E15. Overview of new ultrasound technology and its application in breast imaging

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Introduction

Three-dimensional (3D) and four-dimensional (4D) mammasonography are the most recent developments in breast ultrasound technology, providing more information than conventional 2-dimensional (2D) sonography. 4D ultrasound offers almost real-time 3D rendered image information and is taken as a basis for multidimensional imaging of the breast. In the following, volume contrast imaging (VCI), inversion mode rendering, virtual computer-aided lesion analysis (VoCal), tomographic ultrasound imaging (TUI), extended view (XTD View) documentation and real-4D breast biopsy in combination with 3D-targeting technique are discussed.

Static volume contrast imaging

Static volume contrast imaging (VCI) allows the study of a static three-dimensional dataset with pre-selected slice thickness (1–10 mm) simultaneously in all three planes with different render algorithms. The benefit of this technique is that it enhances the contrast between the lesion and the background structures, with the aim of optimising the contours, in order to make accurate measurements and correct differential criteria analysis.

4D volume contrast imaging

4D VCI is a real-time 4D ultrasound technique which offers thick-slice rendering (6–10 mm slice thickness) or thin-slice rendering (2–4 mm slice thickness) [1,2]. The render algorithm is a combination of surface mode and transparency mode. The Voluson 730 technology (GE Medical Systems Kretz-Ultrasound) offers VCI in the typical 2D-ultrasound accessible planes as well as in the coronal plane. The advantage of the VCI technique compared with conventional 2D ultrasound is the contrast-enhanced representation of almost isoechogenic lesions compared with the background. As a consequence VCI provides an accurate measurement and safe needle guidance into, for example, an echo-poor fibroadenoma surrounded by echo-poor fatty tissue. VCI in the coronal plane (VCI-C) is the preferred technique for studying a lesion and the surrounding tissue under 4D related sonopalpation and dynamic 4D investigation. As a consequence of this, VCI-C is, for example, able to help differentiate between a spiculation of the breast mass and an ultrasound artefact caused by shadowing from the borderline between a fatty tissue lobule of mid-echogenicity and the hyperechogenic fibroglandular constituents mimicking a spiculation. Sonopalpation means to compress and decompress the breast tissue with the finger and to monitor the movements between the different tissue layers with VCI-C. Dynamic 4D-ultrasound studies present the imaging information from a circular movement of the transducer under the C-plane aspect of the lesion and the surrounding breast tissue.

Inversion mode

Echo-poor breast lesions are suitable to be rendered by the inversion mode technology. The volume of interest (VOI) has to cover the entire lesion. The inversion render mode shows the lesion in a 50% mixed surface smooth and 50% gradient light algorithm as a white 3D model. The threshold level ‘low’ has to be customised, on the one hand to suppress the echogenic constituents in the VOI, on the other hand to present the echo-poor lesion in a 3D-surface algorithm. The additional echo-poor structures, not related to the lesion, can be removed with an electronic scalpel. To understand which structures are not related to the lesion, the entire rendered VOI has to be rotated, for example, around the y- and/or the x-axis. The inversion mode is a tool that offers quick access to the three-dimensional morphology of the investigated breast mass.

Volume calculation

The basic principle of volume calculation (VoCal) is to combine geometric surface information with the volume dataset of a lesion [1,3,4]. On the condition that the lesion is circumscribed with clear contours, the VoCal software enables automated or manual volume calculation. The surface geometry is defined by rotation of an image plane around a fixed axis. The surface geometry can be visualised as a coloured surface, a wire mesh model or a rendered greyscale surface. Well-defined lesions, including fibroadenomas, papillomas or rare, well-defined breast cancers such as medullary or mucous carcinomas, can be evaluated by VoCal.

Tomographic ultrasound imaging

Tomographic ultrasound imaging (TUI) presents diagnostic information as a static 3D dataset in a two-dimensional documentation, for example a thermoprint or laserprint, comparable with computed tomography or magnetic resonance imaging scans. A topogram tells exactly the spatial position of the slices obtained from the 3D dataset and the customised distance between the different slices. TUI is primarily the basis for offering comprehensive diagnostic information about the three-dimensional extent of a lesion in a two-dimensional display. To optimise information transfer, TUI enables us to slice and to document the lesion in all three planes.

Extended view documentation

Extended view (XTD View) is a two-dimensional technique that estimates the probe movement through analysis of subsequent images. Based on the computed movement all images in a sequence can be mapped into a common reference system, thus generating a compound panorama image [5]. This technique offers the basis for the precise documentation of a lesion in the breast with one image. In the radiary scan direction (duct parallel) the transducer will be moved from a mid-lesion position directly on a radiary path towards the mid-nipple position. The shortest distance between the lesion and the nipple will be measured. The shortest distance between the skin surface and the lesion then determines the depth of the lesion. The breast pictogram tells us whether it is the right or left breast. The position of the radiary transducer path towards the lesion is documented by the transducer icon in the breast pictogram using the clock for description. Another target of XTD View documentation is to produce an image to study the structure (homogeneous versus inhomogeneous) and density of the breast tissue (fibroglandular tissue versus fatty tissue). For this purpose for each breast quadrant a XTD View image from the periphery to the nipple is obtained and documented using the breast pictogram.

Real-4D ultrasound breast biopsy and 3D targeting

Dedicated software allows real-4D ultrasound needle guidance during breast biopsy [1,2, 4,6]. The permanently acquired real-4D ultrasound volume data are displayed in a multi-planar scan plane analysis or in a combination of A-plane and rendered C-plane mode [1]. Compared with conventional freehand 2D-ultrasound needle guidance, real-4D additionally offers permanent information about all three planes in the multi-planary display mode, a rendered image of the breast lesion and needle position. The three-dimensional permanent analysis of lesion position as well as needle position allows one to navigate the core needle to an optimal pre-fire position. The Voluson technique offers the option to acquire a 3D-ultrasound volume dataset with one and the same transducer without freehand movement of the probe. In about 2–3 s the system acquires the entire 3D data volume and accurately displays information about the needle position in relation to the lesion in a multi-planar imaging mode. This needle position check in all 3 planes is called 3D targeting [1–4,7,8].

Conclusion

New 2D, 3D and 4D ultrasound technologies are helpful diagnostic and interventional tools, fit for use in everyday diagnostic practice. They provide a perfect documentation of breast anatomy and pathology.

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