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Description

Shockwave or pressure-wave type therapeutic apparatus,
such as a lithotripter

The present invention relates to a shockwave or pressure-wave type therapeutic apparatus, for instance for performing extracorporeal shockwave lithotripsy, whose therapy head is inter alia equipped with a shockwave source with which it is possible to destroy a concrement located in the body of a living being in a contactless way. Moreover, e.g. pathological tissue changes in living beings, above all in humans, can also be treated in a non-invasive way.

It sometimes happens that when passing through the tissue of living beings shockwaves produce a sufficiently known disadvantageous result in the form of the formation of bubbles. Said bubbles are created as a direct consequence of the interaction of the shockwave with the coupling liquid or the tissue. The duration of said bubbles is in general short. However, cavitation nuclei and long-life bubbles that intensify the formation of bubbles of a subsequent shockwave may also be created. This phenomenon is designated by the experts as cavitation in the broadest sense.
Cavitation is disadvantageous in two respects, namely during the destruction of concrements, which lasts much longer due to cavitation and is disadvantageous for the patient for this reason alone.

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In the meantime it was found during research work in this field that the cavitation in the shockwave path increases with the intensity of the shockwave and the frequency with which the shockwaves follow one another. The absorption of the respectively successive shockwaves in the cavitation field leads, on the one hand, to a reduction of the fragmentation of the concrements and, on the other hand, to an increase in the side effects on the patient, above all in the form of painful tissue impairments.

These problems were e.g. already pointed out in 1998, namely in a scientific treatise by Peter Huber et al., published in "Phys. Med. Biol. 43 (1998) 3113 – 3128. Printed in UK".

Furthermore, it is known from an article by Ryan Paterson et al., published in the "JOURNAL OF UROLOGY", Vol. 165, No. 5, Supplement, June 6, 2001" that the efficiency of stone destruction is associated with decreasing the pulse frequency in shockwave lithotripsy.

Finally, H. WIKSELL and A.-C. KINN already concluded in 1995 that with an increasing shockwave release frequency in lithotripsy the efficiency thereof is decreasing.

It is the object of the present invention to avoid, as much as possible, the above-mentioned drawbacks in shockwave or pressure-wave type therapeutic apparatus of the above-mentioned kind, and to suggest a means which enables a physician to work as efficiently as possible with the above-mentioned therapeutic apparatus with the disadvantageous impacts on the patient being as small as possible.

This object is essentially achieved with the characterizing features of patent claim 1. The shock generator of an above-mentioned therapeutic apparatus that supplies the electrical energy for the shockwave or pressure wave source is connected to a

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control means which controls the release frequency of the shockwaves or pressure waves, hereinafter only called shockwaves, as a function of the pulse energy thereof in such a manner that higher pulse energies correlate with lower release frequencies of the shockwaves, and vice versa.

The further patent claims relate to special designs of the connection of the control means of the invention to the shock generator.

The energy applied per time unit can be fixed to a critical limit value by coupling the release frequency with the shockwave energy; this limit value can not or must not be exceeded. A high pulse energy determines the low release frequency, and higher release frequencies can be chosen for lower pulse energies. A coupling between shock generator and control means can be fixed according to hardware, software or software/hardware, i.e. in an obligatory or optional manner. For instance, the user may be bound by prerequisites or he is only informed that in a given case he is leaving the critical range. In practice, the critical values are empirically determined values. Scientifically speaking, it may be useful to determine said critical value from the so-called half-life period; half-life period is the period after which the intensity of the cavitation bubble has decreased to half the amount. The critical value may be lowered in an extreme case to such an extent that an interaction between successive shockwaves can be ruled out.

For controlling the intensity of the cavitation bubbles, it is possible – via a measuring device, e.g. via a measurement of light scattering or absorption, on the cavitation bubbles, to measure the intensity thereof in the shockwave field of the coupling liquid or the transmission medium of the shockwave to choose the measurement values according to the invention as a reference for the release frequency.
It is useful to correlate said measurement values also with the half-life period; the theoretical half-life period can here serve as a threshold value.

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In this connection it is possible to use a high-resolution ultrasound in the manner known per se to measure in vivo the cavitation as to its decrease intensity in the shockwave path, e.g. in kidney parenchyma.

It is e.g. also known that shockwaves introduced into the human body may affect cardiac activity by extrasystoly. In this case the shockwaves should be released in ECG-triggered manner. It is of advantage when the ECG signal from the ECG is processed for shockwave release also in the control means as additional information such that, when the ECG release frequency is above the critical release frequency, the ECG release frequency is reduced in that e.g. every second, third, ... trigger pulse is ignored so that the desired release frequency is achieved on average. Such a precautionary measure may save human lives under specific circumstances.

Description of the figures

The invention is graphically explained in the figures. Figs. 1 to 3 show three different block diagrams for illustrating the connection of the control means according to the invention to a shock generator of a shockwave source.

According to Fig. 1 a shockwave source 1 is connected via a shock generator 2 to a control means 3 in which control data to be observed can be input as limit values above all with respect to the pulse energy and the release frequencies of the shockwaves via an input means 4. The control means 3 of the invention can thus indicate to the treating physician via an alarm means 5 connected to the control means 3, namely by way of alarm signals, such as flash light, audio signals, or the like, that specific limit values will be reached soon or have already been exceeded. In principle, the connection of the control means 3 to the shock generator 2 may also be designed such that the limit values for the pulse energy and the release

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frequencies of the shockwaves are observed automatically and will thus have to be observed by the treating physician by necessity. For reasons of circuitry the shock generator 2 is additionally connected to the control means 3 via a trigger unit. A coupling bellows 8 is positioned between the patient 7 and the shockwave source 1.

Fig. 2 shows a further block diagram illustrating a possible different integration of the control means 3 of the invention into the surroundings of a shockwave type therapeutic apparatus.

The cavitation bubbles are here sensed via a detector 9 in the coupling pad 8 and the corresponding signals are evaluated in an analyzer 10. This kind of determining control data is based on the fact that the strength of the formation of the cavitation bubbles inside the coupling pad 8 between the shockwave source 1 and the patient 7 correlates with the cavitation bubble formation in the body of patient 7.

Additional information can be provided via the input channel 4 of the control means 3, e.g. an algorithm, as to how the analyzed cavitation is to be evaluated and the release frequency is to be controlled.

For detecting the cavitation bubbles the light scattering or absorption can e.g. be used with the help of a transmitter 11 in the form of a light source and a detector 9. The use of ultrasound would also be suited therefor.

According to the block diagram in Fig. 3 a transmitter 12 and a detector 13 measure the cavitation directly in the body of a patient 7. For this measurement ultrasound is preferably suited. Transmitter 12 and detector (receiver) 13 can advantageously be accommodated in one and the same housing.

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The physician may here also be warned via the control means 3 with the help of alarm means 5 as soon as he is within critical ranges. The alarm means 5 may also be used for automatically correlating the release frequency with the pulse energy of the shockwave.

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Patent Claims

1. Shockwave or pressure-wave type therapeutic apparatus, such as a lithotripter, whose therapy head is inter alia equipped with a shockwave source, characterized in that the shockwave source (1) is connected via a shock generator (2) to a control means (3) which controls the release frequency of the shockwaves as a function of the pulse energy thereof such that increased pulse energies correlate with lower release frequencies of the shockwaves, and vice versa.

2. Shockwave or pressure-wave type therapeutic apparatus according to claim 1, characterized in that in the control means (3) the correlation between release frequency and pulse energy of the shockwaves can be set according to software and/or hardware.

3. Shockwave or pressure-wave type therapeutic apparatus according to claims 1 and 2, characterized in that the release frequency of the shockwaves is below a critical value, e.g. the so-called half-life period.

4. Shockwave or pressure-wave type therapeutic apparatus according to claims 1 to 3, characterized in that the control means (3) is connected to an alarm means (5).

5. Shockwave or pressure-wave type therapeutic apparatus according to one or several of claims 1 to 4, characterized in that the control means (3) automatically controls the shock generator (2) according to a fixed program according to the limit values entered for pulse energy and release frequency of the shockwaves.

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6. Shockwave or pressure-wave type therapeutic apparatus according to one or several of claims 1 to 5, characterized in that the shockwave source (1) can exclusively be switched on via the control means (3) and is only operative via said means as long as said control means (3) controls the therapy according to the predetermined correspondence curves of release frequency and pulse energy.

7. Shockwave or pressure-wave type therapeutic apparatus according to one or several of claims 1 to 6, characterized in that a detector (9) is arranged in the coupling pad (8) connected to said shockwave source (1), said detector corresponding with a transmitter (11) for checking the intensity of the cavitation bubbles in the coupling liquid or in the transfer medium, and said detector passing on the detected signals via an analyzer (10) to the control means (3).

8. Shockwave or pressure-wave type therapeutic apparatus according to claim 7, characterized in that the transmitter (11) is designed as a light source so that light scattering and/or absorption of the cavitation bubbles is detected by the detector (9) and can be passed on via the analyzer (10) to the control means (3).

9. Shockwave or pressure-wave type therapeutic apparatus according to claim 8, characterized in that the transmitter (11) is designed as an ultrasonic generator, and that the detected signals are passed on - by analogy to claim 8 - to the control means (3).

10. Shockwave or pressure-wave type therapeutic apparatus according to one or several of claims 1 to 7, characterized in that the intensity of the cavitation bubbles is detected by means of a transmitter (12) or a detector (13) directly

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in the body of a patient (7) and is passed on via the analyzer (10) to the control means (3).

11. Shockwave or pressure-wave therapeutic apparatus according to claim 10, characterized in that the transmitter (12) is designed as an ultrasonic generator.

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