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(54) **Title:** METHOD FOR CALIBRATING AN EXPANDABLE MEANS OF A MEDICAL DEVICE AND METHOD FOR MONITORING THE PRESSURE EXERTED BY THE INTERIOR WALL OF A BIOLOGICAL CHANNEL

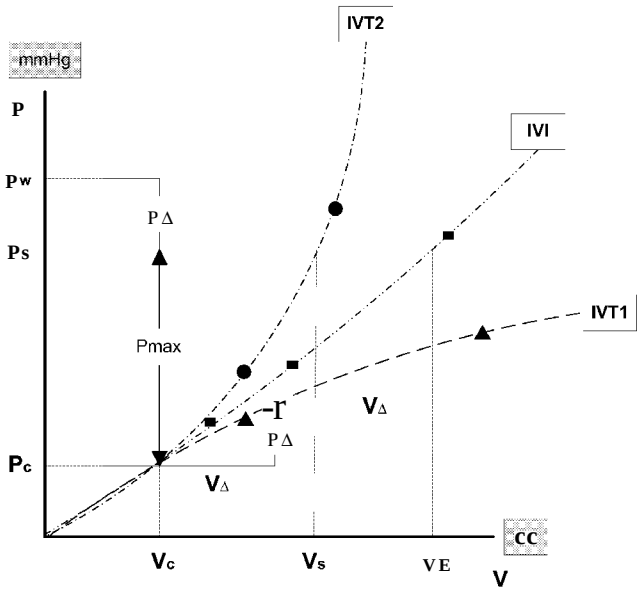


FIG. 1

(57) **Abstract:** The present invention relates to a method for determining the working pressure (PW) of an expandable means placed in the lumen of a biological channel of diameter (d) such that the expandable means exerts a maximum pressure ($P_{M^{ax}}$) on the interior wall of the biological channel without causing damage to the tissues of the channel. The invention further provides a method for determining the contact pressure (PC) of an expandable means placed in the lumen of a biological channel such that the expandable means comes into full contact with the interior wall of the biological channel. The invention also provides a method for the real-time monitoring of the pressure exerted by the interior wall of a biological channel.

METHOD FOR CALIBRATING AN EXPANDABLE MEANS OF A MEDICAL DEVICE AND METHOD FOR MONITORING THE PRESSURE EXERTED BY THE INTERIOR WALL OF A BIOLOGICAL CHANNEL

Field of the Invention

The present invention relates to the field of medical devices. More specifically, the invention relates to methods for calibrating the expandable means of a medical device located in the lumen of a biological channel so as to avoid harming the tissues surrounding it, and methods for determining and/or monitoring the pressure exerted by the interior wall of a biological channel.

Background of the Invention

Modern medical devices use expandable means (EM) and in particular inflatable balloons for achieving different operations. Examples of such devices can be found for instance in WO 2010/016054.

WO 2010/016054, which is incorporated herein by reference, relates to an enteral feeding device that enables the administration of nutritive solutions directly into the stomach of a patient. The device disclosed therein significantly reduces the risks of aspirations from the alimentary tract into the respiratory system and allows deglutition of biological fluids secreted in the upper part of the digestive system into the stomach. The middle section of the feeding device of WO 2010/016054 comprises at least three expandable means surrounding a flexible tube, which can be inflated or deflated by introducing or draining a fluid into/from the internal volume of the expandable means. Some of the purposes of the expandable means of the device disclosed in WO 2010/016054 are as follows: 1) blocking the progression of the gastrointestinal fluids in the esophagus, 2) allowing the redirection of the gastrointestinal fluids towards the stomach, and 3) enabling the swallowing of the oropharynx fluids naturally secreted by the patient.

However, the use of expandable means in the field of medical devices is not straightforward and may raise several technical issues. For instance, the inflated/deflated status of the expandable means should be carefully monitored during the introduction or removal of the medical device into the body of the patient as well as during its use within the body of the patient. Moreover, damages to the tissues belonging to the interior wall of the biological channel wherein the medical device has been introduced should be avoided. To the knowledge of the inventors, there is to date no available method for calibrating the working pressure of an expandable means when placed in the lumen of a biological channel. Furthermore, there is currently a need for a method for determining and/or monitoring the pressure exerted by the interior wall of a biological channel on the fluids flowing in the lumen.

Therefore, it is an object of the invention to provide a method for calibrating the working pressure of an expandable means of a medical device placed in the lumen of a biological channel.

It is another object of the invention to provide a method for determining and/or monitoring the pressure exerted by the interior wall of a biological channel.

Further purposes and advantages of this invention will appear as the description proceeds.

Summary of the Invention

In a first aspect, the present invention provides a method for determining the working pressure (Pw) of an expandable means placed in the lumen of a biological channel of diameter (d) such that said expandable means exerts a maximum pressure (PMax) on the interior wall of said biological channel without causing damage to the tissues of said channel, said method comprising the steps of:

a) obtaining a first *"in vitro"* calibration curve (IVIT1) of said expandable means, which shows the pressure of said expandable means as a function of the volume of fluid introduced therein, when no external constraints are applied to said expandable means;

b) obtaining a second *"in vitro"* calibration curve (IVIT2) of said expandable means, which shows the pressure of said expandable means as a function of the volume of fluid introduced therein, when said expandable means is placed inside a rigid tube having said diameter (d);

c) obtaining an *"in vivo"* calibration curve (IVI) of said expandable means, which shows the pressure of said expandable means as a function the volume of fluid introduced therein, when said expandable means is placed in the lumen of a biological channel of a patient;

d) adjusting the data of the three curves obtained in steps a) - c) so as to obtain a point characterized by a pressure value Pc and a volume Vc corresponding to the pressure and volume at which the expandable means comes into full contact with the interior wall of said biological channel;

e) determining the pressure P_S by adding P_{Max} to P_C;

f) determining the volume Vs by reporting the pressure Ps on the calibration curve IVIT2;

g) determining the volume V_E by reporting the pressure P_S on the calibration curve IVI;

h) determining the volume V_Δ by subtracting Vs from V_E;

i) determining P_Δ by reporting V_Δ on the calibration curve IVIT1, with Pc/Vc as reference; and

j) determining P_W by adding the value of P_C, $P\Delta$ and P_{Max}.

In a specific embodiment of the method described above, the biological channel belongs to the blood circulation system, the digestive system, the respiratory system, the urinary system or the reproductive system.

In another aspect, the invention provides a method for determining the contact pressure (Pc) of an expandable means placed in the lumen of a biological channel such that said expandable means comes into full contact with the interior wall of said biological channel, said method comprising the steps of:

a) obtaining an *"in vitro"* calibration curve (IVIT1) of said expandable means, which shows the pressure of said expandable means as a function of the

volume of fluid introduced therein, when no external constraints are applied to said expandable means;

b) obtaining an *"in vivo"* calibration curve (IVI) of said expandable means, which shows the pressure of said expandable means as a function the volume of fluid introduced therein, when said expandable means is placed in the lumen of a biological channel of a patient; and

c) adjusting the data of the curves obtained in steps a) and b) so as to obtain a point characterized by a pressure value P_c and a volume Vc corresponding to the pressure and volume at which the expandable means comes into full contact with the interior wall of said biological channel.

In a further aspect, the invention provides a method for the real-time monitoring of the pressure exerted by the interior wall of a biological channel, said method comprising the following steps:

a) introducing at least one expandable means in the lumen of said biological channel;

b) determining the contact pressure (Pc) of each of said at least one expandable means following the method of claim 3;

c) inflating each of said at least one expandable means to a pressure corresponding to its contact pressure P_c; and

d) monitoring in real time the pressure exerted by the interior wall of said biological channel by measuring the pressure exerted on said at least one expandable means.

In a specific embodiment of the method described above, the biological channel is the esophagus.

In another specific embodiment of the method described above, the pressure exerted by the esophagus is used for determining the transpulmonary pressure.

Brief Description of the Drawings

The above and other characteristics and advantages of the invention will be more readily apparent through the following examples, and with reference to the appended drawings, wherein:

FIG. 1 is a graph showing three calibration curves (pressure measured as a function of volume of fluid injected) obtained for a specific expandable means, as well as the different critical points used in an embodiment of the method of the invention for calibrating this specific expandable means; the first *in vitro* calibration curve is represented by IVT1 **(A),** the second *in vitro* calibration is represented by IVT2 (·), and the *in vivo* calibration curve is represented by IVI (■).

FIG. 2 is a scheme representing an embodiment of a method for the real-time monitoring of the transpulmonary pressure with an expandable means; PTP corresponds to the transpulmonary pressure; PAW corresponds to the tracheal air pressure; and PES corresponds to the esophageal pressure.

Detailed Description

Expandable means used with medical devices, such as inflatable balloons, are made of different material such as silicon, polyurethane, PVC and alike. While the manufacturing processes are developed to ensure that all the characteristics of the elements of a medical device are reproducible from one device to the other, it is technically very difficult to guarantee that elements such as expandable means will have exactly the same configurations and the exact physical characteristics (thickness, elasticity, self tension when inflated etc.). Furthermore, while the average value of the diameter, rigidity or flexibility of a biological channel such as the trachea, the esophagus, aorta, or any other physiological lumen in the body can be found in the art, the value may vary from patient to patient according to several factors such as age, genetic background or medical antecedents. Therefore, there is a need for a method that enables determining the working pressure of an expandable means when placed in the lumen of a biological channel, so it fulfills its role in said biological channel without damaging the surrounding tissues.

In a first aspect, the present invention aims to provide a method for calibrating an expandable means placed inside the biological channel of a patient and determining its working pressure (Pw)- The expandable means is preferably placed within the lumen of a biological channel that belongs to the blood circulation system (heart, artery, vein), the digestive system (esophagus, stomach, duodenum, small intestine, large intestine, anus), the respiratory system (trachea, bronchi), the urinary system (kidney, ureter, bladder, urethra) or the reproductive system (vas deferens, ejaculatory duct, vagina, uterus, fallopian tube). The methods of the present invention may be also applied to biological channels belonging to animal organisms other than human, plant organisms, or other tubular structure from the industry.

The maximum pressure that can be applied for a long period of time on epithelial tissues without damaging them is known in the art. In most cases, this pressure should serve as a target pressure or maximum pressure ($\mathbf{P}_{\mathbf{M}ax}$) that can be applied continuously by an expandable means on the interior wall of the channel. However, the pressure of the fluid measured within the expandable means by external pressure sensors does not correspond to the pressure effectively applied by the expandable means on the wall of the biological channel. Indeed, it was found by the inventors that several additional factors should be considered when calibrating the expandable means, such as the pressure developed to inflate the expandable means up to the full contact with the wall of the biological channel (called hereafter the "contact pressure" P_c), and additional factors such as the pressure applied to compensate the deformation of the biological channel ($P\Lambda$)· The contact pressure P_c depends on severable variables inherent to the expandable means such as the material, thickness, elasticity, diameter, or shape. The pressure P_Δ merely reflects the pressure which causes the flexible biological channel to enlarge its diameter, but is not a pressure directly applied onto the wall of the channel.

In summary, the pressure relative to the expandable means as measured by the external sensors (referred herein as the working pressure (Pw)) can be defined as follows:

$$P_W = P_c + P_{Max} + P_\Delta$$

wherein

Pw corresponds to the working pressure as measured by the external sensors;

Pc corresponds to the contact pressure, in other words the pressure used to inflate the expandable means and bring it into the full contact with the wall of the channel (no effect on the tissues);

Piviax corresponds to the maximum pressure that can be continuously applied on the wall of the biological channel; and

P_{Δ} corresponds to the pressure due to additional factors, such as the deformation of the biological channel.

The working pressure (Pw) should be calibrated for each expandable means independently, so that the pressure continuously applied to the wall of the biological channel by said expandable means does not exceed the maximum pressure (PMax) described in the literature, above which damages are made to the tissues.

The inventors surprisingly found that the calibration of P_W can be achieved by using the following method. It should be emphasized that all the tests are performed on a medical device comprising the expandable means to be calibrated. For the sake of conciseness, the term "expandable means" as used thereafter can be understood as either an expandable means alone or an expandable means located on a medical device.

During the manufacturing process of the medical device, two *"in vitro"* tests are made on the expandable means. The first *in vitro* test comprises the following steps:

1) the expandable means is deflated and a volume of fluid is gradually injected in the expandable means until a predetermined volume threshold is reached;

2) the pressure inside the expandable means is recorded as a function of the volume of fluid injected and a calibration curve (IVT1) is recorded; and

3) the recorded data are transferred on a digital media (e.g. electronic chip) associated with the expandable means.

The second *in vitro* test comprises the following steps:

1) the expandable means is placed in a rigid tubular structure having a diameter corresponding to the target biological channel (e.g. average diameter of an esophagus);

2) the expandable means is deflated and a volume of fluid is gradually injected in the expandable means until a predetermined volume threshold is reached;

3) the pressure inside the expandable means is recorded as a function of the volume of fluid injected and a calibration curve (IVT2) is recorded; and

4) the recorded data are transferred on a digital media (e.g. electronic chip) associated with the expandable means.

The data recorded are used for determining the working pressure of the expandable means after the *in vivo* test has been performed.

The *in vivo* test comprises the following steps:

1) the expandable means is introduced in the lumen of the biological channel of the patient;

2) the expandable means is deflated and a volume of fluid is gradually injected in the expandable means until a predetermined volume threshold is reached; and

3) the pressure inside the expandable means is recorded as a function of the volume of fluid injected and a calibration curve (IVI) is recorded.

The data obtained from the *in vivo* test and those obtained from the two *in vitro* tests are then automatically treated and analyzed via a software program. The data of the three curves are adjusted and the best fit between the three curves is determined (see Fig.l). By doing so, a characteristic point appears, above which a discrepancy between the values of the pressures obtained in the three different curves is observed. This characteristic point corresponds to the pressure P_C and the volume Vc at which the expandable means comes into full contact with the interior wall of the biological channel/rigid tube. Up to the pressure Pc, the pressure measured in the expandable means represents the pressure needed to inflate the expandable means and bring it into full contact with the surrounding wall/tube with no actual pressure effect on the tissue. To the pressure P_C, the pressure P_{Max} is added in order to reach a pressure P_S. Reporting the value P_S to the calibration curve IVT2 (·) gives a volume Vs, which is the volume necessary to apply PMax to the wall of the rigid tube in the second *in vitro* experiment (as described above). Similarly, reporting the value Ps to the calibration curve IVI (■) gives the volume V_E. The difference between the volume V_E and the volume Vs corresponds to a volume V_Δ, which reflects the volume of fluid injected in the expandable means to enlarge the flexible biological channel surrounding. In order

to determine the pressure P_{Δ} which is the pressure used to inflate the expandable means in the biological channel until it applies a pressure on the wall, the volume V_{Δ} is reported to the calibration curve IVT1 **(A),** taking Pc/Vc as a reference (see Fig.l).

The value of the working pressure Pwis therefore determined as follows:

$$P_W = P_C + P_{Max} + P_{\Delta}$$

wherein

P_W corresponds to the working pressure as measured by the external sensors;

Pc corresponds to the contact pressure, in other words the pressure used to inflate the expandable means and bring it into the full contact with the wall of the channel (no effect on the tissues);

Piviax corresponds to the maximum pressure that can be continuously applied on the wall of the biological channel; and

P_{Δ} corresponds to the pressure due to additional factors, such as the deformation of the biological channel.

As it can be understood from the above, the working pressure P_W is characteristic of a specific expandable means at a certain position within the body of the patient, and corresponds to the optimal working pressure of the expandable means guarantying its full functionality without damaging the surrounding tissues.

A further aspect of the invention provides a method for monitoring the pressure exerted by the interior wall of a biological channel. By applying the calibration method described above, the working pressure at which the expandable means is in contact with the wall of the biological channel (P_c) can be determined. When the expandable means is inflated at a pressure value of P_c, any deformation of the biological channel that would have resulted in the application of a pressure on the material flowing inside the biological channel is applied instead on the inflated expandable means. The pressure exerted on the expandable means can be reported to a central unit and may help monitoring the pressure exerted by the interior wall of a biological channel in real time.

This is for instance of particular relevance when monitoring the transpulmonary pressure of a treated patient (see Example 2). The transpulmonary pressure s calculated as follows:

$$P_{TP} = P_{AW} - P_{ES}$$

wherein

P_{TP} corresponds to the transpulmonary pressure;

P_{AW} corresponds to the tracheal air pressure; and

P_{ES} corresponds to the esophageal pressure.

The following examples, which further describe the invention, are offered by way of illustration and are not intended to limit the invention in any manner.

EXAMPLE 1

Method for determining the optimal working pressure of an expandable means in a human esophagus

The present example reports the calibration of an expandable means belonging to a device similar to the one described in WO 2010/016054. The pressure inside the expandable means is measured via a control and monitoring unit (CMU) as described in WO 2010/01604. The presently described method aims to determine the optimal working pressure (Pw) of the expandable means when located in the esophagus of a treated patient. As discussed above, determining P_W is important to insure that the expandable means achieve the desired function without damaging the tissues of the esophagus during the treatment. In the present example, a maximum pressure P_{Max} of 30 mmHg is to be applied by the expandable means on the internal wall of the esophagus.

Phase 1: In vitro calibration test 1 (IVT1)

1) the expendable means is deflated;

2) the expendable means is gradually inflated by injecting a volume of 0.2 cc of air until a total volume of 5 cc is reached;

3) when a total volume of 5 cc has been injected in the expendable means, the calibration curve reporting the pressure as a function of the volume of air is generated; and

4) the graph obtained in step 3 is recorded on an electronic chip which also contains information relative to the identification number of the expandable means.

This calibration curve corresponds to the *"in vitro"* test number 1 (IVT1).

Phase 2: In vitro calibration test 2 (IVT2)

1) the expandable means is placed in a rigid tubular structure having a diameter corresponding to the average diameter of an esophagus, namely 14 mm;

2) the expendable means is deflated;

3) the expendable means is gradually inflated by injecting a volume of 0.2 cc of air until a total volume of 5 cc is reached;

4) when a total volume of 5 cc has been injected in the expendable means, the calibration curve reporting the pressure as a function of the volume of air is generated; and

5) the graph obtained in step 4 is recorded on an electronic chip which also contains information relative to the identification number of the expandable means.

This graph corresponds to the *"in vitro"* test number 2 (IVT2).

Phase 3: In vivo calibration (IVI)

1) the expandable means is placed in the patient's esophagus;

2) the expendable means is deflated;

3) the expendable means is gradually inflated by injecting a volume of 0.2 cc of air until a total volume of 5 cc is reached;

4) when a total volume of 5 cc has been injected in the expendable means, the calibration curve reporting the pressure as a function of the volume of air is generated; and

5) the graph obtained in step 4 is recorded and stored in the CMU.

Phase 4: Adjusting the calibration curves

1) the expandable means is identified via its identification number by the CMU;

2) the CMU is importing the data corresponding to the two in vitro tests performed in Phase 1 and Phase 2 described above;

3) a software present in the CMU is adjusting the 3 graphs obtained during Phases 1-3 (e.g. by calculating and comparing the derivative of each point of the graphs for a same specific volume);

4) once adjusted, the system determines the pressure corresponding to the pressure at the contact point of the expandable means on the internal esophagus wall/rigid tube wall (Pc).

Phase 5: Determining the optimal working pressure

1) a pressure value P_s is determined by adding the pressure $\mathbf{P_{Max}}$ (30 mmHg) to the pressure Pc (in this case 10 mmHg).

2) the pressure Ps is reported on the calibration curve obtained from the data of the second *in vitro* experiment to find Vs;

3) the pressure P_s is reported on the calibration curve obtained from the data of the *in vi*vo experiment to find V_E;

4) the volume V_Δ is calculating by the difference V_E - Vs;

5) the value of V_Δ is reported on the calibration curve obtained from the data of the first *in vitro* experiment and the pressure P_Δ is determined; and

6) eventually, the optimal P_W is determined by effecting the following operation:

$$P_W = P_C + P_{MAX} + P_\Delta$$

In a particular case (data not shown), the pressure at the contact point (Pc) has been determined at 11 mmHg, $\mathbf{P_{Max}}$ at 30 mmHg and P_Δ at 11 mmHg. Therefore, the optimal working pressure P_W in this case has been set to **52 mmHg.** In conclusion, when this specific expandable means is inserted inside the esophagus, the working pressure should be about 52 mmHg so that said expandable means effectively applies a continuous pressure on the interior wall of the esophagus of about 30 mmHg, effectively closing the lumen space without damaging the surrounding tissues.

EXAMPLE 2

Method for the real-time monitoring of the transpulmonary pressure.

Ventilated patients in the intensive care unite are often needed to be monitored for their esophageal pressure during ventilator setting especially during peep adjustment. Pleural pressure can be measured via an esophageal balloon catheter and allows for calculation of the transpulmonary pressure which is the difference between the alveolar pressure (the pressure measured at the airway opening when flow is stopped) and pleural pressure. The measurements are done in the upright position and the expandable means is placed in lower third of the esophagus. Cardiac oscillations are ignored. Because the pressure of an expandable can be measured, the esophageal pressure applied on the expandable can be determined by using the expandable means as a manometer.

In the present example, a device similar to the one in WO 2010/016054 is employed in the esophagus of a patient. All three balloons are deflated and then inflated simultaneously to reach their respective contact pressures Pc(l), Pc(2) and Pc(3). As it can be understood from the description, the values Pc(l), Pc(2) and Pc(3), while similar in some cases, are usually distinct since each one of them corresponds to a specific expandable means (having inherent properties) at a specific position of the esophagus. The transpulmonary pressure s calculated as follows:

$$P_{TP} = P_{AW} - P_{ES}$$

wherein

P_{TP} corresponds to the transpulmonary pressure;

P_{AW} corresponds to the tracheal air pressure; and

P_{ES} corresponds to the esophageal pressure with $P_{ES} = P_M - Pc$, wherein

P_M corresponds to the pressure measured within the expendable means; and

P_c corresponds to the contact pressure of the same expandable means

As shown in Fig.2, the tracheal air pressure (P_{AW}) is obtained from the data transferred by the tracheal tube. The esophageal pressure (P_{ES}) is determined in real-time by measuring at least one of the pressure values of expandable means 1-3, which have

been inflated at their respective contact pressure and are used to measure the pressure variations in the lumen of the esophagus. The average of the values reported by the expandable means (or any other combinations) is also considered as a possible embodiment. In the present example (Fig.3), P_{AW} as measured is 38 cmH_20 and P_{ES} is the average value reported by the three expandable means and corresponds to 24 cmH20. Therefore, the transpulmonary pressure $P_T\rho$ corresponds in this case to 14 cmH_20 (or 19 mmHg, when considering that 1 cmH_20 = 1.359 mmHg).

It is clear from the above that the present method allows real-time monitoring of the transpulmonary pressure via the use of at least one expandable means placed in the esophagus and further data obtained from a tracheal tube.

Although embodiments of the invention have been described by way of illustration, it will be understood that the invention may be carried out with many variations, modifications, and adaptations, without exceeding the scope of the claims.

Claims :

1. A method for determining the working pressure (Pw) of an expandable means placed in the lumen of a biological channel of diameter (d) such that said expandable means exerts a maximum pressure (PMax) on the interior wall of said biological channel without causing damage to the tissues of said channel, said method comprising the steps of:

a) obtaining a first *"in vitro"* calibration curve (IVIT1) of said expandable means, which shows the pressure of said expandable means as a function of the volume of fluid introduced therein, when no external constraints are applied to said expandable means;

b) obtaining a second *"in vitro"* calibration curve (IVIT2) of said expandable means, which shows the pressure of said expandable means as a function of the volume of fluid introduced therein, when said expandable means is placed inside a rigid tube having said diameter (d);

c) obtaining an *"in vivo"* calibration curve (IVI) of said expandable means, which shows the pressure of said expandable means as a function the volume of fluid introduced therein, when said expandable means is placed in the lumen of a biological channel of a patient;

d) adjusting the data of the three curves obtained in steps a) - c) so as to obtain a point characterized by a pressure value P_c and a volume Vc corresponding to the pressure and volume at which the expandable means comes into full contact with the interior wall of said biological channel;

e) determining the pressure Ps by adding PMax to Pc;

f) determining the volume Vs by reporting the pressure P_s on the calibration curve IVIT2;

g) determining the volume V_E by reporting the pressure Ps on the calibration curve IVI;

h) determining the volume V_Δ by subtracting Vs from V_E;

i) determining P_Δ by reporting V_Δ on the calibration curve IVIT1, with Pc/Vc as reference; and

j) determining P_W by adding the value of Pc, $P\Delta$ and PMax-

2. The method according to claim 1, wherein said biological channel belongs to the blood circulation system, the digestive system, the respiratory system, the urinary system or the reproductive system.

3. A method for determining the contact pressure (Pc) of an expandable means placed in the lumen of a biological channel such that said expandable means comes into full contact with the interior wall of said biological channel, said method comprising the steps of:

a) obtaining an *"in vitro"* calibration curve (IVIT1) of said expandable means, which shows the pressure of said expandable means as a function of the volume of fluid introduced therein, when no external constraints are applied to said expandable means;

b) obtaining an *"in vivo"* calibration curve (IVI) of said expandable means, which shows the pressure of said expandable means as a function the volume of fluid introduced therein, when said expandable means is placed in the lumen of a biological channel of a patient; and

c) adjusting the data of the curves obtained in steps a) and b) so as to obtain a point characterized by a pressure value Pc and a volume Vc corresponding to the pressure and volume at which the expandable means comes into full contact with the interior wall of said biological channel.

4. A method for the real-time monitoring of the pressure exerted by the interior wall of a biological channel, said method comprising the following steps:

a) introducing at least one expandable means in the lumen of said biological channel;

b) determining the contact pressure (P_c) of each of said at least one expandable means following the method of claim 3;

c) inflating each of said at least one expandable means to a pressure corresponding to its contact pressure Pc; and

d) monitoring in real time the pressure exerted by the interior wall of said biological channel by measuring the pressure exerted on said at least one expandable means.

5. A method according to claim 4, wherein said biological channel is the esophagus.

6. A method according to claim 5, wherein the pressure exerted by the esophagus is used for determining the transpulmonary pressure.

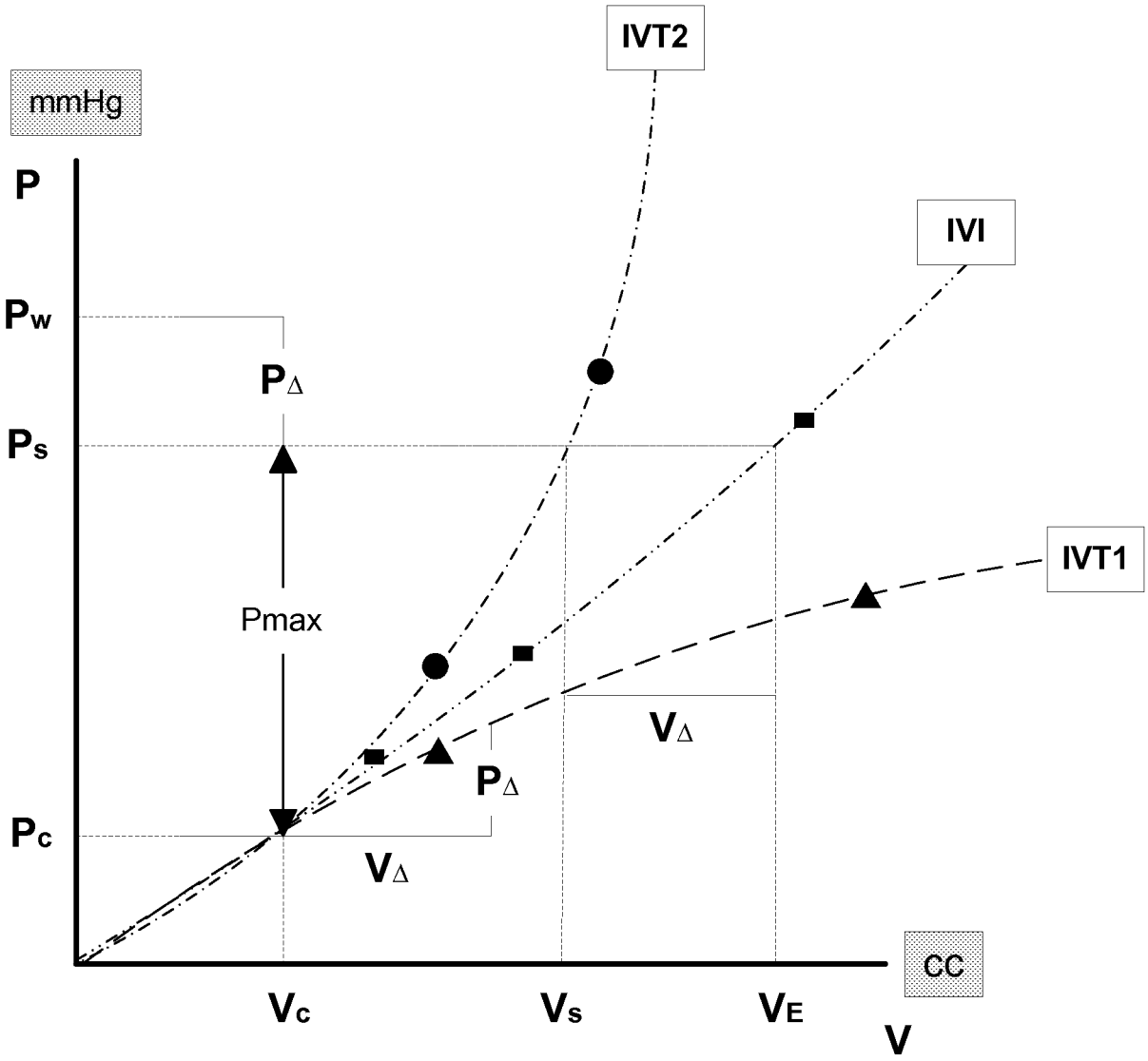
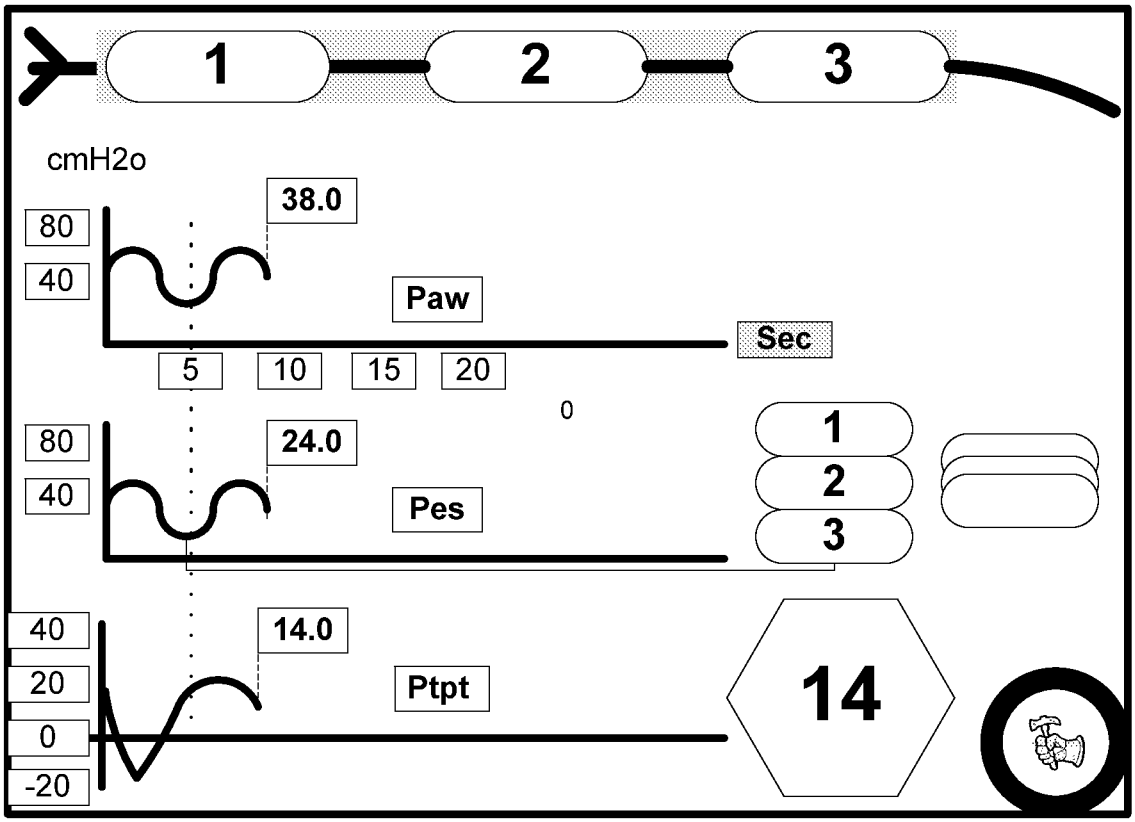


FIG. 1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38.0
80
40
Paw
Sec
5
10
15
20
0
80
24.0
40
Pes
1
2
3
40
14.0
20
0
-20
Ptpt
14

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL2013/050597

A. CLASSIFICATION OF SUBJECT MATTER
IPC (2013.01) A61M 25/10, A61M 29/00, A61B 5/00

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 (2013.01) A61M 25/10, A61M 29/00, A61B 5/00

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

Electronic data base consulted during the international search (name of data base and, **where** practicable, search terms used)
Databases consulted: THOMSON INNOVATION, Esp@cenet, Google Patents

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5275 169 A Afromowitz et al. 04 Jan 1994 (1994/01/04) (The whole document)	3-6
Y	(The whole document)	1,2
Y	US 7993336 B2 Jackson et al. 09 Aug 20 11 (201 1/08/09) (the whole documents especially abstract, Figs. 2-4, 9, 10, 15, col. 1 lines 24-26, col. 2 lines 47-49, col. 5 lines 4-12, col. 7 lines 25-40, col. 8 lines: 5-20, 37-46, 55-57, col. 10 lines 26-27, col. 13 line 56-col. 14 line 34).	1-6
A	US 201 1130650 A l Dayan et al. 02 Jun 201 1 (201 1/06/02) (Abstract, Figs. 1-6, 8-12, paragraphs 8, 9, 23, 44-49, 50, 80, 89, 101, 123, 125, 130).	1-6
A	US 7947001 B l Sarvazyan et al. 24 May 201 1 (201 1/05/24) (Abstract, Figs. 1-16).	1-6

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is ¾¾al re as n as specified) to establish the publication date of another citation or other
"0" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than toe priority date claimed
"T" later document published alter the international fiiing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"χ" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent laimly

Date of the actual completion of the International search	Date of mailing of the international search report
04 Nov 2013	05 Nov 2013

Name and mailing address of the ISA:	Authorized officer
Israel Patent Office Technology Park, Bldg.5, Malcha, Jerusalem, 9695101, Israel Facsimile No. 972-2-5651616	NEVER Emad Telephone No. 972-2-5657801

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL2013/050597

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2005 124920 A1 Gregersen. 09 Jun 2005 (2005/06/09) (aAstract, Figs. 1, 3, 4).	1-6
A	CA 107683 1 A1 Elam. 06 May 1980 (1980/05/06) (Abstract, Figs. 4, 7).	1-6
A	US 2010023038 A1 Santra et al. 28 Jan 2010 (2010/01/28) (Abstract, Figs. 3C, 6, 7A).	1-6

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IL2013/050597

Patent document cited search report	Publication date	Patent family member(s)	Publication Date
US 5275 169 A	04 Jan 1994	AU 3423893 A	03 Aug 1993
		CA 2130255 A1	22 Jul 1993
		CA 2130255 C	11 Nov 2003
		DE 69232491 D1	18 Apr 2002
		DE 69232491 T2	04 Jul 2002
		EP 0632709 A1	11 Jan 1995
		EP 0632709 A4	04 Nov 1998
		EP 0632709 B1	13 Mar 2002
		US 5275 169 A	04 Jan 1994
		WO 93 13709 A1	22 Jul 1993
US 7993336 B2	09 Aug 201 1	AT 378014 T	15 Nov 2007
		AU 1617401 A	30 May 2001
		AU 780278 B2	10 Mar 2005
		AU 63 14301 A	27 May 2002
		AU 2001263 143 B2	07 Dec 2006
		AU 2003234332 A1	17 Nov 2003
		AU 2003234332 A8	17 Nov 2003
		AU 2005206098 A1	04 Aug 2005
		AU 2005206098 B2	30 Jun 201 1
		AU 2006302688 A1	19 Apr 2007
		AU 2006302688 B2	12 Jul 2012
		BR PI06 16840 A2	05 Jul 20 11
		CA 2388861 A1	25 May 2001
		CA 2388861 C	03 Sep 2013
		CA 2427978 A1	23 May 2002
		CA 2427978 C	15 Oct 2013
		CA 2552787 A1	04 Aug 2005
		CA 2624792 A1	19 Apr 2007
		CA 2825425 A1	25 May 2001
		DE 6013 1443 D1	27 Dec 2007

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IL2013/050597

Patent document cited search report	Publication date	Patent family member(s)	Publication Date
		DE 6013 1443 T2	18 Sep 2008
		EP 1229849 A1	14 Aug 2002
		EP 1335677 A1	20 Aug 2003
		EP 1335677 B1	14 Nov 2007
		EP 1708636 A1	11 Oct 2006
		EP 1708636 A4	26 May 2010
		EP 193 1272 A2	18 Jun 2008
		EP 193 1272 A4	07 Apr 2010
		EP 2604212 A1	19 Jun 2013
		EP 2604213 A1	19 Jun 2013
		ES 2296754 T3	0 1 May 2008
		JP 2009509713 A	12 Mar 2009
		JP 5222144 B2	26 Jun 2013
		JP 2005503 181 A	03 Feb 2005
		JP 201 1218189 A	04 Nov 201 1
		JP 2013066725 A	18 Apr 2013
		PT 1335677 E	30 Nov 2007
		US 655 13 10 B1	22 Apr 2003
		US 2003 158550 A1	2 1 Aug 2003
		US 7530979 B2	12 May 2009
		US 2007100333 A1	03 May 2007
		US 7993336 B2	09 Aug 201 1
		US 2010234840 A1	16 Sep 2010
		US 8012149 B2	06 Sep 201 1
		US 2012004654 A1	05 Jan 2012
		US 8377055 B2	19 Feb 2013
		US 2009048593 A1	19 Feb 2009
		US 839863 1 B2	19 Mar 2013
		US 2004087936 A1	06 May 2004
		US 2004215235 A1	28 Oct 2004
		US 2004215296 A1	28 Oct 2004

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IL2013/050597

Patent document cited search report	Publication date	Patent family member(s)	Publication Date
		US 2006095032 A1	04 May 2006
		US 2012004656 A1	05 Jan 2012
		US 2012330298 A1	27 Dec 2012
		US 2013 13 1661 A1	23 May 2013
		WO 0135846 A1	25 May 2001
		WO 0135846 A9	23 May 2002
		WO 0239915 A1	23 May 2002
		WO 03092609 A2	13 Nov 2003
		WO 03092609 A3	26 Feb 2004
		WO 03092609 A9	13 Jan 2005
		WO 2005070061 A2	04 Aug 2005
		WO 2005070061 A3	07 Dec 2006
		WO 20050703 16 A1	04 Aug 2005
		WO 2007044244 A2	19 Apr 2007
		WO 2007044244 A3	05 Jul 2007
US 201 1130650 A1	02 Jun 201 1	AU 2009278778 A1	11 Feb 2010
		CA 273 1555 A1	11 Feb 2010
		CN 102333562 A	25 Jan 2012
		EP 23 18083 A1	11 May 201 1
		IL 210770 DO	31 Mar 201 1
		JP 201 1529766 A	15 Dec 201 1
		US 201 1130650 A1	02 Jun 201 1
		WO 2010016054 A1	11 Feb 2010
US 7947001 B1	24 May 20 11	US 7947001 B1	24 May 20 11
US 2005 124920 A1	09 Jun 2005	AU 2003208309 A1	09 Sep 2003
		US 2005 124920 A1	09 Jun 2005
		US 7479120 B2	20 Jan 2009
		WO 03070091 A1	28 Aug 2003

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IL2013/050597

Patent document cited search report	Publication date	Patent family member(s)	Publication Date
CA 1076831 A1	06 May 1980	CA 1076831 A1	06 May 1980
		GB 1586992 A	25 Mar 1981
		US 4134407 A	16 Jan 1979
US 2010023038 A1	28 Jan 2010	US 2005033334 A1	10 Feb 2005
		US 7618434 B2	17 Nov 2009
		US 2010023038 A1	28 Jan 2010
		WO 2004100772 A2	25 Nov 2004
		WO 2004100772 A3	24 May 2007

专利名称(译)	用于校准医疗装置的可扩张装置的方法和用于监测由生物通道的内壁施加的压力的方法		
公开(公告)号	EP2895232A4	公开(公告)日	2016-04-27
申请号	EP2013837502	申请日	2013-07-15
申请(专利权)人(译)	lunguard公司		
当前申请(专利权)人(译)	lunguard公司		
[标]发明人	PINTEL OFER		
发明人	PINTEL, OFER		
IPC分类号	A61M25/10 A61M29/00 A61B5/00		
CPC分类号	A61B5/6885 A61B5/4233 A61B5/6853 A61B2560/0228 A61M25/10184		
优先权	61/699326 2012-09-11 US		
其他公开文献	EP2895232A1		
外部链接	Espacenet		

摘要(译)

本发明涉及一种用于确定放置在直径（d）的生物通道的内腔中的可扩张装置的工作压力（PW）的方法，使得可扩张装置在内壁上施加最大压力（PMax）。生物通道不会对通道组织造成损害。本发明还提供了一种用于确定放置在生物通道内腔中的可扩张装置的接触压力（PC）的方法，使得可扩张装置与生物通道的内壁完全接触。本发明还提供了一种用于实时监测由生物通道的内壁施加的压力的方法。