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(54) **OEDEMA DETECTION**

NACHWEIS VON ÖDEM

DETECTION D'OEDEME

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Description

Background of the Invention

[0001] The present invention relates to an apparatus for detecting tissue oedema, and in particular, to an apparatus for detecting tissue oedema using impedance measurements.

Description of the Prior Art

[0002] The reference to any prior art in this specification is not, and should not be taken as, an acknowledgment or any form of suggestion that the prior art forms part of the common general knowledge.

[0003] Lymphoedema is a condition characterised by excess protein and oedema in the tissues as a result of reduced lymphatic transport capacity and/or reduced tissue proteolytic capacity in the presence of a normal lymphatic load. Acquired, or secondary lymphoedema, is caused by damaged or blocked lymphatic vessels. "The commonest inciting events are surgery and/or radiotherapy. However, onset of lymphoedema is unpredictable and may develop within days of its cause or at any time during a period of many years after that cause.

[0004] WO00/79255 describes a method of detection of oedema by measuring bioelectrical impedance at two different anatomical regions in the same subject at a single low frequency alternating current. The two measurements are analysed to obtain an indication of the presence of tissue oedema by comparing with data obtained from a normal population.

[0005] Other known methods of analysis of bioelectrical impedance measurements involve determining a phase and amplitude value for the measured signals. The measurement of amplitude is straightforward but the measurement of phase is more complicated and therefore the required equipment is costly.

[0006] US6496725 discloses an apparatus for determining a degree of restoration of a diseased part, comprising: two pairs of electrodes; an electric current source; a voltage measuring unit; and an arithmetic unit. Two pairs of electrodes are contacted with a skin in the surrounding area of the diseased part, and the electric current source feeds a measuring current via a selected pair of the electrodes. The voltage measuring unit measures a voltage between another selected pair of the electrodes, and the arithmetic unit calculates a parameter representing a degree of restoration of the diseased part based on the measurement data from the voltage measuring unit.

Summary of the Present Invention

[0007] In a first broad form the present invention provides an apparatus for detecting tissue oedema in a subject according to claim 1.

[0008] Other forms are described by dependent claims 2 - 5.

Brief Description of the Drawings

[0009] An example of the present invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a schematic of an example of a theoretical equivalent circuit for biological tissue;
Figure 2 is an example of a locus of impedance known as a Cole-Cole plot;
Figure 3 is a schematic of an example of a single channel bioimpedance apparatus;
Figure 4 is a schematic of an example of a dual channel bioimpedance apparatus; and,
Figure 5 is a flow chart of an example of a process for evaluating tissue oedema.

Detailed Description of the Preferred Embodiments

[0010] Figure 1 is an example of an equivalent circuit that effectively models the electrical behaviour of biological tissue. The equivalent circuit has two branches that represent current flow through extracellular fluid and intracellular fluid. The extracellular component of biological impedance is represented by R_e and the intracellular component is represented by R_i. Capacitance of the cell membrane in the intracellular path is represented by C.

[0011] The relative magnitudes of the extracellular and intracellular components of impedance of an alternating current (AC) are frequency dependent. At zero frequency the capacitor acts as a perfect insulator and all current flows through the extracellular fluid, hence the resistance at zero frequency, R_0, equals R_e. At infinite frequency the capacitor acts as a perfect conductor and the current passes through the parallel resistive combination. The resistance at infinite frequency is given by $R_\infty = R_iR_e/(R_i+R_e)$. The measured values of R_0 and R_∞ would therefore directly provide the values of R_e and R_i. required for estimation of extracellular water (ECW) and intracellular water (ICW), which lead to identification of

oedema by comparison between affected and unaffected body regions. However, as is well known, the practical constraints of skin-electrode impedance do not permit application of DC or very high frequency AC currents, hence the values of the frequencies commonly used can only approximate the ideal measurement frequencies.

[0012] The impedance of the equivalent circuit of Figure 1 at an angular frequency ω, where $\omega=2\pi$*frequency, is given by:

$$Z = R_\infty + \frac{R_0 - R_\infty}{1+(j\omega\tau)} \qquad (1)$$

where:

$$R_\infty = R_i R_e/(R_i+R_e),$$

$R_0=R_e$ and,
τ is the time constant of the capacitive circuit.

[0013] These values can be estimated by extrapolating what is known as a Cole-Cole plot, which is a plot of the vector sum of the resistance R and reactance X that sum to impedance Z. A Cole-Cole plot of reactance against resistance is shown in Figure 2 with an impedance vector Z at a given frequency.

[0014] It is also known that biological specimens deviate from the equivalent circuit because the cell membrane is an imperfect capacitor and there is a large variation between cell types in the current path. This results in a Cole-Cole plot of a biological specimen having a depressed centre compared to the equivalent circuit plot shown in Figure 2. A more accurate expression for impedance in a biological sample is therefore given by:

$$Z = R_\infty + \frac{R_0 - R_\infty}{1+(j\omega\tau)^{(1-\alpha)}} \qquad (2)$$

where α has a value between 0 and 1 and can be thought of as an indicator of the deviation of a real system from the ideal model.

[0015] Another important value is the impedance Z_c at the peak of the locus in Figure 2. This peak occurs when $\omega=1/\tau$, which is referred to as the characteristic angular frequency, ω_c which equals $2\pi f_c$.

[0016] As explained above, the prior art approach to determining the desired values of R_0 and R_∞ has been to make impedance measurements at multiple frequencies and to construct a section of a Cole-Cole plot. The plot can be extrapolated to determine R_0, R_∞ and Z_c. This procedure takes a significant amount of processing time and therefore makes real time monitoring of bioimpedance problematic. Furthermore, the measurements require determination of both phase and amplitude values which require relatively sophisticated, and therefore expensive, equipment.

[0017] Equation (2) has four, unknowns, R_0, R_∞, τ and α. The values of these unknowns can be determined by taking measurements at four discrete frequencies, and solving four simultaneous equations. Any of the established methods such as matrix inversion or numerical iteration can be used to solve the equations for the unknown values.

[0018] The values determined by this process compare favourably with the values obtained by the conventional curve fitting technique, in which measured impedances are used to plot a locus similar to that shown in Figure 2, thereby allowing values of R_0 and R_∞ to be obtained.

[0019] Greater, accuracy can be achieved by taking measurements at a larger number of frequencies, albeit at a cost in processing overhead. Furthermore, accurate results can usefully be derived by selecting discrete frequencies that span the range of frequencies normally used in multiple frequency bioelectrical impedance analysis (5KHz to 1000KHz).

[0020] Once the values of R_0, R_∞ and Z_c are determined they can be used in various ways to detect and quantify oedema in a body region. One approach to this quantification is to compare measurements taken at a first body region against measurements taken at a second body region.

[0021] The second measurements may be taken in a paired unaffected body region. For example, a first measurement may be made at a location on the left leg and a second measurement made at the same location on the right leg of the same patient where the right leg is unaffected by tissue oedema. It is clear to a skilled addressee that other paired anatomical regions may be similarly used when performing the above described methodology. For example, paired areas of the thorax may be assessed.

[0022] It is, however, possible to take the second measurement at a dissimilar body region. For example, the first reading may be taken on a leg, and a second reading may be taken on an arm. The analysis of these readings will necessarily involve some different considerations. Again, it is clear to a skilled addressee that a wide range of dissimilar anatomical structures may be used for these measurements, such as a leg and the chest wall. This form of the method is of particular use where two paired anatomical sites are both affected by tissue oedema. The comparison of readings taken in two such affected sites will be distorted and will not produce a reliable indicator of tissue oedema.

[0023] As a further alternative, the method may be applied to two or more measurements on the same anatomical region of a subject where those readings are separated in time. For example, a series of readings may be taken on a single limb prior to and subsequent to surgery with a known risk of lymphoedema as a side effect. Analysis of any two or more readings may indicate the early stage of developing lymphoedema and thereby provide a distinct advantage in that the prognosis may be greatly improved by early and aggressive therapeutic intervention. This technique may also be used to monitor the progress of oedema with comparison made between measurements of an affected site.

[0024] In the case of comparison of any two dissimilar regions it is known that a correcting factor may be required. A correcting factor may be established by surveying a population of clinically unaffected subjects:
Another approach is a modification of the technique described in a publication, (Cornish, B.H.; Thomas B.J.; Ward L.C. ; Angiology Vol 53, No 1, pp 41-47 2002). In this approach the measured parameters are used to calculate an index Ri/Re. as indicative of the ratio of extracellular fluid to intracellular fluid. The extracellular fluid resistance Re is determined from

$$R_e = R_0$$

and intracellular fluid resistance R_i is determined from

$$R_i = \frac{R_\infty R_e}{R_e - R_\infty}$$

[0025] Thus, the index *I*, which is indicative of the ratio of extra- to intra-cellular fluid is given by the equation:

$$I = \frac{R_i}{R_e} = \frac{R_\infty}{R_0 - R_\infty} \qquad (3)$$

[0026] This approach has particular application to monitoring oedema overtime as a plot of the index against time can disclose the onset and rate of advance of oedema.

[0027] Referring to Figure. 3, there is shown a schematic of an apparatus for measuring impedance, including an oscillator 20, divider 21 and filter 22 connected in series to produce alternating current at a number of discrete frequencies when connected to a power, source (not shown). The alternating current passes through cable 23 to electrode 24 through intervening tissue (not shown) to electrode 25, which is connected to a reference 26 via cable 27.

[0028] Monitoring electrodes 28, 29 are in connection with bioimpedance measuring meter 30 via cables 31, 32. Signals from bioimpedance measuring meter 30 are passed to analogue/digital converter 33, which is in signal connection with data storing unit 34, which retains the digitised reading of bioimpedance.

[0029] The applied signal is suitably derived from a constant current source to ensure that the generated current does not exceed the Australian Standard of a maximum of 32V and a maximum current of 100μA at 10 kHz. The current limit increases to an upper threshold of 1mA at 1000kHz. The applied signal could be derived from a constant voltage source rather than a constant current source providing a mechanism is provided to maintain the safety standard.

[0030] A first reading of bioelectrical impedance is taken from a first anatomical region of a subject and stored in data storing unit 34.

[0031] The processor 35 calculates the values R_0, R_∞, τ and α by solving the equation (2) and transfers the result to second data storing unit 36. The values may also be presented on display 37.

[0032] The processor may also calculate an indicator of oedema, such as the R_i/R_e index, and display this on a scale with a movable indicator. There may also be a simple series of lights which, when illuminated, indicate any one of "unaffected", "possibly affected" or "affected". The display may be any other suitable form of indicator.

[0033] It is more convenient for many of the techniques for assessing oedema to use a two-channel bioimpedance meter as shown in Figure 4. In this case, current is passed between the electrodes 24, 25 on, for example, one arm 47 and between the electrodes 24A, 25A on the opposite arm 48. This can be achieved either sequentially, for example

through the use of multiplexing, or simultaneously. Monitoring electrodes 28, 29 on the first arm 47 measure bioelectrical impedance while monitoring electrodes 28A, 29A measure bioelectrical impedance on the opposite arm 48. A measuring meter 30 has two channels for simultaneously monitoring signals provided from the monitoring electrodes 28, 29; 28A; 29A. The signals are passed through an analogue/digital converter 33 and then analysed by processor 35. The results are stored in memory 36 and shown on display 37.

[0034] Accordingly the processor 35 operates to analyse the impedance signals and use this to provide an evaluation of the presence, absence or degree of tissue oedema. This is typically performed in accordance with applications software provided in the memory. It will be appreciated from this that the processor 35, the memory 36 and the display 37 may typically be formed from a processing system, such as a computer system, computer server, desktop computer, laptop, specialised hardware, or the like.

[0035] An example of the process for monitoring the impedance signals and evaluating tissue oedema will now be described with reference to the flowchart shown in Figure 5.

[0036] In particular, at step 600, the impedance at first and second body segments are measured using the apparatus shown in Figure 4. In this example, the body segments are different body segments and may include for example an arm and a leg.

[0037] At step 610 the processor 35 determines values of R_0 and R_∞ for each body segment. This can be achieved using a number of mechanisms. For example, given that there are four unknown parameters R_0, R_∞, τ, α, the equation (2) can be used to determine four simultaneous equations, which can then be solved using appropriate mathematical techniques. Alternatively, the measured impedance values can be plotted to derive an arc similar to that shown in Figure 2, which then further allows the values of R_0 and R_∞ to be determined. Alternative techniques may also be used.

[0038] At step 620 the values of R_0 and R_∞ are used to determine an index *I* for each body segment. The index is based on the ratio of the extracellular to intracellular fluid and is therefore calculated using equation (3).

[0039] At step 630 an index ratio *IR* based on a ratio of the first body segment index I_1 to second body segment index I_2 is calculated, with this being used in evaluating the presence, absence or degree of oedema.

[0040] This is possible, as, for a healthy subject, there is generally a degree of similarity of intra- and extra-cellular fluid levels, even between different body segments. Thus, for example, if the subject is suffering from a condition other than oedema, which causes a general change in the ratio of extra- to intra- cellular fluid, then this should affect all body segments roughly equally. As a result, assuming that neither body segment has tissue oedema, then the index ratio *IR* should remain relatively constant for a given individual.

[0041] It will be appreciated that in the event that the properties of each body segment are equal, then the index ratio should have a value in the region of 1. Typically however, minor variations in tissue will occur between different body segments, and this can be accounted for in one of two ways.

[0042] Firstly, as shown at step 640, the index ratio *IR* can be compared to a predetermined range. In this case, the range is used to account for variations between body segments that are not attributable to tissue oedema. It will therefore be appreciated that the range is therefore typically set to take into account the difference in index ratio *IR* between different body portions in a number of different subjects. This range can therefore be set based on data collected from a number of healthy subjects.

[0043] In any event, if the index ratio *IR* falls outside the predetermined range, then this is used by the processor 35 to determine that tissue oedema is present in one of the body segments at step 650.

[0044] Furthermore, an assessment of the value of the index ratio *IR* can be used in assessing the degree of tissue oedema. Thus, for example, a number of value ranges can be defined, with each range corresponding to a different degree of oedema. In this instance, the processor 35 determines within which range the index ratio *IR* falls, and uses this to generate an indication of the likely degree of tissue oedema.

[0045] The value of the index ratio *IR* will also depend on the body segments that have been selected and accordingly, in general a different range will be selected for the comparison depending on the body segments under consideration.

[0046] It will also be appreciated that the index ratio *IR* can be used to indicate in which body segment the oedema is present, and this can be based on whether the index ratio *IR* is greater than or less than 1.

[0047] The index ratio *IR* may also depend on a number of factors, such as the subject's age, weight, sex and height, and again a respective range can be selected based on these factors. However, to avoid the need for an assessment of such factors, an alternative process of longitudinal analysis can be performed.

[0048] In this case, at step 660 the processor 35 can compare the index ratio *IR* to previously determined index ratios IR_{prev} measured for the same subject, on the same body segments. In this situation, the previously determined index ratios IR_{prev} are preferably determined prior to the onset of oedema but this is not essential.

[0049] In any event, previous measurements of the same body segments on the same subject will automatically account for inherent variations in tissue properties, which in turn cause different values for the ratio of extra- to intracellular fluid even if tissue oedema is not present.

[0050] In this case, the processor 35 assesses whether the current index ratio *IR* value is different to the previous index ratio IR_{prev}. If there is change in the value, then the direction in change in value can indicate either increasing or

decreasing levels of tissue oedema, with the magnitude of the change being used to indicate a degree of change at step 650.

[0051] In general, at step 650, the display 37 is used to display an indication of one or more of:

- one or more index ratios
- one or more indexes; and,
- the presence, absence or degree of tissue oedema.

[0052] It will therefore be appreciated from this that the above-described methodology provides two different methods of determining the onset for oedema. This can be achieved either by performing a longitudinal analysis in which the index ratio *IR* is compared to previously determined index ratios IR_{prev}. Alternatively the index ratio *IR* can be compared to one or more absolute index ratio ranges.

[0053] In practice, a combination for the two approaches will generally be used. Thus, for example, when a patient is first admitted for a procedure to be performed, a comparison to absolute index ratio ranges may be used to confirm that it is unlikely that the patient has oedema.

[0054] The measured index ratio *IR* can then be used to form the reference value of the index ratio IR_{prev}, allowing subsequent measurements to be compared thereto.

[0055] By using the index ratio *IR* described above, this allows variation in tissue properties between different body portions to be taken into account when assessing the presence, absence or degree of tissue oedema, and accordingly, this allows the onset of bilateral oedema to be detected. This is in contrast to previous techniques, in which like body segments are compared. In this case, if impedance measurements of a limb, such as a leg, are compared to measurements from the other corresponding limb, then in the event that oedema is present in both limbs, the impedance measurements will be similar, and will not therefore indicate that oedema is present.

[0056] As mentioned above, the values of R_0 and R_∞ can be determined in any one of a number of ways. However, in general it is preferred to be able to determine the values in real-time to thereby vastly enhance the oedema assessment process. In particular, this allows measurements to be made of the patient, with the processor 35 generating an indication of the degree of tissue oedema in real-time.

[0057] The discussion has referred to both oedema and lymphoedema, as it is clear to a skilled addressee that the above apparatus may be utilised on any form of tissue oedema. However, it is also likely that the predominant use of the apparatus will be directed mainly to lymphoedema due to its clinical relevance. However, this may change in a specific situation or with time. The apparatus may also be used in comparing a reading from one anatomical region with a separate unpaired region. For example, a reading taken on central localised oedema (eg: ascites) may be referenced against a nonoedematous structure such as a limb.

[0058] Throughout the specification, the aim has been to describe the preferred embodiments of the invention without limiting the invention to any one embodiment or specific collection of features. Various changes and modifications may be made to the embodiments described and illustrated without departing from the present invention.

Claims

1. Apparatus for detecting tissue oedema in a subject, the apparatus including a processing system adapted to:

a) determine a measured impedance for each of a first and a second body segments, where the first and second body segments are different types of body segments; and

b) determine the presence, absence or degree of tissue oedema using measured impedances for the first and second body segments wherein: determining a measured impedance for each of the first and second body segments comprises

i) determining (600) a measured impedance for each of the first and second body segments at four discrete frequencies (ω); and

ii) determining (610) values for parameters R0, R∞, τ, and α from the measured impedance values by solving the equation:

$$Z = R_\infty + \frac{R_0 - R_\infty}{1 + (j\omega\tau)^{(1-\alpha)}}$$

for each of the body segments at the four discrete frequencies (ω), where:

Z is the measured impedance at angular frequency ω,
R_0 is the resistance at zero frequency;
$R\infty$ is the resistance at infinite frequency;
τ is a time constant, and
α has a value between 0 and 1; and wherein determining the presence, absence or degree of tissue oedema comprises:

i) for each of the body segements, and using the determined parameter values for R0 and R∞, determining (620) an index (I) indicative of a ratio of the extra-cellular to intra-cellular fluid using the equation:

$$I = \frac{R_\infty}{R_0 - R_\infty}$$

ii) calculating (630) an index ratio (IR) based on a ratio of the first body segment index to the second body segment index;
iii) determining (650) the presence, absence or degree of tissue oedema based on the index ratio (IR).

2. Apparatus according to claim 1, wherein the processing system is for:

a) comparing the index ratio to at least one reference; and,
b) determining the presence, absence or degree of bilateral tissue oedema based on the results of the comparison.

3. Apparatus according to claim 2, wherein the reference includes an index ratio previously determined for the subject.

4. Apparatus according to any one of the claims 1 to 3, wherein the apparatus includes a display (37), and wherein the processing system is for displaying an indication on the display (37) of at least one of:

a) the parameter values;
b) the ratio of extra-cellular to intra-cellular fluid; and,
c) an indication of the at least one of the presence, absence or degree of tissue oedema in the subject.

5. Apparatus according to claim 1, wherein the apparatus includes:

a) a current supply (20) for generating an alternating current at each of a plurality of frequencies;
b) at least two supply electrodes (25, 26) for applying the generated alternating current to a subject;
c) at least two measurement electrodes (28, 29) for detecting a voltage across the subject; and,
d) a sensor (30) coupled to the measurement electrodes (28, 29) for determining the voltage, the sensor (30) being coupled to the processing system to thereby allow the processing system to determine the measured impedances.

Patentansprüche

1. Vorrichtung zum Detektieren eines Gewebeödems bei einem Patienten, wobei die Vorrichtung ein Verarbeitungssystem enthält, das ausgelegt ist zum:

a) Bestimmen einer gemessenen Impedanz für jeweils ein erstes und ein zweites Körpersegment, wobei das erste und das zweite Körpersegment unterschiedliche Arten von Körpersegmenten sind; und
b) Bestimmen des Vorhandenseins, der Abwesenheit oder des Grads eines Gewebeödems unter Verwendung gemessener Impedanzen für das erste und das zweite Körpersegment, wobei:

das Bestimmen einer gemessenen Impedanz für jeweils das erste und das zweite Körpersegment umfasst:

i) Bestimmen (600) einer gemessenen Impedanz für jeweils das erste und das zweite Körpersegment

bei vier diskreten Frequenzen (ω); und
ii) Bestimmen (610) von Werten für die Parameter R0, R∞, τ und α von den gemessenen Impedanzwerten durch Lösen der Gleichung:

$$Z = R_\infty + \frac{R_0 - R_\infty}{1 + (j\omega\tau)^{(1-\alpha)}}$$

für jedes der Körpersegmente bei den vier diskreten Frequenzen (ω), wobei:

Z die gemessene Impedanz bei der Winkelfrequenz ω ist,
R_0 der Widerstand bei Nullfrequenz ist;
R∞ der Widerstand bei unendlicher Frequenz ist;
T eine Zeitkonstante ist, und
α einen Wert zwischen 0 und 1 aufweist; und wobei

das Bestimmen des Vorhandenseins, der Abwesenheit oder des Grads eines Gewebeödems umfasst:

i) für jedes der Körpersegmente und unter Verwendung der bestimmten Parameterwerte für R0 und R∞, Bestimmen (620) eines Index (I), der ein Verhältnis des extrazellulären zu dem intrazellulären Fluid anzeigt, unter Verwendung der Gleichung:

$$I = \frac{R_\infty}{R_0 - R_\infty}$$

ii) Berechnen (630) eines Indexverhältnisses (IR) basierend auf einem Verhältnis des ersten Körpersegmentindex zum zweiten Körpersegmentindex;
iii) Bestimmen (650) des Vorhandenseins, der Abwesenheit oder des Grads eines Gewebeödems basierend auf dem Indexverhältnis (IR).

2. Vorrichtung nach Anspruch 1, wobei das Verarbeitungssystem für Folgendes dient:

a) Vergleichen des Indexverhältnisses mit mindestens einer Referenz; und
b) Bestimmen des Vorhandenseins, der Abwesenheit oder des Grads eines bilateralen Gewebeödems basierend auf den Ergebnissen des Vergleichs.

3. Vorrichtung nach Anspruch 2, wobei die Referenz ein Indexverhältnis enthält, das zuvor für den Patienten bestimmt wurde.

4. Vorrichtung nach einem der Ansprüche 1 bis 3, wobei die Vorrichtung eine Anzeige (37) enthält und wobei das Verarbeitungssystem zum Anzeigen einer Angabe auf der Anzeige (37) von mindestens einem der Folgenden dient:

a) den Parameterwerten;
b) dem Verhältnis von extrazellulärem zu intrazellulärem Fluid; und
c) einer Angabe des Vorhandenseins, der Abwesenheit und/oder des Grads eines Gewebeödems in dem Patienten.

5. Vorrichtung nach Anspruch 1, wobei die Vorrichtung enthält:

a) eine Stromversorgung (20) zum Erzeugen eines Wechselstroms bei jeder einer Vielzahl von Frequenzen;
b) mindestens zwei Versorgungselektroden (25, 26) zum Anlegen des erzeugten Wechselstroms an einen Patienten;
c) mindestens zwei Messelektroden (28, 29) zum Detektieren einer Spannung an dem Patienten; und
d) einen Sensor (30), der mit den Messelektroden (28, 29) zum Bestimmen der Spannung gekoppelt ist, wobei der Sensor (30) mit dem Verarbeitungssystem gekoppelt ist, um dadurch dem Verarbeitungssystem zu gestat-

ten, die gemessenen Impedanzen zu bestimmen.

Revendications

1. Appareil permettant de détecter un oedème tissulaire chez un patient, l'appareil comprenant un système de traitement conçu pour :

a) déterminer une impédance mesurée pour chacun d'un premier et d'un second segment corporel, les premier et second segments corporels étant des types différents de segments corporels ; et
b) déterminer la présence, l'absence ou le degré de l'oedème tissulaire à l'aide des impédances mesurées pour les premier et second segments corporels, dans lequel :

la détermination d'une impédance mesurée pour chacun des premier et second segments corporels consiste à

i) déterminer (600) une impédance mesurée pour chacun des premier et second segments corporels à quatre fréquences discrètes (ω) ; et
ii) déterminer (610) des valeurs pour les paramètres R_0, $R\infty$, τ et α à partir des valeurs d'impédance mesurées en résolvant l'équation :

$$Z = R_\infty + \frac{R_0 - R_\infty}{1 + (j\omega\tau)^{(1-\alpha)}}$$

pour chacun des segments corporels aux quatre fréquences discrètes (ω), où :

Z est l'impédance mesurée à une fréquence angulaire ω,

R_0 est la résistance à une fréquence nulle ;
$R\infty$ est la résistance à une fréquence infinie ;
τ est une constante de temps, et
α a une valeur entre 0 et 1 ; et dans lequel

la détermination de la présence, de l'absence ou du degré de l'oedème tissulaire consiste à :

i) pour chacun des segments corporels, et à l'aide des valeurs de paramètres déterminées pour R_0 et $R\infty$, déterminer (620) un indice (I) indiquant un rapport du fluide extracellulaire au fluide intracellulaire à l'aide de l'équation :

$$I = \frac{R_\infty}{R_0 - R_\infty}$$

ii) calculer (630) un rapport d'indice (IR) basé sur un rapport du premier indice de segment corporel au second indice de segment corporel ;
iii) déterminer (650) la présence, l'absence ou le degré de l'oedème tissulaire sur la base du rapport d'indice (IR).

2. Appareil selon la revendication 1, dans lequel le système de traitement est destiné à :

a) comparer le rapport d'indice à au moins une référence ; et,
b) déterminer la présence, l'absence ou le degré de l'oedème tissulaire bilatéral sur la base du résultat de la comparaison.

3. Appareil selon la revendication 2, dans lequel la référence comprend un rapport d'indice précédemment déterminé pour le patient.

4. Appareil selon l'une quelconque des revendications 1 à 3, l'appareil comprenant un afficheur (37), et dans lequel le système de traitement est destiné à afficher une indication sur l'afficheur (37) d'au moins un parmi :

a) les valeurs de paramètres ;
b) le rapport du fluide extracellulaire au fluide intracellulaire ; et,
c) une indication de la présence et/ou de l'absence et/ou du degré de l'oedème tissulaire chez le patient.

5. Appareil selon la revendication 1, l'appareil comprenant :

a) une alimentation en courant (20) permettant de générer un courant alternatif à chaque fréquence d'une pluralité de fréquences ;
b) au moins deux électrodes d'alimentation (25, 26) permettant d'appliquer le courant alternatif généré à un patient ;
c) au moins deux électrodes de mesure (28, 29) permettant de détecter une tension sur le patient ; et,
d) un capteur (30) couplé aux électrodes de mesure (28, 29) permettant de déterminer la tension, le capteur (30) étant couplé au système de traitement pour permettre de ce fait que le système de traitement détermine les impédances mesurées.

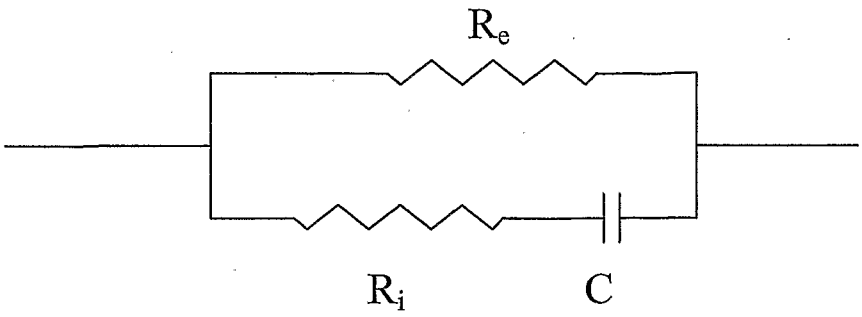


FIG 1

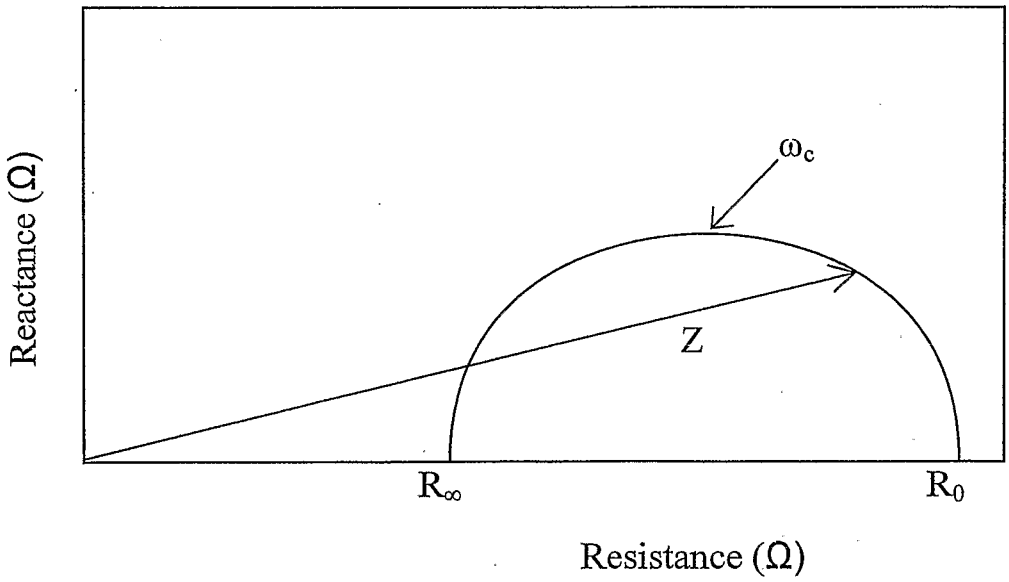


FIG 2

FIG. 3

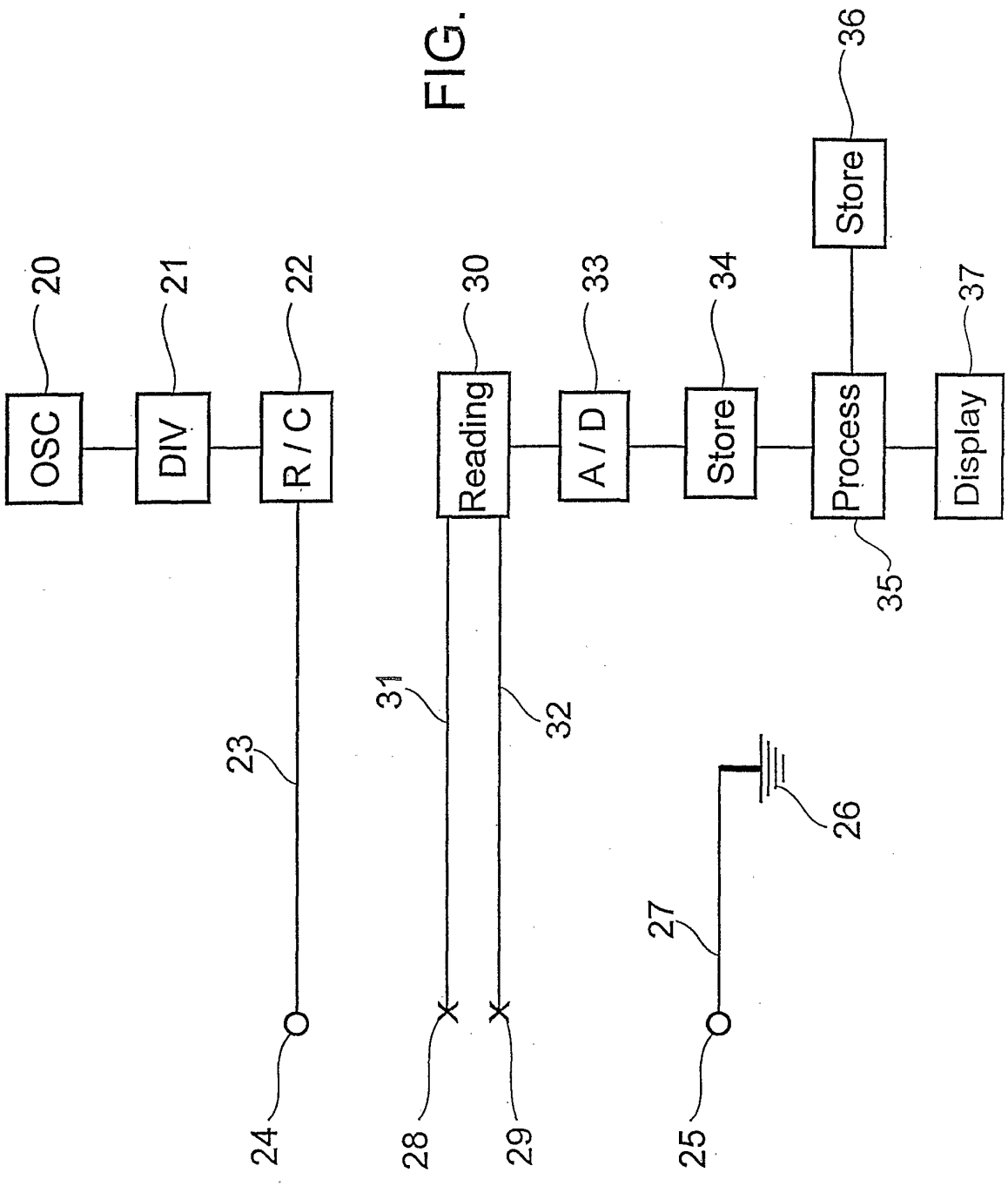
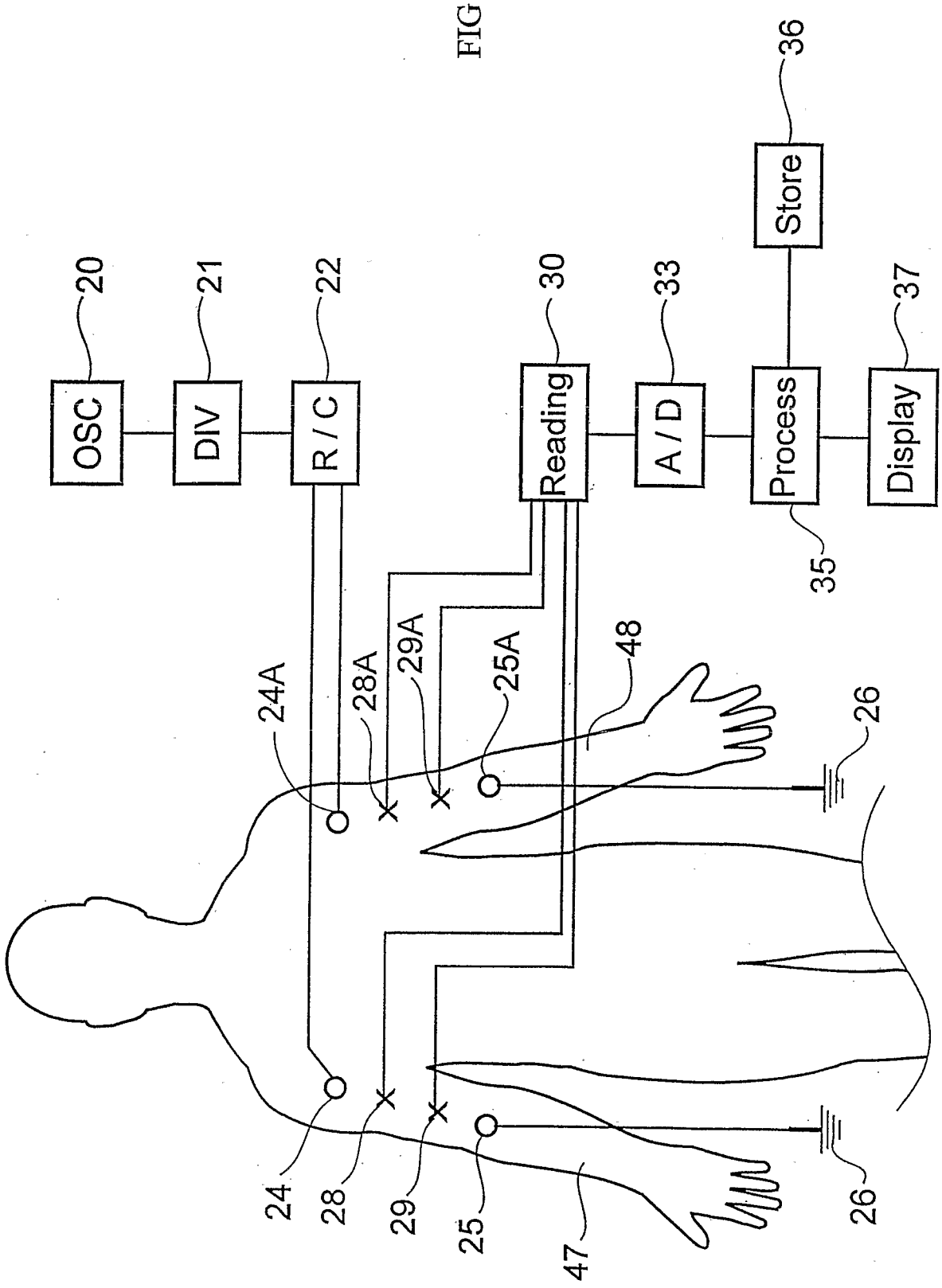

OSC
DIV
R / C
Reading
A / D
Store
Process
Display
Store
20
21
22
30
33
34
37
36
35
23
24
31
32
28
29
27
25
26

FIG 4


OSC
DIV
R / C
Reading
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20
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24A
28A
29A
25A
48
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25
47
26

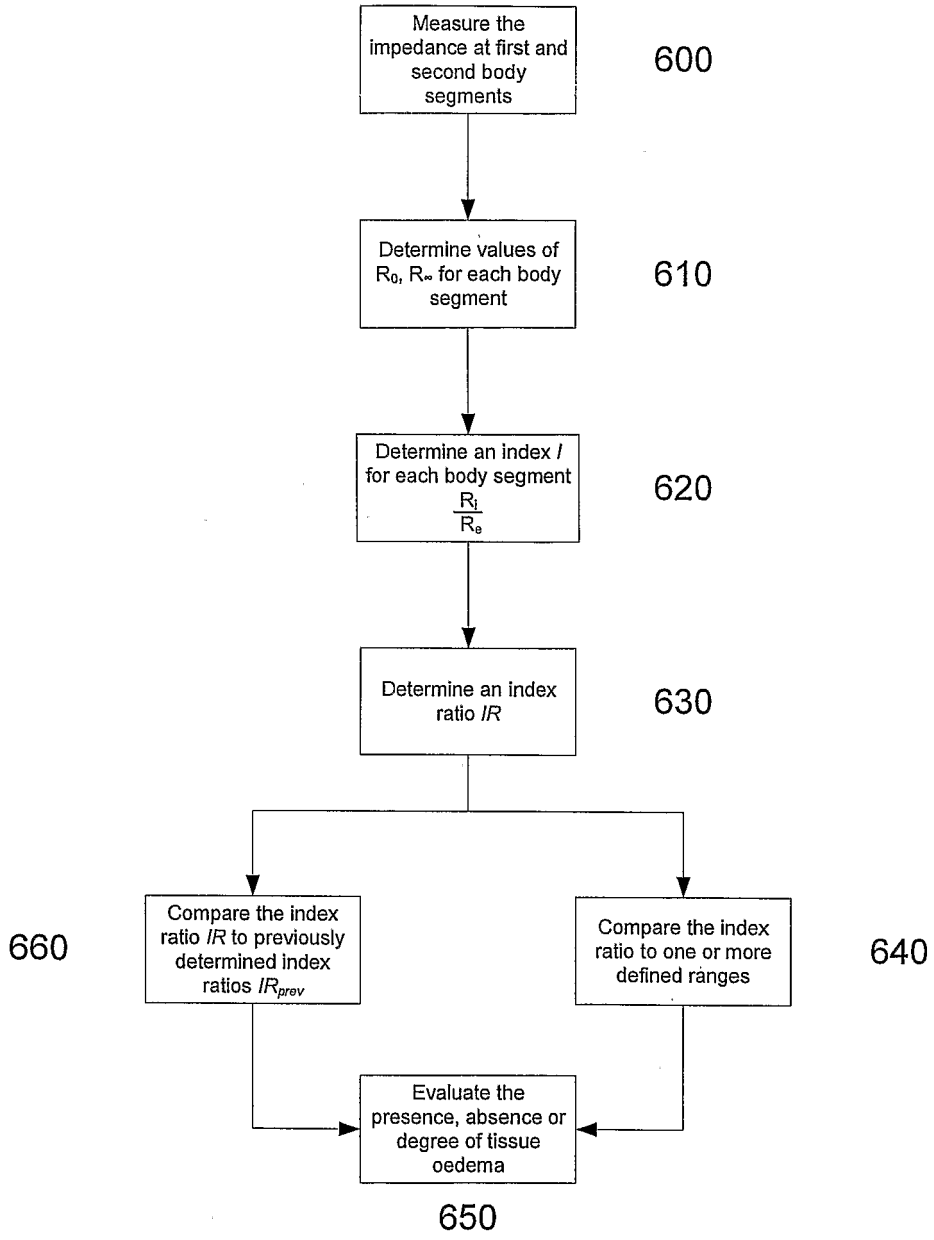
Measure the impedance at first and second body segments
600
Determine values of R_0, R_∞ for each body segment
610
Determine an index *I* for each body segment $\frac{R_i}{R_e}$
620
Determine an index ratio *IR*
630
Compare the index ratio *IR* to previously determined index ratios IR_{prev}
660
Compare the index ratio to one or more defined ranges
640
Evaluate the presence, absence or degree of tissue oedema
650

Fig. 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 0079255 A **[0004]**
- US 6496725 B **[0006]**

Non-patent literature cited in the description

- **CORNISH, B.H. ; THOMAS B.J. ; WARD L.C.** *Angiology,* 2002, vol. 53 (1), 41-47 **[0024]**

专利名称(译)	水肿检测		
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申请号	EP2005750150	申请日	2005-06-17
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申请(专利权)人(译)	昆士兰大学 作者：昆士兰大学		
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IPC分类号	A61B5/053 A61B5/00		
CPC分类号	A61B5/0537 A61B5/4869 A61B5/4878 A61B5/7225		
优先权	2004903314 2004-06-18 AU		
其他公开文献	EP1765161A4 EP1765161A1		
外部链接	Espacenet		

摘要(译)

一种检测受试者的组织水肿的方法。该方法包括确定第一和第二身体部分的测量阻抗。然后针对每个身体片段计算指示细胞外液与细胞内液之比的指数，将其用于基于第一和第二身体片段的指数确定指数比。指数比值可以依次用于例如通过将指数比值与参考值或先前确定的指数比值进行比较来确定组织水肿的存在，不存在或程度。