensing a physical parameter of the patient. The physical parameter may be at least one selected from the group consisting of pressure, volume, diameter, stretching, elongation, extension, movement, bending, elasticity, muscle contraction, nerve impulse, body temperature, blood pressure, blood flow, heartbeats and breathing. The sensor may sense any of the above physical parameters. For example, the sensor may be a pressure or motility sensor. Alternatively, the sensor 325 may be arranged to sense a functional parameter. The functional parameter may be correlated to the transfer of energy for charging an implanted energy source and may further include at least one selected from the group of parameters consisting of; electricity, pressure, volume, diameter, stretch, elongation, extension, movement, bending, elasticity, temperature and flow.

[00301] The feedback may be sent to the internal control unit or out to an external control unit preferably via the internal control unit. Feedback may be sent out from the body via the energy transfer system or a separate communication system with receiver and transmitters.

[00302] The internal control unit 315, or alternatively the external wireless remote control of the external energy-transmission device 304, may control the apparatus 301 in response to signals from the sensor 325. A transceiver may be combined with the sensor 325 for sending information on the sensed physical parameter to the external wireless remote control. The wireless remote control may comprise a signal transmitter or transceiver and the internal control unit 315 may comprise a signal receiver or transceiver. Alternatively, the wireless remote control may comprise a signal receiver or transceiver and the internal control unit 315 may comprise a signal transmitter or transceiver. The above transceivers, transmitters and receivers may be used for sending information or data related to the apparatus 301 from inside the patient's body to the outside thereof.
[00303] Where the motor/pump unit 309 and battery 322 for powering the motor/pump unit 309 are implanted, information related to the charging of the battery 322 may be fed back. To be more precise, when charging a battery or accumulator with energy feed back information related to said charging process is sent and the energy supply is changed accordingly.

[00304] Fig. 66 shows an alternative embodiment wherein the apparatus 301 is regulated from outside the patient's body. The system 300 comprises a battery 322 connected to the apparatus 301 via a subcutaneous electric switch 326. Thus, the regulation of the apparatus 301 is performed non-invasively by manually pressing the subcutaneous switch, whereby the operation of the apparatus 301 is switched on and off. It will be appreciated that the shown embodiment is a simplification and that additional components, such as an internal control unit or any other part disclosed in the present application can be added to the system. Two subcutaneous switches may also be used. In the preferred embodiment one implanted switch sends information to the internal control unit to perform a certain predetermined performance and when the patient press the switch again the performance is reversed.

[00305] Fig. 67 shows an alternative embodiment, wherein the system 300 comprises a hydraulic fluid reservoir 313 hydraulically connected to the apparatus. Non-invasive regulation is performed by manually pressing the hydraulic reservoir connected to the apparatus.

[00306] The system may include an external data communicator and an implantable internal data communicator communicating with the external data communicator. The internal communicator feeds data related to the apparatus or the patient to the external data communicator and/or the external data communicator feeds data to the internal data communicator.

[00307] Fig. 68 schematically illustrates an arrangement of the system that is capable of sending information from inside the patient's body to the outside thereof to give feedback information related to at least one functional parameter of the apparatus or system, or related to a physical parameter of the patient, in order to supply an accurate amount of energy to an implanted internal energy receiver 302
connected to implanted energy consuming components of the apparatus 301. Such an energy receiver 302 may include an energy source and/or an energy-transforming device. Briefly described, wireless energy is transmitted from an external energy source 304a located outside the patient and is received by the internal energy receiver 302 located inside the patient. The internal energy receiver is adapted to directly or indirectly supply received energy to the energy consuming components of the apparatus 301. An energy balance is determined between the energy received by the internal energy receiver 302 and the energy used for the apparatus 301, and the transmission of wireless energy is then controlled based on the determined energy balance. The energy balance thus provides an accurate indication of the correct amount of energy needed, which is sufficient to operate the apparatus 301 properly, but without causing undue temperature rise.

[00308] In Fig. 68 the patient's skin is indicated by a vertical line 305. Here, the energy receiver comprises an energy-transforming device 302 located inside the patient, preferably just beneath the patient's skin 305. Generally speaking, the implanted energy-transforming device 302 may be placed in the abdomen, thorax, muscle fascia (e.g. in the abdominal wall), subcutaneously, or at any other suitable location. The implanted energy-transforming device 302 is adapted to receive wireless energy E transmitted from the external energy-source 304a provided in an external energy-transmission device 304 located outside the patient's skin 305 in the vicinity of the implanted energy-transforming device 302.

[00309] As is well known in the art, the wireless energy E may generally be transferred by means of any suitable Transcutaneous Energy Transfer (TET) device, such as a device including a primary coil arranged in the external energy source 304a and an adjacent secondary coil arranged in the implanted energy-transforming device 302. When an electric current is fed through the primary coil, energy in the form of a voltage is induced in the secondary coil which can be used to power the implanted energy consuming components of the apparatus, e.g. after storing the incoming energy in an implanted energy source, such as a rechargeable battery or a capacitor. However, the present invention is generally not limited to any particular energy transfer technique, TET devices or energy sources, and any kind of wireless energy may be used.
[00310] The amount of energy received by the implanted energy receiver may be compared with the energy used by the implanted components of the apparatus. The term "energy used" is then understood to include also energy stored by implanted components of the apparatus. A control device includes an external control unit 304b that controls the external energy source 304a based on the determined energy balance to regulate the amount of transferred energy. In order to transfer the correct amount of energy, the energy balance and the required amount of energy is determined by means of a determination device including an implanted internal control unit 315 connected to the apparatus 301. The internal control unit 315 may thus be arranged to receive various measurements obtained by suitable sensors or the like, not shown, measuring certain characteristics of the apparatus 301, somehow reflecting the required amount of energy needed for proper operation of the apparatus 301. Moreover, the current condition of the patient may also be detected by means of suitable measuring devices or sensors, in order to provide parameters reflecting the patient's condition. Hence, such characteristics and/or parameters may be related to the current state of the apparatus 301, such as power consumption, operational mode and temperature, as well as the patient's condition reflected by parameters such as; body temperature, blood pressure, heartbeats and breathing. Other kinds of physical parameters of the patient and functional parameters of the device are described elsewhere.

[00311] Furthermore, an energy source in the form of an accumulator 316 may optionally be connected to the implanted energy-transforming device 302 for accumulating received energy for later use by the apparatus 301. Alternatively or additionally, characteristics of such an accumulator, also reflecting the required amount of energy, may be measured as well. The accumulator may be replaced by a rechargeable battery, and the measured characteristics may be related to the current state of the battery, any electrical parameter such as energy consumption voltage, temperature, etc. In order to provide sufficient voltage and current to the apparatus 301, and also to avoid excessive heating, it is clearly understood that the battery should be charged optimally by receiving a correct amount of energy from the implanted energy-transforming device 302, i.e. not too little or too much. The accumulator may also be a capacitor with corresponding characteristics.
For example, battery characteristics may be measured on a regular basis to determine the current state of the battery, which then may be stored as state information in a suitable storage means in the internal control unit 315. Thus, whenever new measurements are made, the stored battery state information can be updated accordingly. In this way, the state of the battery can be "calibrated" by transferring a correct amount of energy, so as to maintain the battery in an optimal condition.

Thus, the internal control unit 315 of the determination device is adapted to determine the energy balance and/or the currently required amount of energy, (either energy per time unit or accumulated energy) based on measurements made by the above-mentioned sensors or measuring devices of the apparatus 301, or the patient, or an implanted energy source if used, or any combination thereof. The internal control unit 315 is further connected to an internal signal transmitter 327, arranged to transmit a control signal reflecting the determined required amount of energy, to an external signal receiver 304c connected to the external control unit 304b. The amount of energy transmitted from the external energy source 304a may then be regulated in response to the received control signal.

Alternatively, the determination device may include the external control unit 304b. In this alternative, sensor measurements can be transmitted directly to the external control unit 304b wherein the energy balance and/or the currently required amount of energy can be determined by the external control unit 304b, thus integrating the above-described function of the internal control unit 315 in the external control unit 304b. In that case, the internal control unit 315 can be omitted and the sensor measurements are supplied directly to the internal signal transmitter 327 which sends the measurements over to the external signal receiver 304c and the external control unit 304b. The energy balance and the currently required amount of energy can then be determined by the external control unit 304b based on those sensor measurements.

Hence, the present solution according to the arrangement of Fig. 68 employs the feedback of information indicating the required energy, which is more efficient than previous solutions because it is based on the actual use of energy that is compared to the received energy, e.g. with respect to the amount of energy, the
energy difference, or the energy receiving rate as compared to the energy rate used by implanted energy consuming components of the apparatus. The apparatus may use the received energy either for consuming or for storing the energy in an implanted energy source or the like. The different parameters discussed above would thus be used if relevant and needed and then as a tool for determining the actual energy balance. However, such parameters may also be needed per se for any actions taken internally to specifically operate the apparatus.

[00316] The internal signal transmitter 327 and the external signal receiver 304c may be implemented as separate units using suitable signal transfer means, such as radio, IR (Infrared) or ultrasonic signals. Alternatively, the internal signal transmitter 327 and the external signal receiver 304c may be integrated in the implanted energy-transforming device 302 and the external energy source 304a, respectively, so as to convey control signals in a reverse direction relative to the energy transfer, basically using the same transmission technique. The control signals may be modulated with respect to frequency, phase or amplitude.

[00317] Thus, the feedback information may be transferred either by a separate communication system including receivers and transmitters or may be integrated in the energy system. In accordance with the present invention, such an integrated information feedback and energy system comprises an implantable internal energy receiver for receiving wireless energy, the energy receiver having an internal first coil and a first electronic circuit connected to the first coil, and an external energy transmitter for transmitting wireless energy, the energy transmitter having an external second coil and a second electronic circuit connected to the second coil. The external second coil of the energy transmitter transmits wireless energy which is received by the first coil of the energy receiver. This system further comprises a power switch for switching the connection of the internal first coil to the first electronic circuit on and off, such that feedback information related to the charging of the first coil is received by the external energy transmitter in the form of an impedance variation in the load of the external second coil, when the power switch switches the connection of the internal first coil to the first electronic circuit on and off. In implementing this system in the arrangement of Fig. 68, the switch 326 is either separate and controlled by the internal control unit 315, or integrated in the
internal control unit 315. It should be understood that the switch 326 should be interpreted in its broadest embodiment. This means a transistor, MCU, MCPU, ASIC FPGA or a DA converter or any other electronic component or circuit that may switch the power on and off.

[00318] To conclude, the energy supply arrangement illustrated in Fig. 68 may operate basically in the following manner. The energy balance is first determined by the internal control unit 315 of the determination device. A control signal reflecting the required amount of energy is also created by the internal control unit 315, and the control signal is transmitted from the internal signal transmitter 327 to the external signal receiver 304c. Alternatively, the energy balance can be determined by the external control unit 304b instead depending on the implementation, as mentioned above. In that case, the control signal may carry measurement results from various sensors. The amount of energy emitted from the external energy source 304a can then be regulated by the external control unit 304b, based on the determined energy balance, e.g. in response to the received control signal. This process may be repeated intermittently at certain intervals during ongoing energy transfer, or may be executed on a more or less continuous basis during the energy transfer.

[00319] The amount of transferred energy can generally be regulated by adjusting various transmission parameters in the external energy source 304a, such as voltage, current, amplitude, wave frequency and pulse characteristics.

[00320] This system may also be used to obtain information about the coupling factors between the coils in a TET system even to calibrate the system both to find an optimal place for the external coil in relation to the internal coil and to optimize energy transfer. Simply comparing in this case the amount of energy transferred with the amount of energy received. For example if the external coil is moved the coupling factor may vary and correctly displayed movements could cause the external coil to find the optimal place for energy transfer. Preferably, the external coil is adapted to calibrate the amount of transferred energy to achieve the feedback information in the determination device, before the coupling factor is maximized.
This coupling factors information may also be used as a feedback during energy transfer. In such a case, the energy system of the present invention comprises an implantable internal energy receiver for receiving wireless energy, the energy receiver having an internal first coil and a first electronic circuit connected to the first coil, and an external energy transmitter for transmitting wireless energy, the energy transmitter having an external second coil and a second electronic circuit connected to the second coil. The external second coil of the energy transmitter transmits wireless energy which is received by the first coil of the energy receiver. This system further comprises a feedback device for communicating out the amount of energy received in the first coil as a feedback information, and wherein the second electronic circuit includes a determination device for receiving the feedback information and for comparing the amount of transferred energy by the second coil with the feedback information related to the amount of energy received in the first coil to obtain the coupling factors between the first and second coils. The transmitted energy may be regulated depending on the obtained coupling factor.

With reference to Fig. 69, although wireless transfer of energy for operating the apparatus has been described above to enable non-invasive operation, it will be appreciated that the apparatus can be operated with wire bound energy as well. Such an example is shown in Fig. 69, wherein an external switch 326 is interconnected between the external energy source 304a and an operation device, such as an electric motor 307 operating the apparatus 301. An external control unit 304b controls the operation of the external switch 326 to effect proper operation of the apparatus 301.

Fig. 70 illustrates different embodiments for how received energy can be supplied to and used by the apparatus 301. Similar to the example of Fig. 68, an internal energy receiver 302 receives wireless energy E from an external energy source 304a which is controlled by a transmission control unit 304b. The internal energy receiver 302 may comprise a constant voltage circuit, indicated as a dashed box "constant V" in the figure, for supplying energy at constant voltage to the apparatus 301. The internal energy receiver 302 may further comprise a constant current circuit, indicated as a dashed box "constant C" in the figure, for supplying energy at constant current to the apparatus 301.
[00324] The apparatus 301 comprises an energy consuming part 301a, which may be a motor, pump, restriction device, or any other medical appliance that requires energy for its electrical operation. The apparatus 301 may further comprise an energy storage device 301b for storing energy supplied from the internal energy receiver 302. Thus, the supplied energy may be directly consumed by the energy consuming part 301a, or stored by the energy storage device 301b, or the supplied energy may be partly consumed and partly stored. The apparatus 301 may further comprise an energy stabilizing unit 301c for stabilizing the energy supplied from the internal energy receiver 302. Thus, the energy may be supplied in a fluctuating manner such that it may be necessary to stabilize the energy before consumed or stored.

[00325] The energy supplied from the internal energy receiver 302 may further be accumulated and/or stabilized by a separate energy stabilizing unit 328 located outside the apparatus 301, before being consumed and/or stored by the apparatus 301. Alternatively, the energy stabilizing unit 328 may be integrated in the internal energy receiver 302. In either case, the energy stabilizing unit 328 may comprise a constant voltage circuit and/or a constant current circuit.

[00326] It should be noted that Fig. 68 and Fig. 70 illustrate some possible but non-limiting implementation options regarding how the various shown functional components and elements can be arranged and connected to each other. However, the skilled person will readily appreciate that many variations and modifications can be made within the scope of the present invention.

[00327] Fig. 71 schematically shows an energy balance measuring circuit of one of the proposed designs of the system for controlling transmission of wireless energy, or energy balance control system. The circuit has an output signal centered on 2.5V and proportionally related to the energy imbalance. The derivative of this signal shows if the value goes up and down and how fast such change takes place. If the amount of received energy is lower than the energy used by the implant, more energy is transferred and thus charged into the energy source. The output signal from the circuit is typically feed to an A/D converter and converted into a digital format. The digital information can then be sent to the external energy-transmission device allowing it to adjust the level of the transmitted energy. Another possibility is
to have a completely analog system that uses comparators comparing the energy balance level with certain maximum and minimum thresholds sending information to external energy-transmission device if the balance drifts out of the max/min window.

[00328] The schematic Fig. 7.1 shows a circuit implementation for a system that transfers energy to the implanted energy components of the apparatus of the present invention from outside of the patient's body using inductive energy transfer. An inductive energy transfer system typically uses an external transmitting coil and an internal receiving coil. The receiving coil, L1, is included in the schematic Fig. 7.1; the transmitting parts of the system are excluded.

[00329] The implementation of the general concept of energy balance and the way the information is transmitted to the external energy transmitter can of course be implemented in numerous different ways. The schematic Fig. 7.1 and the above described method of evaluating and transmitting the information should only be regarded as examples of how to implement the control system.

[00330] CIRCUIT DETAILS

[00331] In Fig. 7.1 the symbols Y1, Y2, Y3 and so on symbolize test points within the circuit. The components in the diagram and their respective values are values that work in this particular implementation which of course is only one of an infinite number of possible design solutions.

[00332] Energy to power the circuit is received by the energy receiving coil L1. Energy to implanted components is transmitted in this particular case at a frequency of 25 kHz. The energy balance output signal is present at test point Y1.

[00333] Those skilled in the art will realize that the above various embodiments of the system could be combined in many different ways. For example, the electric switch 306 of Fig. 55 could be incorporated in any of the embodiments of Figs. 57-63, the hydraulic valve shifting device 314 of Fig. 57 could be incorporated in the embodiment of Fig. 56B, and the gear box 324 could be incorporated in the embodiment of Fig. 56A. Please observe that the switch simply could mean any electronic circuit or component.

[00334] The embodiments described in connection with Figs. 68, 70 and 71 identify a method and a system for controlling transmission of wireless energy to implanted energy consuming components of an electrically operable apparatus. Such a method and system will be defined in general terms in the following.

[00335] A method is thus provided for controlling transmission of wireless energy supplied to implanted energy consuming components of the apparatus as described above. The wireless energy E is transmitted from an external energy source located
outside the patient and is received by an internal energy receiver located inside the patient, the internal energy receiver being connected to the implanted energy consuming components of the apparatus for directly or indirectly supplying received energy thereto. An energy balance is determined between the energy received by the internal energy receiver and the energy used for the apparatus. The transmission of wireless energy \( E \) from the external energy source is then controlled based on the determined energy balance.

[00336] The wireless energy may be transmitted inductively from a primary coil in the external energy source to a secondary coil in the internal energy receiver. A change in the energy balance may be detected to control the transmission of wireless energy based on the detected energy balance change. A difference may also be detected between energy received by the internal energy receiver and energy used for the medical device, to control the transmission of wireless energy based on the detected energy difference.

[00337] When controlling the energy transmission, the amount of transmitted wireless energy may be decreased if the detected energy balance change implies that the energy balance is increasing, or vice versa. The decrease/increase of energy transmission may further correspond to a detected change rate.

[00338] The amount of transmitted wireless energy may further be decreased if the detected energy difference implies that the received energy is greater than the used energy, or vice versa. The decrease/increase of energy transmission may then correspond to the magnitude of the detected energy difference.

[00339] As mentioned above, the energy used for the medical device may be consumed to operate the medical device, and/or stored in at least one energy storage device of the medical device.

[00340] When electrical and/or physical parameters of the medical device and/or physical parameters of the patient are determined, the energy may be transmitted for consumption and storage according to a transmission rate per time unit which is determined based on said parameters. The total amount of transmitted energy may also be determined based on said parameters.

[00341] When a difference is detected between the total amount of energy received by the internal energy receiver and the total amount of consumed and/or stored energy, and the detected difference is related to the integral over time of at least one measured electrical parameter related to said energy balance, the integral may be determined for a monitored voltage and/or current related to the energy balance.

[00342] When the derivative is determined over time of a measured electrical parameter related to the amount of consumed and/or stored energy, the derivative may be determined for a monitored voltage and/or current related to the energy balance.

[00343] The transmission of wireless energy from the external energy source may be controlled by applying to the external energy source electrical pulses from a first electric circuit to transmit the wireless energy, the electrical pulses having leading and trailing edges, varying the lengths of first time intervals between successive
leading and trailing edges of the electrical pulses and/or the lengths of second time intervals between successive trailing and leading edges of the electrical pulses, and transmitting wireless energy, the transmitted energy generated from the electrical pulses having a varied power, the varying of the power depending on the lengths of the first and/or second time intervals.

[00344] In that case, the frequency of the electrical pulses may be substantially constant when varying the first and/or second time intervals. When applying electrical pulses, the electrical pulses may remain unchanged, except for varying the first and/or second time intervals. The amplitude of the electrical pulses may be substantially constant when varying the first and/or second time intervals. Further, the electrical pulses may be varied by only varying the lengths of first time intervals between successive leading and trailing edges of the electrical pulses.

[00345] A train of two or more electrical pulses may be supplied in a row, wherein when applying the train of pulses, the train having a first electrical pulse at the start of the pulse train and having a second electrical pulse at the end of the pulse train, two or more pulse trains may be supplied in a row, wherein the lengths of the second time intervals between successive trailing edge of the second electrical pulse in a first pulse train and leading edge of the first electrical pulse of a second pulse train are varied.

[00346] When applying the electrical pulses, the electrical pulses may have a substantially constant current and a substantially constant voltage. The electrical pulses may also have a substantially constant current and a substantially constant voltage. Further, the electrical pulses may also have a substantially constant frequency. The electrical pulses within a pulse train may likewise have a substantially constant frequency.

[00347] The circuit formed by the first electric circuit and the external energy source may have a first characteristic time period or first time constant, and when effectively varying the transmitted energy, such frequency time period may be in the range of the first characteristic time period or time constant or shorter.

[00348] A system comprising an apparatus as described above is thus also provided for controlling transmission of wireless energy supplied to implanted energy consuming components of the apparatus. In its broadest sense, the system comprises a control device for controlling the transmission of wireless energy from an energy-transmission device, and an implantable internal energy receiver for receiving the transmitted wireless energy, the internal energy receiver being connected to implantable energy consuming components of the apparatus for directly or indirectly supplying received energy thereto. The system further comprises a determination device adapted to determine an energy balance between the energy received by the internal energy receiver and the energy used for the implantable energy consuming components of the apparatus, wherein the control device controls the transmission of wireless energy from the external energy-transmission device, based on the energy balance determined by the determination device.

[00349]

[00350] Further, the system may comprise any of the following:
[00351] - A primary coil in the external energy source adapted to transmit the wireless energy inductively to a secondary coil in the internal energy receiver.

[00352] - The determination device is adapted to detect a change in the energy balance, and the control device controls the transmission of wireless energy based on the detected energy balance change.

[00353] - The determination device is adapted to detect a difference between energy received by the internal energy receiver and energy used for the implantable energy consuming components of the apparatus, and the control device controls the transmission of wireless energy based on the detected energy difference.

[00354] - The control device controls the external energy-transmission device to decrease the amount of transmitted wireless energy if the detected energy balance change implies that the energy balance is increasing, or vice versa, wherein the decrease/increase of energy transmission corresponds to a detected change rate.

[00355] - The control device controls the external energy-transmission device to decrease the amount of transmitted wireless energy if the detected energy difference implies that the received energy is greater than the used energy, or vice versa, wherein the decrease/increase of energy transmission corresponds to the magnitude of said detected energy difference.

[00356] - The energy used for the apparatus is consumed to operate the apparatus, and/or stored in at least one energy storage device of the apparatus.

[00357] - Where electrical and/or physical parameters of the apparatus and/or physical parameters of the patient are determined, the energy-transmission device transmits the energy for consumption and storage according to a transmission rate per time unit which is determined by the determination device based on said parameters. The determination device also determines the total amount of transmitted energy based on said parameters.

[00358] - When a difference is detected between the total amount of energy received by the internal energy receiver and the total amount of consumed and/or stored energy, and the detected difference is related to the integral over time of at least one measured electrical parameter related to the energy balance, the determination device determines the integral for a monitored voltage and/or current related to the energy balance.

[00359] - When the derivative is determined over time of a measured electrical parameter related to the amount of consumed and/or stored energy, the determination device determines the derivative for a monitored voltage and/or current related to the energy balance.

[00360] - The energy-transmission device comprises a coil placed externally to the human body, and an electric circuit is provided to power the external coil with electrical pulses to transmit the wireless energy. The electrical pulses have leading and trailing edges, and the electric circuit is adapted to vary first time intervals between successive leading and trailing edges and/or second time intervals between successive trailing and leading edges of the electrical pulses to vary the power of the
transmitted wireless energy. As a result, the energy receiver receiving the transmitted wireless energy has a varied power.

[00361] - The electric circuit is adapted to deliver the electrical pulses to remain unchanged except varying the first and/or second time intervals.

[00362] - The electric circuit has a time constant and is adapted to vary the first and second time intervals only in the range of the first time constant, so that when the lengths of the first and/or second time intervals are varied, the transmitted power over the coil is varied.

[00363] - The electric circuit is adapted to deliver the electrical pulses to be varied by only varying the lengths of first time intervals between successive leading and trailing edges of the electrical pulses.

[00364] - The electric circuit is adapted to supplying a train of two or more electrical pulses in a row, said train having a first electrical pulse at the start of the pulse train and having a second electrical pulse at the end of the pulse train, and

[00365] - the lengths of the second time intervals between successive trailing edge of the second electrical pulse in a first pulse train and leading edge of the first electrical pulse of a second pulse train are varied by the first electronic circuit.

[00366] - The electric circuit is adapted to provide the electrical pulses as pulses having a substantially constant height and/or amplitude and/or intensity and/or voltage and/or current and/or frequency.

[00367] - The electric circuit has a time constant, and is adapted to vary the first and second time intervals only in the range of the first time constant, so that when the lengths of the first and/or second time intervals are varied, the transmitted power over the first coil are varied.

[00368] - The electric circuit is adapted to provide the electrical pulses varying the lengths of the first and/or the second time intervals only within a range that includes the first time constant or that is located relatively close to the first time constant, compared to the magnitude of the first time constant.

[00369] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.
WHAT IS CLAIMED IS:

1. A method for treating an aneurysmic bulge in a blood vessel in a human or mammal patient, the method comprising:
   a) gently constricting at least one portion of the tissue wall of a blood vessel extending along the aneurysm, to constrict the bulge of the blood vessel caused by the aneurysm, and
   b) stimulating said wall portion to cause contraction of the wall portion to further influence the bulge, increasing the tonus of the wall portion, to prevent expansion of the bulge of the blood vessel.

2. The method according to claim 1, wherein the wall portion is constricted, so that the wall portion at least is constricted and the constricted wall portion is stimulated to at least further contract the wall portion, to strengthen the blood vessel tissue wall, to prevent expansion of the bulge of the blood vessel.

3. The method according to claim 2, wherein the wall portion is constricted to a constricted state, in which the blood circulation in the constricted wall portion is substantially unrestricted and the aneurysm is at least restricted, and the constricted wall portion is stimulated when it is in the constricted state to at least further restrict the bulge of the aneurysm.

4. The method according to claim 1, wherein the wall portion is stimulated while the constriction of the wall portion is changed.

5. The method according to claim 1, wherein the constriction of the wall portion is calibrated by stimulating the wall portion while adjusting the constriction of the wall portion until the desired restriction of the aneurysm is obtained.

6. The method according to claim 1, wherein step (b) is not performed while step (a) is performed.

7. The method according to claim 2, wherein step (a) is performed by constricting the wall portion, so that the bulge of the aneurysm is restricted, and step (b) is performed by stimulating the constricted wall portion to cause contraction thereof, so that the aneurysm is further restricted.
8. The method according to claim 7, further comprising sensing a physical parameter of the patient or and adjusting the intensity of the stimulation of the wall portion in response to the sensed parameter.

9. The method according to claim 7, further comprising (c) ceasing stimulating the wall portion to decrease the contraction of the aneurysm.

10. The method according to claim 9, further comprising (d) releasing the wall portion to restore the restriction.

11. The method according to claim 2, wherein step (a) is performed by constricting the wall portion, so that the flow in the lumen is slightly restricted, and step (b) is performed by stimulating the constricted wall portion to cause contraction thereof to strengthen the tonus of the wall portion still slightly restricted.

12. The method according to claim 11, further comprising (c) ceasing stimulating the wall portion.

13. The method according to claim 12, further comprising (d) releasing the wall portion to restore the aneurysm.

14. The method according to claim 11, further comprising sensing a physical parameter of the patient and adjusting the intensity of the stimulation of the wall portion in response to the sensed parameter.

15. The method according to claim 14, wherein the intensity of the stimulation of the wall portion is increased so that the bulge expansion is hold back when a pressure increase occurs in the lumen.

16. The method according to claim 15, further comprising sensing a physical parameter of the patient's that relates to the pressure in the lumen, and controlling the stimulation of the wall portion in response to the sensed parameter.

17. The method according to claim 16, wherein the physical parameter is a pressure in the patient's blood vessel.

18. The method according to claim 2, wherein step (a) is performed by constricting the wall portion, to hold back expansion of the blood vessel bulge with a predetermined pressure and step (b) is performed by stimulating the constricted wall portion to cause contraction to further hold back expansion of the blood vessel.
19. The method according to claim 18, further comprising (c) ceasing stimulating the wall portion.

20. The method according to claim 19, further comprising (d) releasing the wall portion to restore the blood vessel.

21. The method according to claim 18, further comprising sensing a physical parameter of the patient and adjusting the intensity of the stimulation of the wall portion in response to the sensed parameter.

22. The method according to claim 21, wherein the intensity of the stimulation of the wall portion is increased so that the bulge expansion is withhold when a pressure increase occurs in the lumen.

23. The method according to claim 22, further comprising sensing a physical parameter of the patient's that relates to the pressure in the lumen, and controlling the stimulation of the wall portion in response to the sensed parameter.

24. The method according to claim 23, wherein the physical parameter is a pressure in the patient's body.

25. The method according to claim 1, wherein step (a) is performed by constricting the wall portion, so that the tonus in the bulge is increased.

26. The method according to claim 25, further comprising (d) releasing the wall portion to restore the blood vessel.

27. The method according to claim 25, wherein step (b) is performed by stimulating the constricted wall portion to cause contraction thereof, so that the flow in the bulge expansion remains stopped when a pressure increase occurs in the lumen.

28. The method according to claim 27, further comprising sensing a physical parameter of the patient's that relates to the pressure in the lumen, and controlling the stimulation of the wall portion in response to the sensed parameter.

29. The method according to claim 28, wherein the physical parameter is a pressure in the patient's body.

30. The method according to claim 1, wherein steps (a) and (b) are operated to hold back the expansion of the aneurysm.
31. The method according to claim 30, wherein step (a) is performed by constricting the wall portion to slightly restrict the wall portion, and step (b) is performed by progressively stimulating the constricted wall portion to cause progressive contraction of the wall portion to strengthen the bulge.

32. The method according to claim 31, wherein the constricted wall portion is progressively stimulated in the downstream or upstream direction of the lumen.

33. The method according to claim 30, wherein step (a) is performed by constricting the wall portion to slightly restrict the wall portion, and step (b) is performed by stimulating the constricted wall portion varying the intensity.

34. The method according to claim 30, wherein step (a) is performed by varyingly constricting the wall portion to vary the restriction of the bulge, and step (b) is performed by progressively stimulating the constricted wall portion to cause progressive contraction of the wall portion to strengthen the bulge.

35. The method according to claim 34, wherein the constricted wall portion is progressively stimulated in the downstream or upstream direction of the lumen.

36. The method according to claim 30, wherein step (a) is performed by varyingly constricting different areas of the wall portion to cause progressive constriction of the wall portion in the downstream or upstream direction of the lumen.

37. The method according to claim 36, wherein the constricted wall portion is progressively stimulated to cause progressive contraction thereof in harmony with the progressive constriction of the wall portion.

38. The method according to claim 36, further comprising providing at least one elongated constriction element extending along the wall portion, and controlling the elongated constriction element to progressively constrict the wall portion in the downstream or upstream direction of the lumen.

39. The method according to claim 38, wherein the elongated constriction element comprises contact surfaces dimensioned to contact a length of the wall portion, further comprising providing a plurality of stimulation elements distributed along the contact surfaces, and controlling the stimulation elements to stimulate the different areas of the wall portion along the length of the wall portion.
40. The method according to claim 30, wherein step (a) is performed by constricting any one of a series of wall portions of the tissue wall to at least restrict the bulge, and step (b) is performed by stimulating the constricted wall portion, further comprising successively constricting the wall portions of the series of wall portions to strengthen the bulge in a peristaltic manner.

41. The method according to claim 40, further comprising providing at least one constriction element and at least one stimulation element positioned on the constriction element, moving the constriction element along the blood vessel to successively constrict the wall portions of the series of wall portions, and using the stimulation element to stimulate the wall portion constricted by the constriction element to close the lumen.

42. The method according to claim 41, further comprising cyclically moving the constriction element along the wall portions of the series of wall portions.

43. The method according to claim 40, further comprising providing a plurality of constriction elements and stimulation elements positioned on the constriction elements, moving each constriction element along the blood vessel to successively constrict the wall portions of the series of wall portions, and using the stimulation elements to stimulate the wall portion constricted by any one of the constriction elements to withhold any expansion of the bulge.

44. The method according to claim 43, further comprising cyclically moving the constriction elements one after the other along the wall portions of the series of wall portions.

45. The method according to claim 44, further comprising providing a rotor carrying the constriction elements, and rotating the rotor so that each constriction element cyclically constricts the wall portions of the series of wall portions.

46. The method according to claim 45, wherein each constriction element comprises a roller that rolls on the blood vessel to constrict the latter.

47. The method according to claim 30, wherein step (a) is performed by constricting the wall portion at an upstream or downstream end thereof to close the lumen, further comprising (c) constricting the wall portion between the upstream and downstream ends thereof, to prevent ant up- or down stream expansion of the aneurysmic bulge of the blood vessel.
48. The method according to claim 47, further comprising stimulating the wall portion between the upstream and downstream ends thereof, as step (c) is performed.

49. The method according to claim 47, wherein step (a) is performed by constricting the wall portion at the upstream end thereof to slightly restrict the lumen, and step (b) is performed by stimulating the constricted wall portion at the upstream end to further constrict the wall portion.

50. The method according to claim 47, wherein step (a) is performed by constricting the wall portion at the downstream end thereof to slightly restrict the lumen, and step (b) is performed by stimulating the constricted wall portion at the downstream end to further constrict the wall portion.

51. The method according to claim 30, wherein step (b) is performed by stimulating the wall portion with electric pulses.

52. The method according to claim 1, further comprising controlling the constriction and/or stimulation of the wall portion from outside the patient's body.

53. The method according to claim 52, further comprising controlling by the patient the constriction and/or stimulation of the wall portion.

54. The method according to claim 1, further comprising sensing a physical parameter of the patient and controlling the constriction and/or stimulation of the wall portion in response to the sensed parameter.

55. The method according to claim 54, further comprising automatically controlling the constriction and/or stimulation of the wall portion in response to the sensed parameter.

56. The method according to claim 1, further comprising providing a constriction device that constricts the wall portion, a stimulation device that stimulates the constricted wall portion and a control device that controls the constriction device and/or stimulation device.

57. The method according to claim 56, further comprising operating the control device from outside the patient's body.

58. The method according to claim 57, further comprising operating the control device by the patient.
59. The method according to claim 58, wherein the control device comprises a manually operable switch for switching on and off the constriction device and/or stimulation device, further comprising subcutaneously implanting the switch in the patient and manually operating the implanted switch from outside the patient's body.

60. The method according to claim 58, wherein the control device comprises a hand-held wireless remote control that is operated by the patient.

61. The method according to claim 57, further comprising using the control device to wirelessly control the constriction device and/or stimulation device.

62. The method according to claim 61, further comprising wirelessly controlling the constriction device and/or stimulation device in a non-magnetic manner.

63. The method according to claim 1, wherein step (b) is performed by intermittently and individually stimulating different areas of the wall portion so that at least two of the areas are stimulated at different points of time.

64. The method according to claim 63, wherein step (b) is performed by intermittently stimulating each area of the different areas of the wall portion during successive time periods, each time period being short enough to maintain over time satisfactory blood circulation in the area until the laps of the time period.

65. The method according to claim 64, wherein step (b) is performed by intermittently stimulating the areas of the wall portion so that an area of the wall portion that currently is not stimulated has time to restore substantially normal blood circulation before it is stimulated again.

66. The method according to claim 1, wherein step (b) is performed by stimulating one or more of different areas of the wall portion at a time.

67. The method according to claim 66, wherein step (b) is performed by sequentially stimulating the different areas of the wall portion.

68. The method according to claim 66, wherein step (b) is performed by shifting the stimulation from one area to another over time.

69. The method according to claim 66, wherein step (b) is performed by cyclically propagating the stimulation of the areas along the wall portion in the same or opposite direction of the flow in the patient's lumen.
70. The method according to claim 69, wherein step (b) is performed by propagating the stimulation of the areas in accordance with a determined stimulation pattern.

71. The method according to claim 1, wherein step (b) is performed by stimulating the wall portion with varying stimulation intensity.

72. The method according to claim 71, wherein step (b) is performed by stimulating the wall portion with cyclically varying stimulation intensity.

73. The method according to claim 1, wherein step (b) is performed by stimulating different areas of the wall portion with pulses.

74. The method according to claim 73, wherein step (b) is performed by intermittently and individually stimulating different areas of the wall portion with the pulses.

75. The method according to claim 73, wherein the pulses form pulse trains.

76. The method according to claim 75, wherein the pulse amplitudes of the pulses of the pulse trains are varied.

77. The method according to claim 75, wherein the off time periods between the individual pulses of each pulse train are varied.

78. The method according to claim 75, wherein the off time periods between the pulse trains are varied.

79. The method according to claim 75, wherein the width of each pulse of the pulse trains is varied.

80. The method according to claim 75, wherein the frequency of the pulses of the pulse trains is varied.

81. The method according to claim 75, wherein the off time periods between the pulse trains are varied.

82. The method according to claim 75, wherein each off time period between the pulse trains is kept long enough to restore substantially normal blood circulation in each area when the area is not stimulated during the off time periods.

83. The method according to claim 75, wherein the length of each pulse train is varied.
84. The method according to claim 75, wherein the frequency of the pulse trains is varied.

85. The method according to claim 75, wherein the number of pulses of each pulse train is varied.

86. The method according to claim 1, wherein step (b) is performed by electrically stimulating different areas of the wall portion.

87. The method according to claim 86, wherein step (b) is performed by stimulating the areas of the wall portion with electric pulses.

88. The method according to claim 87, wherein the wall portion includes muscle fibers, and step (b) is performed by stimulating the wall portion including the muscle fibers with the electric pulses.

89. The method according to claim 86, further comprising providing at least one electrical element engaging the wall portion.

90. The method according to claim 89, further comprising providing a plurality of electrical elements engaging the wall portion.

91. The method according to claim 90, further comprising placing the electrical elements in a fixed orientation relative to one another.

92. The method according to claim 91, further comprising providing a structure holding the electrical elements in the fixed orientation.

93. The method according to claim 92, wherein the electrical elements form an elongate pattern of electrical elements with two opposite short ends, further comprising applying the structure on the patient's blood vessel so that the elongate pattern of electrical elements extends along the wall portion of the blood vessel in the direction of the flow in the patient's lumen and the elements abut the respective areas of the wall portion.

94. The method according to claim 92, further comprising electrically energizing the electrical elements.

95. The method according to claim 94, wherein each electrical element is cyclically energized with electric pulses.
96. The method according to claim 95, wherein the electrical elements are energized so that a number or groups of the electrical elements are energized at the same time.

97. The method according to claim 95, wherein the electrical elements are energized one at a time in sequence or groups of the electrical elements are sequentially energized, either randomly or in accordance with a predetermined pattern.

98. The method according to claim 95, further comprising applying the electrical elements on the patient's blood vessel so that the electrical elements form an elongate pattern of electrical elements extending along the wall portion of the blood vessel in the direction of the flow in the patient's lumen and the elements abut the respective areas of the wall portion.

99. The method according to claim 95, wherein the electrical elements are successively energized along the elongate pattern of electrical elements.

100. The method according to claim 99, wherein the electrical elements are successively energized along the elongate pattern of electrical elements in a direction opposite to that of the flow in the patient's lumen.

101. The method according to claim 99, wherein the electrical elements are successively energized along the elongate pattern of electrical elements in the same direction as that of the flow in the patient's lumen.

102. The method according to claim 99, wherein the electrical elements are energized so that electrical elements currently energized form at least one group of adjacent energized electrical elements.

103. The method according to claim 102, wherein the elements in the group of energized electrical elements form a path of energized electrical elements.

104. The method according to claim 103, wherein the path of energized electrical elements extends at least in part around the patient's blood vessel.

105. The method according to claim 104, wherein the path of energized electrical elements extends completely around the patient's blood vessel.
106. The method according to claim 102, wherein the elements in the group of energized electrical elements form two paths of energized electrical elements extending opposite to each other.

107. The method according to claim 106, wherein the two paths of energized electrical elements extend on mutual sides of the patient's blood vessel and at least substantially transverse to the direction of flow in the patient's blood vessel.

108. The method according to claim 98, wherein the electrical elements are applied on the patient's blood vessel in a series of groups of elements extending along the patient's blood vessel in the direction of flow in the patient's lumen.

109. The method according to claim 108, wherein the groups of electrical elements in the series of groups are successively energized in a direction opposite to that of the flow in the patient's lumen.

110. The method according to claim 108, wherein the groups of electrical elements in the series of groups are successively energized in the same direction as that of the flow in the patient's lumen.

111. The method according to claim 108, wherein the electrical elements of each group of electrical elements form a path of elements extending at least in part around the patient's blood vessel.

112. The method according to claim 111, wherein the path of electrical elements of each group of elements extends completely around the patient's blood vessel.

113. The method according to claim 108, wherein the electrical elements of each group of electrical elements form two paths of elements extending on mutual sides of the patient's blood vessel.

114. The method according to claim 113, wherein the two paths of electrical elements of each group of elements extend at least substantially transverse to the direction of flow in the patient's lumen.

115. The method according to claim 1, wherein step (b) is performed by thermally stimulating the wall portion.

116. The method according to claim 115, wherein step (b) is performed by cooling the wall portion to cause contraction of the wall portion.
117. The method according to claim 116, wherein step (a) is performed to at least restrict the bulge of the blood vessel, and step (b) is performed by cooling the wall portion to cause further contraction of the wall portion.

118. The method according to claim 117, wherein step (b) is performed by cooling the wall portion to cause contraction of the wall portion, so that the flow in the lumen is at least further restricted.

119. The method according to claim 117, wherein step (b) is performed by cooling the wall portion to cause contraction thereof.

120. The method according to claim 116, further comprising heating the wall portion, when the wall portion is constricted and contracted, to cause expansion of the wall portion.

121. The method according to claim 116, wherein the wall portion includes a blood vessel and step (b) is performed by cooling the blood vessel to cause contraction thereof, or by heating the blood vessel to cause expansion thereof.

122. The method according to claim 1, further comprising providing a constriction device that constricts the wall portion, a stimulation device that stimulates the constricted wall portion and a control device that controls the constriction device and/or stimulation device.

123. The method according to claim 122, further comprising operating the control device by the patient to control the constriction device and/or stimulation device.

124. The method according to claim 123, wherein the control device comprises a hand-held wireless remote control that is operated by the patient.

125. The method according to claim 122, wherein the control device comprises an internal control unit, further comprising implanting in the patient the internal control unit and controlling by the internal control unit the constriction device and/or stimulation device.

126. The method according to claim 125, wherein the internal control unit is programmable.

127. The method according to claim 126, wherein the control device comprises an external control unit outside the patient's body, further comprising
controlling by the external control unit the constriction device and/or stimulation device.

128. The method according to claim 127, further comprising using the external control unit to program the implanted internal control unit.

129. The method according to claim 128, wherein the internal control unit is programmable for controlling the constriction device and/or stimulation device over time.

130. The method according to claim 128, further comprising controlling by the internal control unit the constriction device over time in accordance with an activity schedule program.

131. The method according to claim 126, wherein the internal control unit comprises a microprocessor.

132. The method according to claim 122, further comprising calibrating the constriction of the wall portion by controlling the stimulation device to stimulate the wall portion while controlling the constriction device to adjust the constriction of the wall portion until the desired restriction of the flow in the lumen is obtained.

133. The method according to claim 122, further comprising implanting at least one sensor and controlling by the control device the constriction device and/or stimulation device in response to signals from the sensor.

134. The method according to claim 133, wherein at least one physical parameter of the patient is directly or indirectly sensed by the sensor.

135. The method according to claim 133, further comprising implanting in the patient a medical implant, wherein at least one functional parameter of the medical implant is directly or indirectly sensed by the sensor.

136. The method according to claim 134, wherein the sensor comprises a pressure sensor that senses a pressure in the patient's body.

137. The method according to claim 136, further comprising controlling the constriction device by the control device to change the constriction of the patient's wall portion in response to the pressure sensor sensing a predetermined value.
138. The method according to claim 133, wherein the control device comprises an internal control unit, further comprising implanting in the patient the internal control unit and directly controlling by the internal control unit the constriction device and/or stimulation device in response to signals from the sensor.

139. The method according to claim 133, wherein the control device comprises an external control unit outside the patient's body, further comprising controlling by the external control unit the constriction device and/or stimulation device in response to signals from the sensor.

140. The method according to claim 133, wherein the control device produces an indication in response to signals from the sensor.

141. The method according to claim 140, wherein the indication comprises a sound signal or displayed information.

142. The method according to claim 1, wherein step (a) is performed by mechanically or hydraulically constricting the wall portion.

143. The method according to claim 142, wherein step (a) is performed by mechanically or hydraulically constricting the wall portion in a non-magnetic and/or non-manual manner.

144. The method according to claim 142, wherein step (a) is performed by constricting the wall portion so that the through-flow area of the lumen assumes a size in the constricted state minimally affecting the lumen when step (b) is performed.

145. The method according to claim 142, wherein step (a) is performed by bending the blood vessel.

146. The method according to claim 142, wherein step (a) is performed by clamping the blood vessel between at least two elements positioned on different sides of the blood vessel.

147. The method according to claim 142, wherein step (a) is performed by clamping the blood vessel between an element and the bone or tissue of the patient.

148. The method according to claim 142, wherein step (a) is performed by rotating at least two elements positioned on different sides of the blood vessel.
149. The method according to claim 142, wherein step (a) is performed by clamping the blood vessel between at least two articulated clamping elements positioned on different sides of the blood vessel.

150. The method according to claim 142, further comprising implanting in the patient a main reservoir containing a predetermined amount of hydraulic fluid and a constriction device engaging the wall portion and having an expandable cavity, wherein step (a) is performed by distributing hydraulic fluid from the main reservoir to increase the volume of the cavity to constrict the wall portion.

151. The method according to claim 150, wherein the main reservoir comprises first and second wall portions, and step (a) is performed by displacing the first and second wall portions towards each other to decrease the volume of the main reservoir, so that fluid is distributed from the main reservoir to the cavity.

152. The method according to claim 151, wherein at least one of a magnetic device, a hydraulic device or an electric control device displaces the first and second wall portions of the main reservoir toward each other.

153. The method according to claim 150, further comprising implanting a reverse servo that distributes hydraulic fluid from the main reservoir to the cavity.

154. The method according to claim 153, wherein the main reservoir comprises first and second wall portions, and the reverse servo displaces the first and second wall portions towards each other to decrease the volume of the main reservoir, so that fluid is distributed from the main reservoir to the cavity.

155. The method according to claim 154, wherein the reverse servo comprises an expandable servo reservoir containing servo fluid and having first and second wall portions, which are displaceable relative to each other in response to a change in the volume of the expandable servo reservoir, and the first and second wall portions of the servo reservoir are operatively connected to the first and second wall portions of the main reservoir, so that the volume of the main reservoir is changed when the volume of the servo reservoir is changed.

156. The method according to claim 155, further comprising dimensioning the servo and main reservoirs so that when the volume of the servo reservoir is changed by a relatively small amount of servo fluid, the volume of the main reservoir is changed by a relatively large amount of hydraulic fluid.
157. The method according to claim 155, wherein the first and second wall portions of the servo reservoir are displaced relative to each other by manual manipulation.

158. The method according to claim 155, wherein the first and second wall portions of the servo reservoir are displaced relative to each other by a magnetic device, a hydraulic device, or an electric control device.

159. The method according to claim 155, wherein the reverse servo comprises a fluid supply reservoir hydraulically connected to the servo reservoir to form a closed conduit system for the servo fluid.

160. The method according to claim 150, further comprising implanting in the patient a pump that pumps fluid between the main reservoir and the cavity.

161. The method according to claim 160, wherein the pump comprises a first activation member that activates the pump to pump fluid from the main reservoir to the cavity and a second activation member that activates the pump to pump fluid from the cavity to the main reservoir.

162. The method according to claim 161, wherein the first and second activation members are operated by manual manipulation thereof.

163. The method according to claim 161 wherein at least one of the activation members operates when subjected to an external predetermined pressure.

164. The method according to claim 161, wherein at least one of the first and second activating members are operated by magnetic means, hydraulic means, or electric control means.

165. The method according to claim 160, further comprising implanting a fluid conduit between the pump and the cavity, the main reservoir forming part of the conduit.

166. The method according to claim 165, wherein the conduit and pump is devoid of any non-return valve.
167. The method according to claim 166, wherein the main reservoir forms a fluid chamber with a variable volume, and step (a) is performed by reducing the volume of the chamber so that fluid is pumped from the chamber to the cavity.

168. The method according to claim 167, wherein the pump comprises a movable wall of the main reservoir for changing the volume of the chamber.

169. The method according to claim 168, further comprising implanting a motor for driving the pump.

170. The method according to claim 1, wherein step (a) is performed by using a constriction device and step (b) is performed by using a stimulation device, further comprising forming the constriction and stimulation devices in an operable constriction/stimulation unit.

171. The method according to claim 1, wherein step (a) is performed by using a constriction device and step (b) is performed by using a stimulation device further, comprising transmitting wireless energy from outside the patient's body to inside the patient's body and using the transmitted wireless energy in connection with the operation of the constriction/stimulation unit.

172. The method according to claim 171, further comprising directly using the wireless energy in connection with the operation of the constriction/stimulation unit as the wireless energy is being transmitted.

173. The method according to claim 172, wherein the wireless energy comprises an electric, an electromagnetic or a magnetic field, or a combination thereof, or electromagnetic waves.

174. The method according to claim 173, further comprising implanting in the patient an electric motor or pump operatively connected to the constriction device and directly powering the motor or pump by wireless energy in the form of a magnetic or an electromagnetic field.

175. The method according to claim 171, wherein the wireless energy comprises energy of a first form, further comprising transmitting the energy of the first form into energy of a second form and operating the constriction/stimulation unit with the energy of the second form.
176. The method according to claim 175, wherein the energy of the second form is different than the energy of the first form.

177. The method according to claim 175, wherein the energy of the second form comprises electric energy.

178. The method according to claim 175, wherein the constriction/stimulation unit is directly operated with the energy of the second form in a non-magnetic, non-thermal or non-mechanical manner.

179. The method according to claim 175, wherein the energy of the first form is directly or indirectly transformed into the energy of the second form.

180. The method according to claim 179, further comprising providing a motor for operating the constriction device and powering the motor with the energy of the second form.

181. The method according to claim 180, wherein the constriction device is operable to perform at least one reversible function, further comprising reversing the function by using the motor.

182. The method according to claim 180, further comprising shifting polarity of the energy of the second form to reverse the motor.

183. The method according to claim 180, further comprising directly powering the motor with the transformed energy of the second form, as the energy of the second form is being transformed from the energy of the first form.

184. The method according to claim 179, wherein the wireless energy of the first form comprises sound waves and the energy of the second form comprises electric energy.

185. The method according to claim 174, further comprising implanting in the patient a source of energy for storing the energy of the second form and supplying energy from the source of energy in connection with the operation of the constriction/stimulation unit.

186. The method according to claim 185, wherein the source of energy comprises an accumulator.
187. The method according to claim 186, wherein the accumulator comprises at least one capacitor or at least one rechargeable battery, or a combination of at least one capacitor and at least one rechargeable battery.

188. The method according to claim 175, further comprising implanting in the patient a source of energy for supplying energy for the operation of the constriction/stimulation unit and a switch for switching the energy supplied by the source of energy.

189. The method according to claim 188, further comprising using the energy of the second form to operate the switch to switch from an "off" mode, in which the source of energy is not in use, to an "on" mode, in which the source of energy supplies energy for the operation of the constriction/stimulation unit.

190. The method according to claim 175, further comprising implanting in the patient a stabilizer for stabilizing the energy of the second form.

191. The method according to claim 190, wherein the energy of the second form comprises electric current and the stabilizer comprises at least one capacitor.

192. The method according to claim 171, wherein the wireless energy is transmitted in at least one wireless signal.

193. The method according to claim 192, wherein the signal comprises a wave signal.

194. The method according to claim 193, wherein the wave signal comprises an electromagnetic wave signal including one of an infrared light signal, a visible light signal, an ultra violet light signal, a laser signal, a micro wave signal, a radio wave signal, an x-ray radiation signal, and a gamma radiation signal.

195. The method according to claim 193, wherein the wave signal comprises a sound or ultrasound wave signal.

196. The method according to claim 192, wherein the signal comprises a digital or analogue signal, or a combination of a digital and analogue signal.

197. The method according to claim 175, wherein the energy of the first form comprises an electric, an electromagnetic or a magnetic field, or a combination thereof.
198. The method according to claim 171, wherein the wireless energy comprises an electric, an electromagnetic or a magnetic field, or a combination thereof, further comprising transmitting the wireless energy in pulses or digital pulses, or a combination of pulses and digital pulses.

199. The method according to claim 175, wherein the energy of the first form is transformed into a direct current or pulsating direct current, or a combination of a direct current and pulsating direct current.

200. The method according to claim 175, wherein the energy of the first form is transformed into an alternating current or a combination of a direct and alternating current.

201. The method according to claim 175, wherein one of the energy of the first form and the energy of the second form comprises magnetic energy, kinetic energy, sound energy, chemical energy, radiant energy, electromagnetic energy, photo energy, nuclear energy or thermal energy.

202. The method according to claim 175, wherein one of the energy of the first form and the energy of the second form is non-magnetic, non-kinetic, non-chemical, non-sonic, non-nuclear or non-thermal.

203. The method according to claim 170, further comprising providing a control device that controls the constriction/stimulation unit.

204. The method according to claim 203, further comprising operating the control device by the patient.

205. The method according to claim 204, wherein the control device comprises a manually operable switch for switching on and off the constriction/stimulation unit, further comprising subcutaneously implanting the switch in the patient.

206. The method according to claim 204, wherein the control device comprises a hand-held wireless remote control operable by the patient, further comprising controlling the constriction/stimulation unit by the patient operating the remote control to adjust the stimulation intensity and/or adjust the constriction of the wall portion.

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207. The method according to claim 203, wherein the control device comprises a remote control that controls the constriction/stimulation unit from outside the patient's body.

208. The method according to claim 207, wherein the remote control comprises a wireless remote control.

209. The method according to claim 208, wherein the wireless remote control transmits at least one wireless control signal for controlling the constriction/stimulation unit.

210. The method according to claim 209, wherein the control signal comprises a frequency, amplitude, phase modulated signal or a combination thereof.

211. The method according to claim 209, wherein the control signal comprises an analogue or a digital signal, or a combination of an analogue and digital signal.

212. The method according to claim 209, wherein the wireless remote control transmits a carrier signal that carries the control signal.

213. The method according to claim 212, wherein the carrier signal comprises digital, analogue or a combination of digital and analogue signals.

214. The method according to claim 213, wherein the signals comprise wave signals.

215. The method according to claim 209, wherein the control signal comprises a wave signal comprising one of a sound wave signal, an ultrasound wave signal, an electromagnetic wave signal, an infrared light signal, a visible light signal, an ultraviolet light signal, a laser light signal, a micro wave signal, a radio wave signal, an x-ray radiation signal and a gamma radiation signal.

216. The method according to claim 209, wherein the control signal comprises an electric or magnetic field, or a combined electric and magnetic field.

217. The method according to claim 211, wherein the wireless remote control transmits an electromagnetic carrier wave signal that carries the digital or analogue control signal.

218. The method according to claim 170, further comprising implanting in the patient an operation device and operating the constriction/stimulation unit with the operation device.
219. The method according to claim 218, further comprising providing a magnet and activating the operation device with the magnet.

220. The method according to claim 219, wherein the magnet activates the operation device from outside the patient's body.

221. The method according to claim 218, wherein the operation device comprises a motor.

222. The method according to claim 221, further comprising providing a source of energy and powering the motor with energy released from the source of energy.

223. The method according to claim 170, further comprising implanting a source of energy, releasing energy from the source of energy and using the released energy in connection with the operation of the constriction/stimulation unit.

224. The method according to claim 223, wherein the source of energy comprises a battery.

225. The method for controlling an expansion of an aneurysmic bulge in a blood vessel, having a lumen formed by a tissue wall of a patient's blood vessel, the method comprising the steps of:

- inserting a needle like tube into a cavity of the patient's body,
- using the needle like tube to fill the cavity with gas thereby expanding the abdominal or thoraxial cavity,
- placing at least two laparoscopic trocars in the patient's body,
- inserting a camera through one of the trocars into the cavity,
- inserting a dissecting tool through any of the trocar and dissecting an area of at least one portion of the tissue wall of the aneurysmic bulge in the blood vessel,
- placing a constriction device and a stimulation device in the dissected area in operative engagement with the blood vessel,
- using the constriction device to gently constrict the wall portion of the blood vessel to constrict the bulge, and
- using the stimulation device to stimulate the constricted wall portion to cause contraction of the wall portion to further influence the tonus in the wall portion, thus preventing expansion of the bulge in the blood vessel.

226. The method according to claim 225, further comprising implanting a powered operation device for operating the constriction device.

227. The method according to claim 226, wherein the operation device comprises a powered hydraulic operation device.

228. The method according to claim 226, wherein the operation device comprises an electrically powered operation device.

229. The method according to claim 228, wherein the operation device comprises an electric motor.

230. The method according to claim 226, further comprising transmitting wireless energy for powering the operation device, and when desired to influence the flow in the patient's blood vessel, powering the operation device with the transmitted energy to operate the constriction device.

231. The method according to claim 225, further comprising implanting a source of energy in the patient, providing an external source of energy, controlling the external source of energy to release wireless energy, transforming the wireless energy into storable energy, non-invasively charging the implanted source of energy with the transformed energy, and controlling the implanted source of energy from outside the patient's body to release energy for use in connection with the operation of the constriction device and/or stimulation device.

232. The method according to claim 231, wherein the wireless energy is transformed into a storable energy different from the wireless energy.

233. The method according to claim 232, wherein the storable energy comprises electric energy.

234. The method according to claim 225, further comprising providing a source of energy outside the patient's body, controlling the external source of energy from outside the patient's body to release wireless energy, and using the released wireless energy for operating the constriction device and/or stimulation device.
235. The method according to claim 234, further comprising transforming the wireless energy into electrical energy inside the patient's body by an implanted energy-transforming device and using the electrical energy in connection with the operation of the constriction device and/or stimulation device.

236. The method according to claim 235, further comprising directly using the electrical energy in connection with the operation of the constriction device and/or stimulation device, as the transforming device transforms the wireless energy into the electrical energy.

237. The method according to claim 234, further comprising controlling the external source of energy from outside the patient's body to release non-magnetic wireless energy, and using the released non-magnetic wireless energy for operating the constriction device and/or stimulation device.

238. The method according to claim 234, further comprising controlling the external source of energy from outside the patient's body to release electromagnetic wireless energy, and using the released electromagnetic wireless energy for operating the constriction device and/or stimulation device.

239. The method for controlling expansion of a bulge in a blood vessel of a patient, the method comprising:
   a) gently constricting at least one portion of the tissue wall of the patient's blood vessel to constrict the bulge in the blood vessel, and
   b) stimulating the constricted tissue wall portion to cause contraction thereof to further prevent bulge expansion in the blood vessel.

240. The method for controlling an expansion of an aneurysmic bulge in a blood vessel having a lumen formed by a tissue wall of a patient's blood vessel, the method comprising the steps of:
   - inserting a needle like tube into a cavity of the patients body,
   - using the needle like tube to fill the cavity with gas thereby expanding the cavity,
   - placing at least two laparoscopical trocars in the patient's body,
   - inserting a camera through one of the trocars into the cavity,
- inserting a dissecting tool through any of the trocar and dissecting an area of at least one portion of the tissue wall of the blood vessel,

- placing a stimulation device in the dissected area in operative engagement with the blood vessel, and

- using the stimulation device to stimulate the wall portion to cause contraction of the wall portion, preventing expansion of the bulge in the blood vessel.

241. A method for controlling an expansion of an aneurysmic bulge in a blood vessel, having a lumen formed by a tissue wall of a patient's blood vessel, the method comprising the steps of:

- inserting a needle like tube into a cavity of the patient's body,

- using the needle like tube to fill the cavity with gas thereby expanding the cavity,

- placing at least two laparoscopical trocars in the patient's body,

- inserting a camera through one of the trocars into the cavity,

- inserting a dissecting tool through any of the trocar and dissecting an area of at least one portion of the tissue wall of the blood vessel,

- placing a constriction device in the dissected area in operative engagement with the blood vessel,

- using the constriction device to constrict the wall, preventing expansion of the bulge in the blood vessel.

242. The method for controlling an expansion of an aneurysmic bulge in a blood vessel, having a lumen formed by a tissue wall of a patient's blood vessel, the method comprising the steps of:

- cutting the skin of the patient,

- inserting a dissecting tool and dissecting an area of at least one portion of the tissue wall of the blood vessel,

- a constriction device and a stimulation device in the dissected area in operative engagement with the blood vessel,
- using the constriction device to gently constrict the wall portion of the blood vessel to influence the flow in the lumen, and

- using the stimulation device to stimulate the constricted wall portion, preventing expansion of the bulge in the blood vessel.

243. The method for controlling an expansion of an aneurysmic bulge in a blood vessel, having a lumen formed by a tissue wall of a patient’s blood vessel, the method comprising the steps of:

- cutting the skin of the patient,

- inserting a dissecting tool and dissecting an area of at least one portion of the tissue wall of the blood vessel,

- placing a stimulation device in the dissected area in operative engagement with the blood vessel, and

- using the stimulation device to stimulate the wall portion to cause contraction of the wall portion, preventing expansion of the bulge in the blood vessel.

244. The method for controlling an expansion of an aneurysmic bulge in a blood vessel, having a lumen formed by a tissue wall of a patient’s blood vessel, the method comprising the steps of:

- cutting the skin of the patient,

- inserting a dissecting tool and dissecting an area of at least one portion of the tissue wall of the blood vessel,

- placing a constriction device in the dissected area in operative engagement with the blood vessel, and

- using the constriction device to constrict the wall portion, preventing expansion of the bulge in the blood vessel.

245. The method according to any one of claim 242 - 244, wherein the cavity comprising; at least one of an abdominal cavity, a cavity in the pelvic region, a thoraxial cavity, a cavity in a limb, a cavity in human soft tissue such as muscle, fat and fibrotic tissue.
246. The method according to claim 1, wherein step (b) is performed by stimulating any constricted wall portions of a series of wall portions.

247. The method according to claim 246, wherein the wall portions of the series of wall portions are constricted by the stimulation device in random or in accordance with a predetermined sequence.

248. The method according to claim 247, further comprising constricting the wall portions of the series of wall portions at least two at a time at positions spaced apart on the organ to move the fluid and/or other bodily matter in the lumen of the patient's organ or to prevent the fluid and/or other bodily matter to move in the lumen of the patient's organ.

249. The method according to claim 248, wherein step (a) is performed by constricting all of the wall portions of the series of wall portions, and step (b) is performed by stimulating any constricted wall portions in random or in accordance with a predetermined sequence to close the organ's lumen.

250. The method according to claim 249, wherein the wall portions of the series of wall portions are further constricted by the stimulation device in random or in accordance with a predetermined sequence.

251. The method according to claim 250, further comprising constricting the wall portions of the series of wall portions at least two at a time at positions spaced apart on the organ.

252. The method according to claim 249, wherein the wall portions of the series of wall portions are successively further constricted by the stimulation device along the organ to move the fluid and/or other bodily matter in the lumen of the patient's organ or to prevent the fluid and/or other bodily matter to move in the lumen of the patient's organ.

253. The method according to claim 1, wherein step (a) and step (b) are performed independently of each other.

254. The method according to claim 1, wherein step (a) and step (b) are performed simultaneously.
255. A method according to claim 236, comprising an internal energy source, wherein said wireless energy is transmitted from an external energy source located outside the patient and is received by the internal energy source located inside the patient, the internal energy source being connected to at least one of the constriction and stimulation devices for directly or indirectly supplying received energy thereto, the method comprising the steps of:

- determining an energy balance between the energy received by the internal energy source and the energy used for at least one of the constriction and stimulation devices device, and

- controlling the transmission of wireless energy from the external energy source, based on the determined energy balance.

256. A method according to claim 255, wherein the wireless energy is transmitted inductively from a primary coil in the external energy source to a secondary coil in the internal energy receiver.

257. A method according to claim 255, wherein a change in said energy balance is detected, and the transmission of wireless energy is controlled based on said detected energy balance change.

258. A method according to claim 255, wherein a difference is detected between energy received by said internal energy receiver and energy used for the medical device, and the transmission of wireless energy is controlled based on said detected energy difference.

259. A method according to claim 257, wherein the amount of transmitted wireless energy is decreased if the detected energy balance change implies that the energy balance is increasing, or vice versa.

260. A method according to claim 259, wherein the decrease/increase of energy transmission corresponds to a detected change rate.

261. A method according to claim 258, wherein the amount of transmitted wireless energy is decreased if the detected energy difference implies that the received energy is greater than the used energy, or vice versa.
262. A method according to claim 261, wherein the decrease/increase of energy transmission corresponds to the magnitude of said detected energy difference.

263. A method according to claim 257, wherein the energy used for at least one of the constriction and stimulation devices is stored in at least one energy storage device of the device.

264. A method according to claim 257, wherein substantially all the energy used for at least one of the constriction and stimulation devices is consumed to operate the device.

265. A method according to claim 263, wherein the energy is consumed after being stabilised in at least one energy stabilising unit of the device.

266. A method according to claim 258, wherein the energy used for at least one of the constriction and stimulation devices is stored in at least one energy storage device of the device.

267. A method according to claim 258, wherein substantially all the energy used for at least one of the constriction and stimulation devices is consumed to operate the device.

268. A method according to claim 266 wherein the energy is consumed after being stabilised in at least one energy stabilising unit of the device.

269. A method according to claim 253, comprising providing an internal energy source located inside the patient connected to at least one of the constriction and stimulation devices for directly or indirectly supplying received energy thereto, determining an energy balance between the energy sent by the external energy source and the energy received by the internal energy source, and controlling the transmission of wireless energy from the external energy source, based on the determined energy balance.

270. The method according to claim 269, wherein the wireless energy is transmitted inductively from a primary coil in the external energy source to a secondary coil in the internal energy receiver.
271. The method according to claim 269, wherein a change in said energy balance is detected, and the transmission of wireless energy is controlled based on said detected energy balance change.

272. The method according to claim 269, wherein a difference is detected between the energy sent by the external energy source and the energy received by said internal energy receiver, and the transmission of wireless energy is controlled based on said detected energy difference.

273. The method according to claim 271, wherein the amount of transmitted wireless energy is decreased if the detected energy balance change implies that the energy balance is increasing, or vice versa.

274. The method according to claim 273, wherein the decrease/increase of energy transmission corresponds to a detected change rate.

275. The method according to claim 272, wherein the amount of transmitted wireless energy is decreased if the detected energy difference implies that the received energy is greater than the used energy, or vice versa.

276. The method according to claim 275, wherein the decrease/increase of energy transmission corresponds to the magnitude of said detected energy difference.

277. The method according to claim 269, wherein said wireless energy is transmitted by means of a primary coil in the external energy source and received inductively by means of a secondary coil in an internal energy source, the internal energy source is connected to a device for directly or indirectly supplying received energy thereto, and wherein feedback control information is transferred from the secondary coil to the primary coil by switching the secondary coil on and off to induce a detectable impedance load variation in the primary coil encoding the feedback control information, and wherein the feedback control information relates to the energy received by the internal energy source and is used for controlling the transmission of wireless energy from the external energy source.
278. The apparatus according to claim 277, wherein the external energy source further comprises an electronic circuit for comparing the feedback information with the amount of energy transmitted by the external energy source.

279. The method according to claim 278, wherein the electronic circuit comprises an analyzer, further comprising analyzing by the analyzer the amount of energy being transmitted and the received feedback information related to the amount of energy received in the receiver, and determining the energy balance by comparing the amount of transmitted energy and the feedback information related to the amount of received energy.

280. The method according to claim 279, further comprising using the feedback information to adjust the level of the energy transmitted from the external energy source.

281. The method according to claim 255, wherein said wireless energy being transmitted by means of a primary coil in an external energy source and received inductively by means of a secondary coil in an internal energy source, the internal energy receiver being connected to the medical device for directly or indirectly supplying received energy thereto, wherein feedback control information (S) is transferred from the secondary coil to the primary coil by switching the secondary coil on and off to induce a detectable impedance load variation in the primary coil encoding the feedback control information, where the feedback control information relates to said energy balance.

282. The method according to claim 277, further comprising the steps of:

- transmitting wireless energy from a coil of the external energy source placed externally to the human body, placing a energy receiver internally in the human body, providing an electric circuit connected to the external coil,

- supplying by the external coil electrical pulses to transmit the wireless energy, the electrical pulses having leading and trailing edges,

- varying by the electric circuit first time intervals between successive leading and trailing edges and/or second time intervals between successive trailing and leading edges of the electrical pulses, thus varying the power of the transmitted wireless energy, and
- receiving by the energy receiver the transmitted wireless energy having a varied power.

283. The method according to claim 282, further comprising delivering by the electric circuit the electrical pulses to remain unchanged except varying the first and/or second time intervals.

284. The method according to claim 282, wherein the electric circuit has a time constant, further comprising

- varying the first and second time intervals only in the range of the first time constant, so that when the lengths of the first and/or second time intervals are varied, and

- varying the transmitted power over the coil.
A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: A61F, A61B, A61N

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

SE, DK, FI, NO classes as above

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
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<tbody>
<tr>
<td>Y</td>
<td>US 20060030887 A1 (LETORT, MICHAEL ET AL), 9 February 2006 (09.02.2006), figures 1,5,7, abstract, [0016]-[0017], [0026]-[0029], [0045]</td>
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<td>241, 244, 245</td>
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Further documents are listed in the continuation of Box C. See patent family annex.

Date of the actual completion of the international search: 3 February 2009
Date of mailing of the international search report: 5-02-2009

Name and mailing address of the ISA/Swedish Patent Office
Box 5055, S-102 42 STOCKHOLM
Facsimile No. +46 8 666 02 86

Authorized officer
Gordana Ninkovic/E ü
Telephone No. +46 8 782 25 00
### INTERNATIONAL SEARCH REPORT

**International application No.**

PCT/SE2008/000595

**Box No. II 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 any 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. □ AS 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.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2008)
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International patent classification (IPC)
A61F 2/06 (2006.01)
A61B 17/12 (2006.01)
A61N 1/36 (2006.01)

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