(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 890 302 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
10.08.2016 Bulletin 2016/32

(21) Application number: **13779925.0**

(22) Date of filing: **12.08.2013**

(51) Int Cl.:
A61B 8/06 *(2006.01)* ***A61B 18/00*** *(2006.01)*

(86) International application number:
PCT/IB2013/056585

(87) International publication number:
WO 2014/033577 (06.03.2014 Gazette 2014/10)

(54) **ULTRASONIC VOLUME FLOW MEASUREMENT FOR ABLATION THERAPY**

ULTRASCHALLVOLUMEN-DURCHFLUSSMESSUNG FÜR EINE ABLATIONSTHERAPIE

MESURE DE DÉBIT VOLUMIQUE ULTRASONORE POUR UNE THÉRAPIE D'ABLATION

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **01.09.2012 US 201261696156 P**

(43) Date of publication of application:
08.07.2015 Bulletin 2015/28

(73) Proprietor: **Koninklijke Philips N.V.**
5656 AE Eindhoven (NL)

(72) Inventors:
- **JAGO, James Robertson**
  5656 AE Eindhoven (NL)
- **NG, Gary Cheng-How**
  5656 AE Eindhoven (NL)

(74) Representative: **Gravendeel, Cornelis**
Philips Intellectual Property & Standards
High Tech Campus 5
5656 AE Eindhoven (NL)

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Description

[0001] This invention is defined in claim 1 and relates to medical diagnostic ultrasound systems and, in particular, to diagnostic ultrasound systems which provide a measure of blood volume flow for ablation therapy.

[0002] The use of local and minimally invasive therapies as alternatives to surgery are growing rapidly for the treatment of many lesions, especially cancer, and in many parts of the body. The advantages of these minimally invasive treatments include fewer side effects, faster recovery and, in some cases, the possibility to treat more advanced disease. One of the most important of these minimally invasive therapies is tissue ablation, where the diseased tissue is destroyed by application of local tissue heating, cooling, or other means. Some examples of ablation methods in most common use are r.f ablation, microwave ablation, HIFU (high intensity focused ultrasound), and cryo-ablation.

[0003] One of the key steps for successful tissue ablation is to determine, prior to conducting the procedure, the appropriate placement of the ablation probe within the lesion and the duration of treatment. Each ablation probe has a treatment region around which the temperature is changed enough to cause cell death. This region is typically called the "burn zone". Fully covering the cancerous lesion with the burn zone ensures that there are no residual cells that could result in recurrence of the cancer. This treatment planning involves assessing the size and shape of the target lesion, typically with CT images and, using known information about the available intensity levels of the ablation device, calculating a predicted treatment volume based on selected treatment times and/or the number of separate ablations required to treat the entire lesion. Specifications for the ablation region associated with a given ablation method, needle size, treatment intensity and time, etc., are provided by manufacturers of ablation devices and are typically based on characterization of those devices performed by their respective manufacturers in a controlled, static environment without the presence of actively circulating blood vessels.

[0004] One challenge for treatment planning is in situations where the target lesion is close to a blood vessel or vessels, which can occur frequently in, for example, liver ablations. It is common in planning a treatment procedure to identify the location of nearby vessels so that they are not damaged in the conduct of the treatment of the lesion. Damaging or disabling blood vessels which supply blood to healthy organs and tissue is to be avoided. One problem which has not been fully addressed heretofore is that the blood flowing through a nearby vessel can have a significant cooling or warming effect (i.e., as a heat sink which conveys thermal treatment energy away from the treatment site) on the tissue, which causes the actual treatment volume to be different from the volume specified by the device manufacturer and used in the treatment plan, and which can ultimately lead to incomplete ablation of the lesion and risk of recurrence of disease. For example, Patterson et al (1998) demonstrated experimentally in porcine liver *in vivo* that the presence of blood vessels can alter the diameter of an r.f. ablation treatment volume by up to 200%. In an attempt to compensate for the cooling effect of vessels, some imaging companies provide treatment planning applications that allow the larger vessels to be identified in the image data, for example from contrast CT images, and then the treatment plan can be adjusted. However, since contrast CT images only show where the vessels are located and not how much blood is flowing through them, it is not possible to accurately predict the cooling effect and hence the treatment plan may still be incorrect.

[0005] US 2012/010479 A1 fails to teach a boundary condition as conferred by the surface shape placement defined in claim 1.

[0006] Cancerous and other benign lesions are especially dangerous due to their rampant growth in the body, rapidly spreading their disease conditions and adversely affecting and crowding healthy organs and tissue. To fuel this rampant growth, these lesions develop their own vasculature which diverts the body's flow of nourishing blood to these lesions. The flow of blood into and out of a cancerous region can also be a contributor to diminishing the thermal effect of ablation energy delivery.

[0007] In order to predict how blood flow in nearby vessels affects the ablation region, one must create a model that characterizes this effect. This model may be developed experimentally, for example using animal models either *in-vivo* or *ex-vivo,* or it may be developed from theoretical principles. For example, modifications to the bioheat equations have been developed that incorporate vessels and flow, although solutions to these typically require finite element methods. The problem for existing methods is that, in order for these models to be reasonably accurate, knowledge of the amount of blood volume (e.g., ml/min) flowing through the vessels is required, and this information is currently not readily available using any non-invasive technique. Accordingly, it is desirable to be able to non-invasively measure blood flow volumes and quantify the thermal effect of regional blood flow and take this information into consideration when planning an ablation procedure.

[0008] In accordance with the present invention, diagnostic imaging is conducted prior to an ablation procedure to identify blood vessels that are in close proximity to a lesion to be treated with ablative therapy. The diagnostic imaging modality can be CT, MR, ultrasound or any other modality capable of visualizing blood vessels. A diagnostic ultrasound system is then used at the time of the procedure to obtain 3D ultrasound Doppler data from the identified blood vessels. The amount of blood flowing through the identified blood vessels is calculated from the Doppler data such as by integrating the flow velocity over the area of a vessel lumen. The amount of blood flow thus measured is used to develop or modify an ablation treatment plan that takes the thermal effects

of this blood flow into consideration. The blood flow information can be used, for example, to modify the predicted r.f. ablation treatment volume for manual planning, or included as input to an automated treatment planning algorithm that seeks to maximize treatment efficacy.

[0009] In accordance with another implementation of the present invention, the ultrasound transducer has tracking capability, for example using electromagnetic (EM) tracking as provided by the Philips Percunav® system. The reference frame of the ultrasound system is aligned with the corresponding image of the imaging modality used to identify the vessels of interest (e.g., through plane matching or automated methods provided by the image fusion capability of the Percunav system) and, since the transducer location is also known, the Doppler region of interest is placed automatically on the vessels of interest, thus improving accuracy, efficiency and ease of use.

[0010] In the drawings:

FIGURE 1 illustrates an ultrasonic diagnostic imaging system constructed to operate in accordance with the present invention.

FIGURE 2 illustrates the ultrasonic imaging of a lesion to be ablated and its vasculature using the ultrasound probe shown in FIGURE 1.

FIGURE 3 is an enlarged view of the lesion of FIGURE 2 and its vasculature.

FIGURES 4a and 4b illustrate the segmentation of the volumetric region of a lesion and its supply vasculature for blood volume flow measurement in accordance with the present invention.

FIGURES 5a and 5b illustrate the measurement of blood volume flow of a blood vessel proximate a lesion to be treated by ablation in accordance with the present invention.

[0011] Referring first to FIGURE 1, an ultrasonic diagnostic imaging system constructed for use in accordance with the present invention is shown in block diagram form. An ultrasound probe 10 capable of three dimensional imaging includes a two dimensional array transducer 12 which transmits electronically steered and focused beams over a volumetric region and receives single or multiple receive beams in response to each transmit beam. Groups of adjacent transducer elements referred to as "patches" or "subarrays" are integrally operated by a microbeamformer (μBF) in the probe 12, which performs partial beamforming of received echo signals and thereby reduces the number of conductors in the cable between the probe and the main system. Suitable two dimensional arrays are described in U.S. Patent 6,419,633 (Robinson et al.) and in U.S. Patent 6,368,281 (Solomon et al.) Microbeamformers are described in U.S. Patents 5,997,479 (Savord et al.) and 6,013,032 (Savord). The transmit beam characteristics of the array are controlled by a beam transmitter 16, which causes the apodized aperture elements of the array to emit a focused beam of the desired breadth in a desired direction through a volumetric region of the body. Transmit pulses are coupled from the beam transmitter 16 to the elements of the array by means of a transmit/receive switch 14. The echo signals received by the array elements and microbeamformer in response to a transmit beam are coupled to a system beamformer 18, where the partially beamformed echo signals from the microbeamformer are processed to form fully beamformed single or multiple receive beams in response to a transmit beam. A suitable beamformer for this purpose is described in the aforementioned Savord '032 patent.

[0012] The receive beams formed by the beamformer 18 are coupled to a signal processor 26 which performs functions such as filtering and quadrature demodulation. The echo signals of the processed receive beams are coupled to a Doppler processor 30 and a B mode processor 24. The Doppler processor 30 processes the echo information into spatially resolved Doppler power or velocity information. For B mode imaging the receive beam echoes are envelope detected and the signals logarithmically compressed to a suitable dynamic range by the B mode processor 24. The echo signals from the volumetric region are buffered in the form of a 3D image dataset 32. The 3D image data may be processed for display in several ways. One way is to produce one or more 2D planes of the volume. This is described in U.S. patent 6,443,896 (Detmer). Such planar images are formed by addressing data of the 3D image data set in spatially discrete image planes, known as multi-planar reformatting. The three dimensional image data may also be rendered to form a perspective or kinetic parallax 3D display by a volume renderer 36. A third way is to produce an "iSlice" image, which is formed by iSlice scan converter 34 from image data of a repetitively scanned plane of the 3D volume. By only scanning one or a few image planes in the volume, the scanning can be done rapidly enough to produce one or more live 2D iSlice images. An effective use of iSlice imaging is performed in what is known as biplane imaging, in which two or more iSlice images are concurrently displayed and can be spatially manipulated with respect to each other as described in US Pat. 6,709,394 (Frisa et al.) One preferred biplane mode is the rotate mode, in which one iSlice image has a fixed orientation with respect to the probe 10 and a second iSlice image intersects the first at a common central scanline and can be rotated around that scanline. The first image provide a spatial reference for the user, and the second image can be rotated to view intersecting planes in the volume. Biplane imaging is useful in the practice of the present invention as described below. The resulting 2D or 3D images, which may be B mode, Doppler or both as described in US patent 5,720,291 (Schwartz), are coupled to a display processor 38, from which they are displayed on an image display 40. In accordance with the present invention, a volume flow calculator 60 is coupled to receive selected Doppler flow data from the 3D image data set 32. The volume flow calculator calculates

volume flow of blood in ml/sec., preferably by integration of the flow data of a surface that intersects a blood vessel as described in US Pat. 6,780,155 (Li et al.) or US Pat. 6,663,568 (Gil). The volume flow calculation is coupled to the display processor 38 for display on the display 40. User control of the beamformer controller 22 and other functions of the ultrasound system are provided through a user interface or control panel 20.

[0013] FIGURE 2 shows ultrasound probe 10 imaging an iSlice image plane 84 of a region of the body such as the liver. In this example the probe 10 is connected to the ultrasound system by a cable and strain relief 37. The iSlice image displays pathology to be treated by ablation, in this case a lesion 70 in the liver such as an HCC lesion. The lesion 70 is seen to be supplied with blood from a surrounding network of vasculature 72. FIGURE 3 is an enlarged view of the lesion 70 and its vasculature, in this view revealing the presence of a nearby large blood vessel 80. In this example the blood vessel 80 is seen to be a source of blood supply for some of the blood vessels of the vasculature 72, although this is not always the situation in a given patient; the large blood vessel 80 may simply be passing through the tissue near the lesion 70. The blood vessel 80 is seen to have its closest proximity to the lesion 70 at a point where it is a distance "d" from the lesion.

[0014] FIGURES 4a and 4b illustrate one implementation of the present invention in which the thermal transfer effect of the blood flow to and from the lesion 70 is determined. In a case where the vasculature nourishing the lesion includes a number of well defined major vessels as illustrated by blood vessels 72 in FIGURE 3, the volume flow of these vessels can be identified and calculated. FIGURE 4a illustrates an ultrasound image of the lesion and its vasculature around which a user has placed an enclosing shape 74. In this example the shape 74 is an oval shape which is seen to intersect the major vessels of the blood supply vessels 72. The user can use the control panel 20 to select a shape of a desired size and shape from an ROI (region of interest) selector 50. The shape is manipulated on the screen from the control panel until it is properly placed to intersect the major vessels as shown in FIGURE 4a. The shape 74 in this example is an oval in two dimensions and an ellipsoid in three dimensions. The biplane imaging mode is well suited to manipulate the shape 70 around the lesion 70, since the user can view initial placement of the shape 74 in one plane as shown in FIGURE 4a, then view the shape as the other biplane image is rotated about the center of the first image, observing that the shape fully encloses the lesion and intersects its supply vessels. While the present example shows an oval or ellipsoidal shape, other shapes such as a circle, sphere, square or rectangular box, or square cubic or rectangular cubic shape can also be used.

[0015] Alternatively, the shape or a graphic designating the ROI is placed automatically in the ultrasound image by the system if the ultrasound image has been aligned (e.g. by multi-modality image registration) with the reference frame of a pre-procedure planning modality. A standard practice in planning an ablation procedure is to first image the pathology by CT or MR imaging. An image in this modality is then analyzed to identify the lesion and its feeding or neighboring blood vessels by a vessel segmentation algorithm. A system which performs this analysis is the Extended Brilliance CT workstation available from Philips Healthcare of Andover Massachusetts. This workstation has a CT vessel segmentation algorithm which will automatically mark blood vessels to be quantified on a CT image, which then becomes the CT reference image frame for the procedure. When the patient is thereafter scanned with 3D ultrasound, a multi-modality image registration system such as an ultrasound system equipped with the Percunav® image fusion option 54 can register the CT reference image with an anatomically matching ultrasound image from the ultrasound 3D dataset. Once aligned, the delineation of the blood vessels marked on the CT image is translated to the ultrasound image, automatically identifying the ROI and/or the vessels to be quantified by ultrasound in the ultrasound image.

[0016] The surface of the enclosing shape 74 intersects the blood vessels passing through it as illustrated in FIGURE 4b. Cross-sectional surfaces 76 of the blood vessels are delineated by the shape 74. The Doppler flow of blood vessels when separately presented from its surrounding B mode tissue image segments the flow of blood in the vessels as explained in US Pat. 5,474,073 (Schwartz et al.) The volume flow of each vessel 72 can be calculated by integration of the Doppler flow values of the flow surfaces 76 that intersects surrounding surface 74. The direction of the blood flow is integrated by the relative polarity of the Doppler signals, identifying the flow of fresh (unablated) blood into the lesion 70 and the flow of thermally treated blood away from the lesion. By summing the different flow volumes the total volume flow to and from the lesion can be calculated and the net effect on thermal transfer estimated. The effect of this thermal transfer can then be used to plan the ablation treatment.

[0017] In some cases it may be desirable to additionally consider the thermal transfer effect of the blood flow in the large neighboring vessel 80. In other cases the large neighboring vessel may be seen as the dominant factor in thermal transfer and only the volume flow of the large vessel is calculated and considered in ablation treatment planning. For a large vessel like blood vessel 80 of FIGURE 3, surface shape 74 used to delineate the flow of the vessel can be a single plane as illustrated in FIGURE 5a. The shape 74 is positioned to intersect the flow 82 of the vessel 80 at an orthogonal or other angle as explained in the Li et al. and Gill patents. This intersection will effectively project the Doppler flow 82 of the vessel 80 onto the plane of the shape 74 as illustrated in FIGURE 5b. In this example an optional template 94 has been placed around the flow area 82 and the endothelial wall 86 of the lumen of blood vessel 80. The blood flow velocity

of the Doppler data values of the flow surface 82 is integrated over the flow area to calculate the volume flow rate through the vessel 80 in ml/min. The volume flow of the vessel 80 is shown on the screen of display 40 where it can be accessed and used in conjunction with the proximity of the vessel to the treatment site (distance "d" in FIGURE 3) and the thermal transport properties of the intervening tissue to plan the ablation therapy of lesion 70.

[0018] A typical ablation planning process may proceed as follows. Planning may be done for a liver r.f. ablation procedure, where an HCC lesion has been previously identified on a contrast CT scan. The clinician would first review this CT study in order to develop a preliminary treatment plan (e.g., deciding on the ablation needle tip location and the nominal r.f. intensity and duration). The clinician may also execute a CT segmentation algorithm, such as one which is commercially available on CT image analysis workstations, that highlights the blood vessels within the liver. Upon identifying a large vessel that is close to the target lesion, the clinician would then understand that this vessel could have a significant effect on the treatment plan. At the beginning of the procedure, the clinician starts scanning with an ultrasound system, the co-ordinates of which had already been registered to the CT co-ordinate system. Various methods exist for registering medical diagnostic images, including external fiducial-based methods and manual tissue landmark-based methods. The Percunav® image fusion option available on the iU22 ultrasound system from Philips Healthcare of Andover, Massachusetts is capable of anatomically registering CT and ultrasound images. By viewing the ultrasound image superimposed on the CT image, including the segmentation of the vessels from the CT data, the clinician would be easily able to target a 3D Doppler ultrasound volume acquisition through the vessel that is close to the target lesion. The identification of the 3D Doppler ultrasound volume in the aligned images may also be automated as described previously, based on the treatment plan. An algorithm would then calculate the blood volume flowing through this vessel, and this information would then be used to modify the treatment plan and hence adjust the needle placement, r.f. intensity and/or duration. A previously acquired CT, MR or 3D ultrasound volume or 3D contrast ultrasound volume may be used as the reference image input to a treatment plan, and for identifying blood vessels near the target lesion.

[0019] Other approaches may also be taken. For instance, it may be of benefit to divide the treatment into multiple phases of treatment, since the blood flow may itself change in response to the treatment. The clinician could perform an initial phase of the planned treatment, taking into consideration the thermal transfer effects of both the supply vessels to the lesion and that of a nearby large blood vessel. The initial phase of treatment may debilitate the lesion such that the blood flow of the supply vessels is largely eliminated. The blood flow of the nearby large vessel is then re-measured and its thermal transport effect re-evaluated to re-calculate the remaining treatment required to complete the ablation procedure.

[0020] Other variations of the present invention may also be employed. For instance, ultrasonic automated border detection may be used to identify and delineate the size of blood vessel lumens as described in US Pat. 6,491,436 (Chenal et al.) The volume flow of the traced blood vessel lumens is then calculated from their size and Doppler flow data. In a particular implementation of the present invention the flow-delineating shapes and surfaces may be displayed or not displayed at the choice of the system designer.

[0021] A system for carrying out the method of the present invention can be used in procedures even in cases where pre-procedure treatment planning is not used. For instance, the lesion and the blood vessels near the lesion are identified with live ultrasound. The ablation probe is introduced into the body and guided into the lesion. The Percunav® EM tracking system, by tracking the location of the probe, provides the ability to display the treatment region (or burn zone) as a graphical overlay around the tip of the ablation probe. The ablation device manufacturer's specified burn zone is used as the initial definition of the burn zone, providing the starting shape and size of the burn zone graphic around the probe tip. Once the flow data from the nearby vessels is measured by Doppler ultrasound in accordance with the present invention, the thermal effect of the flow is used to adjust the burn zone overlay around the probe. The system may initially show a relatively large burn zone around the probe tip, for instance, which is then modified to show a smaller burn zone once the thermal effect of the nearby blood flow is weighed. The user can then adjust the treatment time or other procedure parameters to fully ablate the target lesion.

Claims

1. A method for using ultrasonic information for ablation treatment of pathology comprising:

   acquiring a treatment planning image of pathology (70) to be treated by ablation and one or more blood (80) vessels in proximity to the pathology;

   identifying pathology to be treated by ablation in an ultrasound image (84);

   identifying one or more blood vessels (72) that are in close proximity to the pathology by placing a surface shape (74) at a region of interest in the ultrasound image;

   acquiring three dimensional ultrasound Doppler data from the blood flow of the identified blood vessels by acquiring ultrasound Doppler data at an intersection (76) of flow of the one or more blood vessels with the surface shape;

calculating the amount of blood flowing through the identified blood vessels using the ultrasound Doppler data; and
developing an ablation treatment plan that considers a heat transport characteristic of the amount of blood flowing through the identified blood vessels,
wherein placing the surface shape is performed automatically using knowledge of the location of the blood vessels obtained by registration of the ultrasound image with the treatment planning image.

2. The method of Claim 1, wherein acquiring three dimensional ultrasound Doppler data further comprises acquiring three dimensional ultrasound Doppler velocity data from the blood flow of an identified vessel.

3. The method of Claim 2, wherein calculating the amount of blood flowing through an identified blood vessel further comprises delineating a surface through the blood flow of a vessel and integrating flow velocity data over an area of the surface.

4. The method of Claim 1, wherein identifying one or more blood vessels further comprises identifying one or more blood vessels in a three dimensional ultrasound image.

5. The method of Claim 1, wherein identifying one or more blood vessels further comprises identifying one or more blood vessels in two dimensional biplane ultrasound images.

6. The method of Claim 1, wherein acquiring a treatment planning image further comprises acquiring a CT image of pathology and the structure of one or more blood vessels in proximity to the pathology;
wherein placing the surface shape automatically further comprises anatomically registering an ultrasound reference image with the CT image.

7. The method of Claim 1, wherein placing a surface shape further comprises intersecting one or more blood vessels with a three dimensional shape.

8. The method of Claim 1, wherein placing a surface shape further comprises intersecting one or more blood vessels with a two dimensional shape.

9. The method of Claim 1, wherein developing an ablation treatment plan further comprises developing an ablation treatment plan that considers volume blood flow of a vessel and the proximity of the vessel to the identified pathology.

10. The method of claim 1 further comprising:
using the heat transport characteristic of the amount of blood flowing through the identified blood vessels to modify a graphical display of the treatment region.

11. The method of Claim 10, wherein using the heat transport characteristic further comprises using the heat transport characteristic of the amount of blood flowing through the identified blood vessels to modify a graphical display of the treatment region in relation to an ablation device.

12. The method of Claim 11, wherein modifying a graphical display further comprises modifying a graphical display of the size of a treatment region in relation to a heat transport characteristic.

13. The method of Claim 10, further comprising identifying pathology to be treated by ablation in a non-ultrasound diagnostic image; and
anatomically registering the non-ultrasound diagnostic image with an ultrasound image.

14. The method of Claim 10, wherein the ablation treatment further comprises r.f ablation, microwave ablation, HIFU, or cryo-ablation therapy.

Patentansprüche

1. Verfahren zur Verwendung von Ultraschallinformationen für die Planung einer Ablationsbehandlung von Pathologie, wobei das Verfahren Folgendes umfasst:

Erfassen eines Behandlungsplanungsbilds von der durch Ablation zu behandelnden Pathologie (70) und einem oder mehreren Blutgefäßen (80) in der Nähe der Pathologie;
Identifizieren der durch Ablation zu behandelnden Pathologie in einem Ultraschallbild (84);
Identifizieren von einem oder mehreren Blutgefäßen (72), die sich in der Nähe der Pathologie befinden, durch Platzieren einer Oberflächenform (74) an einer interessierenden Region in dem Ultraschallbild;
Erfassen von dreidimensionalen Ultraschall-Doppler-Daten aus der Blutströmung der identifizierten Blutgefäße durch Erfassen von Ultraschall-Doppler-Daten an einem Schnittpunkt (76) der Strömung von dem einen oder mehreren Blutgefäßen mit der Oberflächenform;
Berechnen der durch die identifizierten Blutgefäße strömenden Blutmenge unter Verwendung der Ultraschall-Doppler-Daten; und
Entwickeln eines Ablationsbehandlungsplans, der eine Wärmetransporteigenschaft der durch die identifizierten Blutgefäße strömenden Blut-

menge berücksichtigt,
wobei das Platzieren der Oberflächenform automatisch unter Verwendung der Kenntnis des Orts der Blutgefäße erfolgt, die durch Registrierung des Ultraschallbilds mit dem Behandlungsplanungsbild gewonnen wurde.

2. Verfahren nach Anspruch 1, wobei das Erfassen der dreidimensionalen Ultraschall-Doppler-Daten weiterhin das Erfassen von dreidimensionalen Ultraschall-Doppler-Geschwindigkeitsdaten aus der Blutströmung eines identifizierten Gefäßes umfasst.

3. Verfahren nach Anspruch 2, wobei das Berechnen der durch ein identifiziertes Blutgefäß strömenden Blutmenge weiterhin das Abgrenzen einer Oberfläche durch die Blutströmung eines Gefäßes und das Integrieren der Strömungsgeschwindigkeitsdaten über eine Fläche der Oberfläche umfasst.

4. Verfahren nach Anspruch 1, wobei das Identifizieren von einem oder mehreren Blutgefäßen weiterhin das Identifizieren von einem oder mehreren Blutgefäßen in einem dreidimensionalen Ultraschallbild umfasst.

5. Verfahren nach Anspruch 1, wobei das Identifizieren von einem oder mehreren Blutgefäßen weiterhin das Identifizieren von einem oder mehreren Blutgefäßen in zweidimensionalen Zweiebenen-Ultraschallbildern umfasst.

6. Verfahren nach Anspruch 1, wobei das Erfassen eines Behandlungsplanungsbilds weiterhin das Erfassen eines CT-Bilds der Pathologie und der Struktur von einem oder mehreren Gefäßen in der Nähe der Pathologie umfasst;
wobei das automatische Platzieren der Oberflächenform weiterhin das anatomische Registrieren eines Ultraschallreferenzbilds mit dem CT-Bild umfasst.

7. Verfahren nach Anspruch 1, wobei das Platzieren einer Oberflächenform weiterhin das Schneiden von einem oder mehreren Blutgefäßen mit einer dreidimensionalen Form umfasst.

8. Verfahren nach Anspruch 1, wobei das Platzieren einer Oberflächenform weiterhin das Schneiden von einem oder mehreren Blutgefäßen mit einer zweidimensionalen Form umfasst.

9. Verfahren nach Anspruch 1, wobei das Entwickeln eines Ablationsbehandlungsplans weiterhin das Entwickeln eines Ablationsbehandlungsplans umfasst, der die Volumenblutströmung eines Gefäßes und die Nähe des Gefäßes zu der identifizierten Pathologie berücksichtigt.

10. Verfahren nach Anspruch 1, das weiterhin Folgendes umfasst:

Verwenden der Wärmetransporteigenschaft der durch die identifizierten Blutgefäße strömenden Blutmenge, um eine grafische Anzeige der Behandlungsregion zu modifizieren.

11. Verfahren nach Anspruch 10, wobei das Verwenden der Wärmetransporteigenschaft weiterhin das Verwenden der Wärmetransporteigenschaft der durch die identifizierten Blutgefäße strömenden Blutmenge umfasst, um eine grafische Anzeige der Behandlungsregion im Verhältnis zu einer Ablationsvorrichtung zu modifizieren.

12. Verfahren nach Anspruch 11, wobei das Modifizieren einer grafischen Anzeige weiterhin das Modifizieren einer grafischen Anzeige der Größe einer Behandlungsregion im Verhältnis zu einer Wärmetransporteigenschaft umfasst.

13. Verfahren nach Anspruch 10, weiterhin umfassend das Identifizieren der durch Ablation zu behandelnden Pathologie in einem Nicht-Ultraschall-Diagnosebild; und
anatomisches Registrieren des Nicht-Ultraschall-Diagnosebilds mit einem Ultraschallbild.

14. Verfahren nach Anspruch 10, wobei die Ablationsbehandlung weiterhin HF-Ablations-, Mikrowellenablations-, HIFU- oder Kryoablationstherapie umfasst.

Revendications

1. Procédé d'utilisation d'informations ultrasonores pour un traitement d'ablation d'une pathologie comprenant les étapes consistant à :

acquérir une image de planification de traitement d'une pathologie (70) à traiter par ablation et une ou plusieurs vaisseaux sanguins (80) à proximité de la pathologie ;
identifier la pathologie à traiter par ablation dans une image ultrasonore (84) ;
identifier un ou plusieurs vaisseaux sanguins (72) qui sont à proximité étroite de la pathologie en plaçant une forme de surface (74) dans une région d'intérêt dans l'image ultrasonore ;
acquérir des données Doppler ultrasonores tridimensionnelles à partir du flux sanguin des vaisseaux sanguins identifiés par acquisition de données Doppler ultrasonores à une intersection (76) de l'écoulement des un ou plusieurs vaisseaux sanguins avec la forme de surface ;
calculer la quantité de sang s'écoulant à travers les vaisseaux sanguins identifiés en utilisant les

données Doppler ultrasonores ; et
développer un plan de traitement par ablation qui considère une caractéristique de transport de chaleur de la quantité de sang s'écoulant à travers les vaisseaux sanguins identifiés,
dans lequel la mise en place de la forme de surface se fait automatiquement en utilisant la connaissance de l'emplacement des vaisseaux sanguins obtenu par mise en registrer de l'image ultrasonore avec une image de planification de traitement.

2. Procédé selon la revendication 1, dans lequel, l'acquisition de données Doppler ultrasonores tridimensionnelles comprend en outre l'acquisition de données de vitesse Doppler ultrasonores tridimensionnelles à partir de l'écoulement de sang d'un vaisseau identifié.

3. Procédé selon la revendication 2, dans lequel le calcul de la quantité de sang s'écoulant à travers un vaisseau sanguin identifié comprend en outre l'esquisse d'une surface à travers l'écoulement sanguin d'un vaisseau et l'intégration de données de vitesse d'écoulement sur une zone de la surface.

4. Procédé selon la revendication 1, dans lequel l'identification d'un ou plusieurs vaisseaux sanguins comprend en outre l'identification d'un ou plusieurs vaisseaux sanguins dans une image ultrasonore tridimensionnelle.

5. Procédé selon la revendication 1, dans lequel l'identification d'un ou plusieurs vaisseaux sanguins comprend en outre l'identification d'un ou plusieurs vaisseaux sanguins dans des images ultrasonores biplanes bidimensionnelles.

6. Procédé selon la revendication 1, dans lequel l'acquisition d'une image de planification de traitement comprend en outre l'acquisition d'une image CT de la pathologie et de la structure d'un ou plusieurs vaisseaux sanguins à proximité de la pathologie ;
dans lequel la mise en place de la forme de surface comprend en outre automatiquement la mise en registre anatomique d'une image de référence ultrasonore avec l'image CT.

7. Procédé selon la revendication 1, dans lequel la mise en place d'une forme de surface comprend en outre l'intersection d'un ou plusieurs vaisseaux sanguins avec une forme tridimensionnelle.

8. Procédé selon la revendication 1, dans lequel la mise en place d'une forme de surface comprend en outre l'intersection d'un ou plusieurs vaisseaux sanguins avec une forme bidimensionnelle.

9. Procédé selon la revendication 1, dans lequel le développement d'un plan de traitement par ablation comprend en outre le développement d'un plan de traitement par ablation qui considère l'écoulement de sang volumique d'un vaisseau et la proximité du vaisseau avec la pathologique identifiée.

10. Procédé selon la revendication 1, comprenant en outre :

l'utilisation de la caractéristique de transport de chaleur de la quantité de sang s'écoulant à travers les vaisseaux sanguins identifiés pour modifier un affichage graphique de la région de traitement.

11. Procédé selon la revendication 10, dans lequel l'utilisation de la caractéristique de transport thermique comprend en outre l'utilisation de la caractéristique de transport thermique de la quantité de sang s'écoulant à travers les vaisseaux sanguins identifiés pour modifier un affichage graphique de la région de traitement par rapport à un dispositif d'ablation.

12. Procédé selon la revendication 11 dans lequel la modification d'un affichage graphique comprend en outre la modification d'un affichage graphique de la taille d'une région de traitement par rapport à la caractéristique de transport thermique.

13. Procédé selon la revendication 10, comprenant en outre l'identification de la pathologie à traiter par ablation dans une image diagnostique non ultrasonore ; et
la mise en registre anatomique de l'image diagnostique non ultrasonore avec une image ultrasonore.

14. Procédé selon la revendication 10, dans lequel le traitement par ablation comprend en outre une ablation par radiofréquences, une ablation par micro-ondes, des ultrasons focalisés à haute fréquence (HIFU) ou une thérapie par cryoablation.

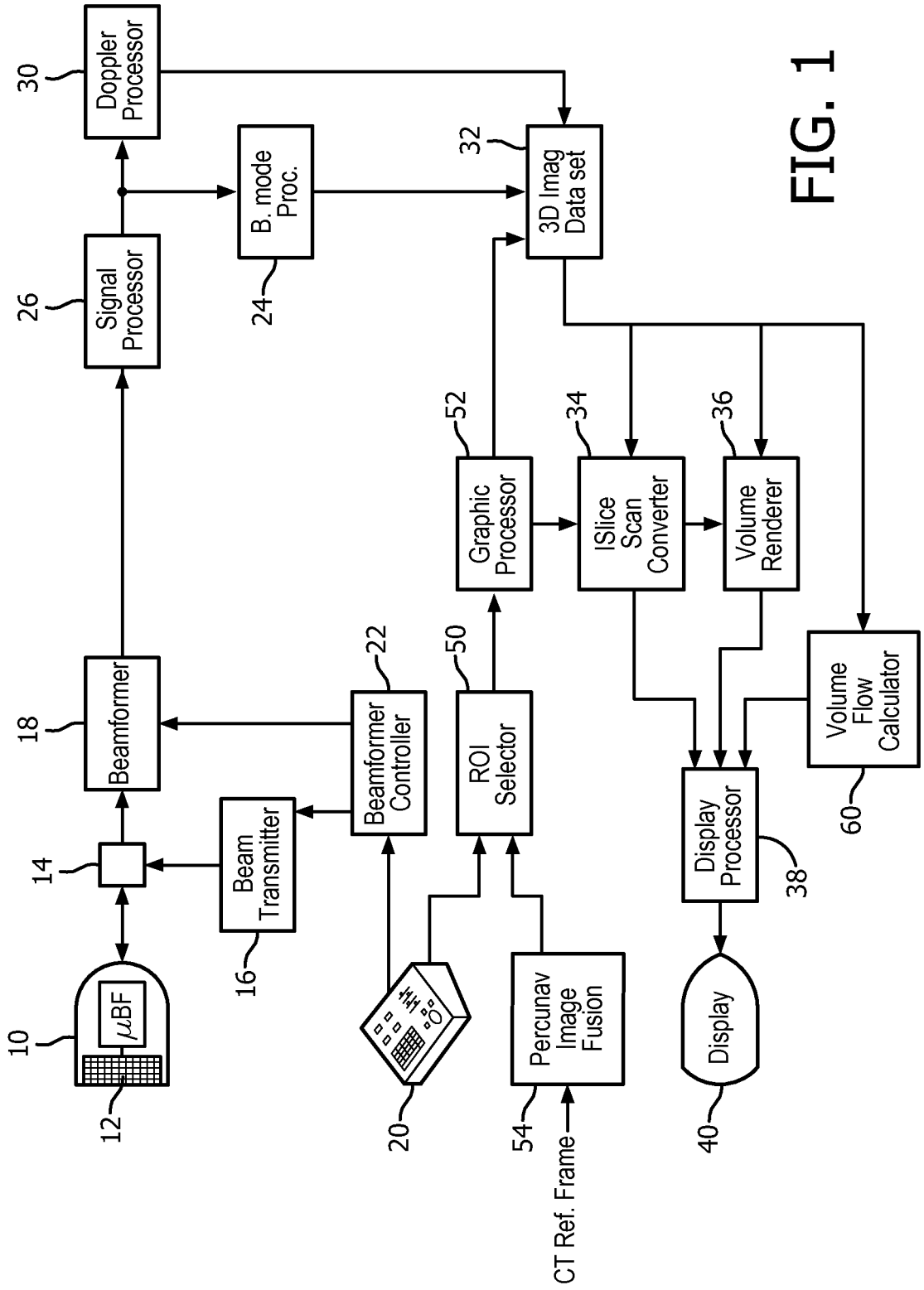
Doppler Processor
30
B. mode Proc.
24
3D Imag Data set
32
Signal Processor
26
Graphic Processor
52
ISlice Scan Converter
34
Volume Renderer
36
Beamformer
18
Beamformer Controller
22
ROI Selector
50
Volume Flow Calculator
60
Beam Transmitter
16
14
Display Processor
38
μBF
10
12
20
Percunav Image Fusion
54
CT Ref. Frame
Display
40

FIG. 1

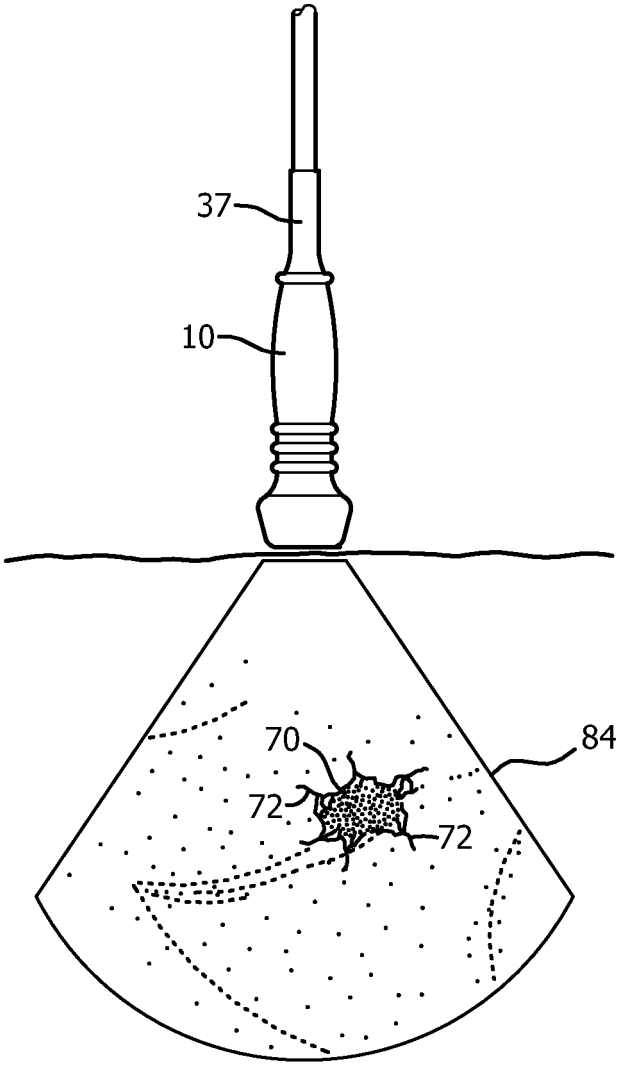

FIG. 2

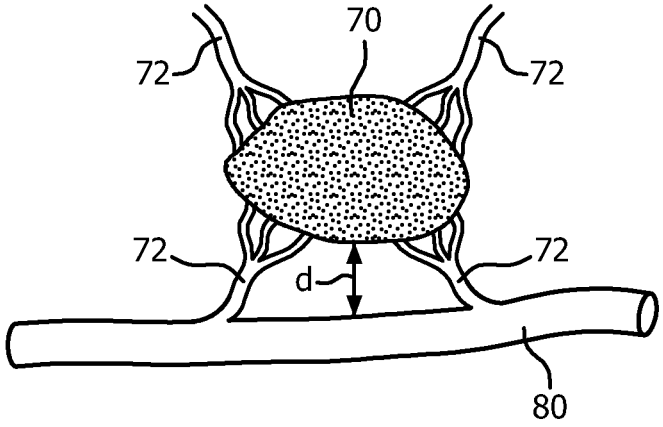

FIG. 3

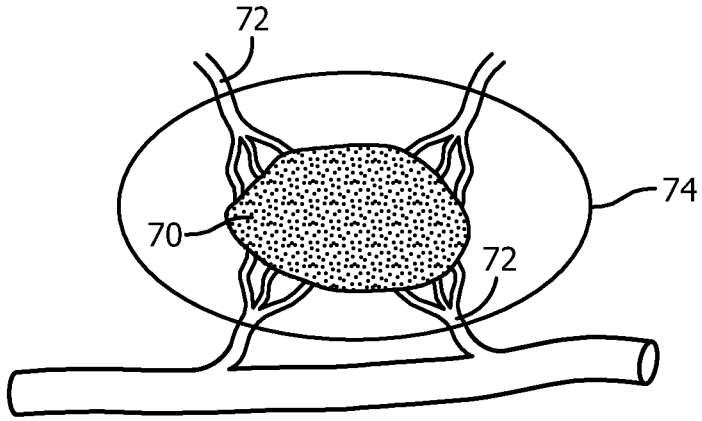

FIG. 4a

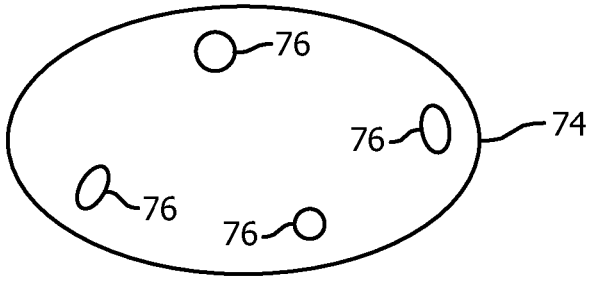

FIG. 4b

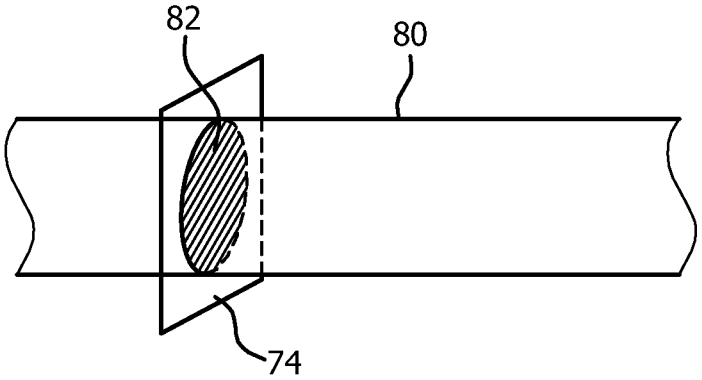

FIG. 5a

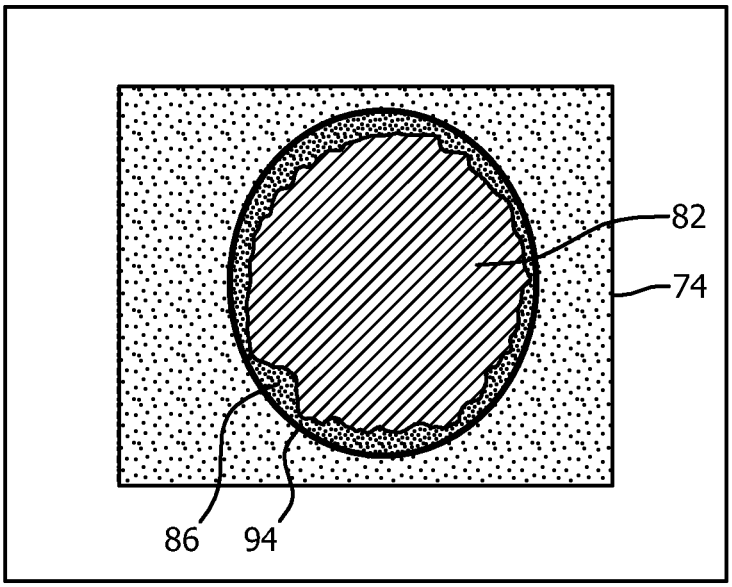

FIG. 5b

REFERENCES CITED IN THE DESCRIPTION

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专利名称(译)	消融治疗的超声波体积流量测量		
公开(公告)号	EP2890302B1	公开(公告)日	2016-08-10
申请号	EP2013779925	申请日	2013-08-12
[标]申请(专利权)人(译)	皇家飞利浦电子股份有限公司		
申请(专利权)人(译)	皇家飞利浦N.V.		
当前申请(专利权)人(译)	皇家飞利浦N.V.		
[标]发明人	JAGO JAMES ROBERTSON NG GARY CHENG HOW		
发明人	JAGO, JAMES ROBERTSON NG, GARY CHENG-HOW		
IPC分类号	A61B8/06 A61B18/00		
CPC分类号	A61B8/469 A61B8/06 A61B8/0891 A61B8/14 A61B8/483 A61B8/488 A61B8/5261 A61B18/00 A61B2018/00529 A61B2018/00577 A61B2034/105 A61B2090/364		
优先权	61/696156 2012-09-01 US		
其他公开文献	EP2890302A1		
外部链接	Espacenet		

摘要(译)

使用超声数据的消融治疗的方法开始于在医学诊断图像中识别待治疗的病理学和治疗部位附近的一个或多个血管。在超声图像中自动指示所识别的ROI和血管。从血管内的血流获取超声多普勒速度数据，并且多普勒数据用于计算通过血管的血流量。在消融治疗的计划或实施中考虑由该血流输送的热量的热效应，如通过改变消融探针尖端周围的燃烧区图形的大小。