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(54) **Process and device for draining blood vessels and lymphatic channels of a limb**

(57) The invention relates to a process and device for adjusting the correct pressure in the different chambers of a device for draining the blood vessels and lymphatic channels of a limb, with a cuff to be applied over the limb, and consisting of several inflatable chambers adjacent to each other, characterised in that the pressure development in the different chambers is measured during the sequential inflating of the different chambers, and that, taking into account the developing pressure differences with respect to the ideal programmed pressure per chamber, the pressure in each chamber is programmed taking into account the pressure changes in those specific chambers, caused by the pressure development in at least one adjacent chamber.

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Description

This invention relates to a device for draining the blood vessels and lymphatic channels of a limb, with a cuff to be applied over the limb and consisting of several inflatable chambers adjacent to each other, in which the pressure is built up from a compressor which is connected with each of said chambers by separate filling tubes, on each of which an electronic valve is installed.

In a device for draining the blood vessels and lymphatic channels belonging to a given limb, a leg or arm cuff is built up of different separate chambers following in succession in longitudinal direction of the cuff.

All chambers are inflated according to a given sequence programme. A compressor is connected to the different chambers by means of filling tubes which are connected to a pressure distribution vessel.

By following the sequence programme, the different chambers are successively brought at the desired pressure. By doing so, the expected massage effect is created on the blood vessels and lymphatic channels of the treated limb and the blood and lymph circulation is thus stimulated.

In reality, variations of the preset or expected pressure values are observed in the different chambers. Thus it could among others be observed that variations occurred between the programmed or preset pressure values and the pressure built up in the chambers.

This can be attributed to one or several of the observations explained below:

- a) The pressure drop over the filling tube causes a first error in the measurement;
- b) The pressure measurement is made through a parallel branch of the filling tube. At the level of this branch, a Venturi effect is created, resulting in a second error in the pressure measurement;
- c) The usual diaphragm compressors cause an important pressure fluctuation which induces erroneous measurement;
- d) Finally, the deformation of the chamber causes a variation of the pressure measurement.

Moreover, each time the pressure is only measured once per chamber, viz. at the end of the inflation stage of the concerned chamber and this without rechecking. However, this pressure is subsequently adversely influenced by the inflation of consecutive, adjacent chambers, also resulting in uncontrollable pressure differences depending on:

- a) the rigidity of the partition walls of the chambers;
- b) the shape of the limb to be treated;
- c) the changing position of joints upon inflating the chambers.

It is the aim of this invention to prescribe a device for draining blood vessels and lymph channels that is

capable of measuring the established pressure in each chamber, and according to the defined programme and the possible observed pressure variations, of adjusting and maintaining the pressure in each chamber at the correct level.

In order to allow this according to the invention, the pressure development is measured in the different chambers during the sequential inflating of the different chambers, and, taking into account the developing pressure differences with respect to the ideal programmed pressure per chamber, the pressure in each chamber is programmed, taking into account the changes of pressure in these specific chambers, caused by the pressure development in at least one adjacent chamber,

In a remarkable embodiment, the pressure build-up in the first said chamber, taking into account an observed pressure increase in a chamber as a result of a pressure built up in at least one adjacent chamber, is maintained below the programmed ideal pressure.

According to a second possible embodiment, means are provided that continuously measure the pressure built up in each chamber and correct it so as to bring it into line with a programmed pressure.

The invention also relates to the device for applying the process according to the second embodiment.

Other details and advantages of the invention will appear from the following description of a device for draining the blood vessels and lymphatic channels of a limb, according to the invention. This description is exclusively given as an example and does not limit the invention. The reference numbers relate to the attached figures.

Figure 1 is a schematic view of a device according to the invention with a cuff presented in longitudinal section.

Figure 2 represents a variant of the invention.

The device shown in these figures is intended to make the desired corrections in a cuff 1, consisting of a series of seven separate chambers 2 - 8. Walls 9 separate the different chambers from each other. The cuff 1 is applied over the limb to be treated, and the different chambers are separately and consecutively brought to the desired pressure level, according to a pre-determined programme.

These operations may be repeated several times, entirely or for certain chambers. This forms the actual massage of blood vessels and lymph channels.

The pressure is delivered by a compressor 10 which supplies the required pressure through a number of filling tubes 11 to each of the chambers 2 - 8, each of them equipped with an electronically controlled valve 12. The apparatus and devices being used up to now correspond to this scheme. The disadvantages of such structures and the resulting erroneous pressures have been described in detail in the preamble.

Pressure differences in the inflated chambers are the cause for not realising the wanted massage effect, and the precise causes thereof have been scientifically

established by the applicant, which allowed to arrive at the solution suggested below.

This solution is formed according to the invention by means which continuously and/or at regular intervals measure the pressure built up in each chamber and correct it to keep it in line with the programmed pressure. In a first embodiment (figure 1) on each tube 11a tube 13 is branched off. Each of those tubes 13 is provided with an electronic pressure gauge 14. Each pressure gauge detects eventual pressure variations with respect to the programmed pressure, and is capable of transmitting the required signals to the concerned electronic valve 12 on the corresponding filling tube 11. The required pressure correction may then simply be made in the chamber where the variation was observed. Between each of the electronic valves 12 and the concerned pressure gauge 14, the appropriate electric and electronic links are provided, which can ensure the immediate pressure correction.

In the variant according to figure 2, a unit 15 is used, which contains at least one pressure gauge which, through the already mentioned filling tubes 11 with electronic valves and their branches 13', detects the observed pressure variations and can immediately make the required correction in the concerned chamber.

An immediate correction of the pressure in a given chamber can be obtained by the feed-back effect. This correction of the pressure in each of the inflatable chambers has a decisive influence on the quality of the draining process. It has been established that the correction of the pressure solves a number of problems, such as the removal of disturbing amounts of lymph fluid in the first place.

According to a very attractive embodiment, the process may be based on a completely different mode of pressurising.

Here the developed process assumes that the pressure level in a specific chamber is brought at a level which 'afterwards', i.e. after changes due to the pressure development in at least one adjacent chamber, will be the desired level.

In practice, in a first step, a pressure will be built up in the concerned chamber which will be too low, but will have a value that, after being influenced by the adjacent chambers, reaches the desired value.

According to this process, the concept of "prediction" is taken into account. This "prediction" however depends on a series of factors, such as the body part, the shape of the established oedema, or the issue of oedema reduction during the treatment. The software of the device is conceived such, that it is self-teaching. Herewith is meant that first the chambers will be inflated and the pressure in the different chambers will be measured, from which it may be derived which pressure must be obtained in a following treatment. Upon sufficient recurrence of this process, and the saving of data resulting from these attempts, it may be imagined that

the software will act increasingly more "intelligently". Software containing such algorithms is known as "artificial intelligence software". Thus the device for draining a limb truly becomes more "sensible" upon each treatment. The process based on this view provides the advantage that adjusting, and consequently also the frequent use of valves and of a compressor, will not be needed any more.

The invention is not limited to the embodiment described herein, and modifications might be applied in as much as they fall within the scope of the attached claims.

Claims

1. Process for adjusting the correct pressure in the different chambers of a device for draining the blood vessels and lymphatic channels of a limb, with a cuff to be applied over the limb, and consisting of several inflatable chambers adjacent to each other, in which the pressure is built up from a compressor which is connected with each of said chambers by separate filling tubes, on each of which an electronic valve is installed, characterised in that the pressure development in the different chambers is measured during the sequential inflating of the different chambers, and that, taking into account the developing pressure differences with respect to the ideal programmed pressure per chamber, the pressure in each chamber is programmed taking into account the pressure changes in these specific chambers, caused by the pressure development in at least one adjacent chamber.
2. Process according to claim 1, characterised in that, taking into account an observed pressure increase in a chamber resulting from a pressure built up in an adjacent chamber, the pressure build-up in the first said chamber is maintained below the programmed ideal pressure.
3. Process according to claim 1, characterised in that means are provided which continuously measure the pressure built up in each chamber and correct it in order to keep it in line with a programmed pressure.
4. Device for the application of the process according to claim 3, characterised in that above said means are formed by individual pressure gauges branched off downstream from the above said electronic valves on each of above said filling tubes, and command above said electronic valves.
5. Device for the application of the process according to claim 3, characterised in that above said means are formed by a unit which is located downstream from above said electronic pressure units, and con-

tains at least the following parts:

- a) a pressure gauge which records through each filling tube and its branch to said pressure gauge the pressure in each chamber, and 5
- b) a selector which according to the pressure to be corrected in each chamber, sends a signal to the pressure valve in order to correct the observed variation of the programmed pressure in a given chamber. 10

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