

ULTRASOUND

technology **UPDATE**

Volume Contrast Imaging in C-plane (VCI-C)

SUMMARY

Volume Contrast Imaging (VCI-C) is a new approach to improved tissue contrast resolution in real-time, coronal plane imaging. Displayed as a 2D slice, the VCI-C technique is based on 4D volumetric data acquisition. In a number of applications such as obstetrics, gynecology, urology, breast, small parts, endocavitary as well as abdominal exams, VCI-C provides scan planes not accessible by conventional B-mode scanning. The remarkable improvement in tissue contrast resolution is based on a volume rendering process performed on a thick slice of tissue data. This process facilitates the detection of suspicious and inhomogeneous areas thus improving the diagnostic confidence. VCI-C is the only 4D real-time technique that demonstrates coronal plane imaging.

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This nodular lesion is located between kidney, renal vein and the IVC. Here VCI-C clearly demonstrates its advantages:

- *access to a scan plane that is inaccessible to a conventional 2D approach.*
- *striking representation of the finding with enhanced tissue contrast.*



INTRODUCTION

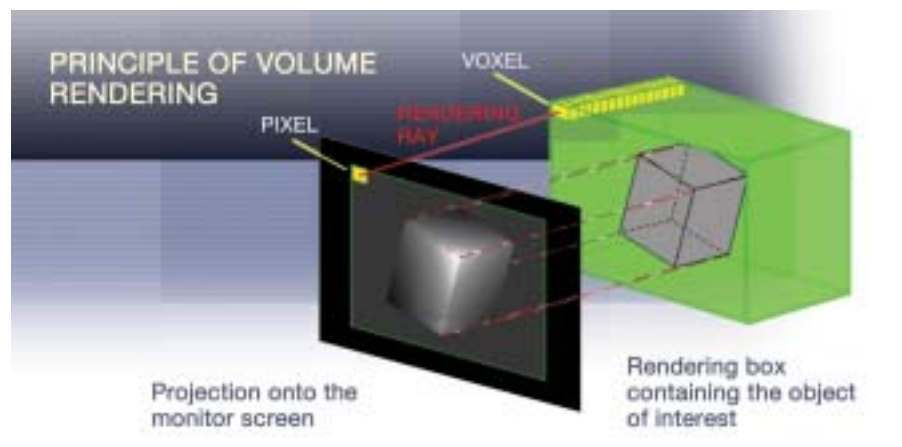
Excellent image quality is essential to achieve an accurate and consistent diagnosis. A combination of both spatial and contrast resolution is important for the appreciation of inhomogeneous areas and visualization of organ boundaries and internal structures. The recently introduced Volume Contrast Imaging (VCI-C) technique is a completely new approach for the enhancement of tissue contrast resolution in ultrasound imaging. VCI-C is based on real-time acquisition of volumetric data and performs a proprietary rendering on a defined thick slice portion in the coronal (horizontal) direction.

TECHNOLOGY

Rendering

The principle of volume rendering is to project three-dimensional data on a two-dimensional screen. In the case of Surface Rendering Mode, render rays pass through the three-dimensional object, detect and display the surface of the structures (Fig. 1). The region of interest is determined by size and position of the render box. Usually the direction of the render rays correlates with the direction of the ultrasound beam due to optimal signal reflection. For 3D/4D volume rendering there are always two render modes applied simultaneously. In the case of VCI-C, a mixture of Surface Mode and Transparent Maximum Mode rendering is implemented.

Fig. 1:
Example of surface rendering: Render rays (red) analyze the object within the render box (green). The surface is detected and displayed as a two-dimensional image on the screen.



METHOD

VCI-C

In 2D the smallest image data are named “pixels” as opposed to “voxels” as they are referred to in three-dimensional data sets. In the case of VCI-C information making up the render box is displayed as a standard 2D image. The slice thickness is adjustable by the user, possible settings range between 2 and 15 mm. The Surface Render Mode incorporates an algorithm which allows render rays for accumulating tissue signals from deeper layers whenever a ray meets with a gap between voxels in the very first layer (see left portion of Fig. 2). Signal noise is of a non-static nature (changing position from one layer to the next). The proprietary surface algorithm separates the noise from the voxel data and the noise is subtracted. Consequently, the information of tissue gray levels is projected into a 2D plane provided by the rendering of all data within the thickness selected (Fig. 2). As a result of noise reduction, the contrast resolution is improved.

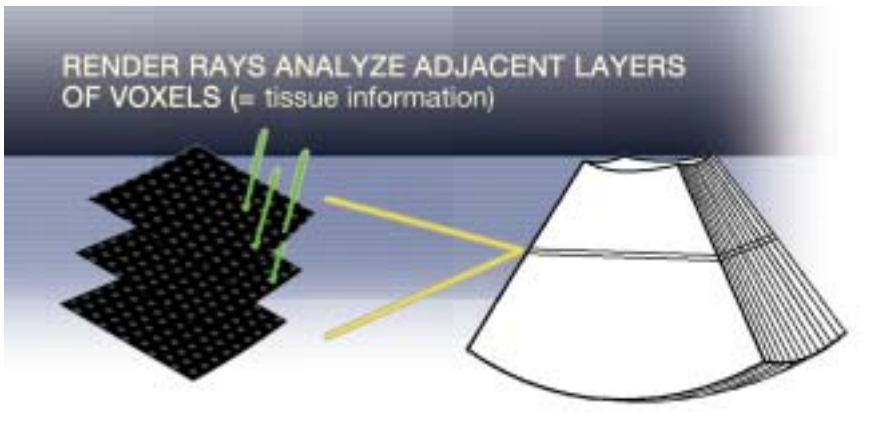
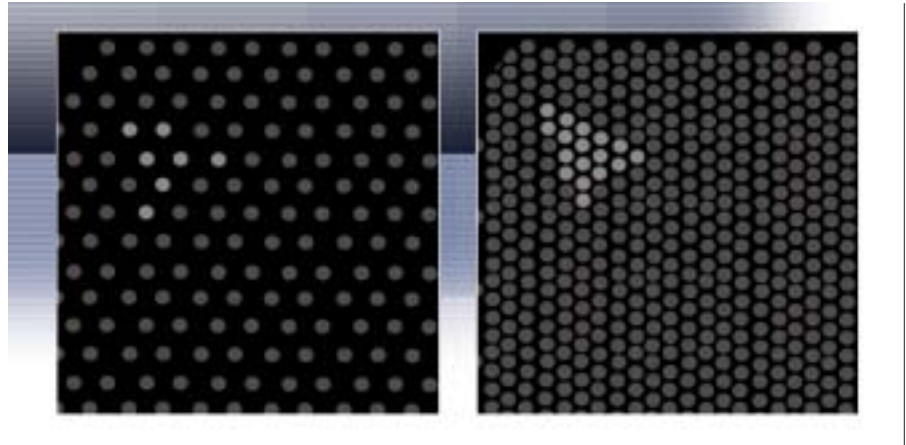


Fig.2:
The VCI-C slice consists of several layers of voxels. The render rays collect tissue signals also from adjacent deeper layers and project them into a 2D plane.

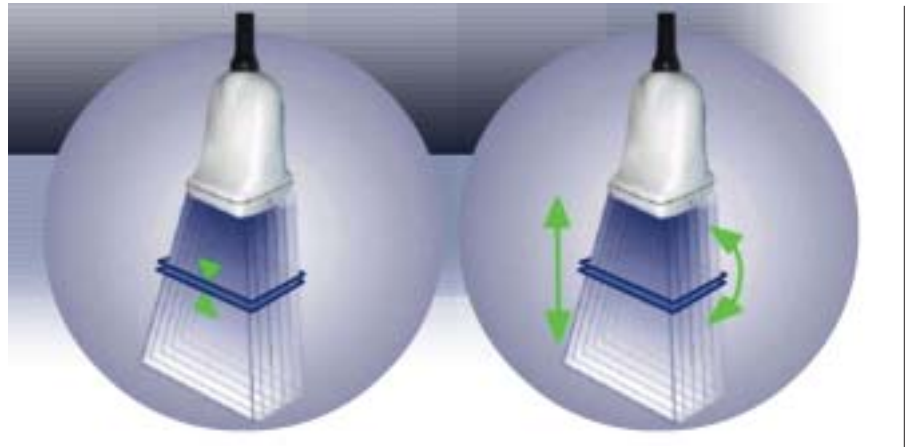
As previously mentioned, a mixture of two render modes is applied to the data: Surface Mode, which retains both the original gray levels of the tissue as well as the image sharpness and Transparent Maximum Mode which contributes to added tissue contrast derived from deeper layers of voxels. The effect of filling up tissue signals, removing noise and enclosing data from adjacent layers results in a smoother image combined with enhanced contrast resolution (Fig. 3).

Fig.3:
Comparison between conventional B (left) and VCI mode. The VCI image appears smooth (speckle filling with true tissue signals) providing enhanced contrast resolution. Please note that the gray levels in both images are identical.



To provide flexibility in various applications, the VCI-C slice is not limited to the exact coronal direction. In addition to setting a certain slice thickness the user can adjust for its depth position and tilt to oblique directions as well (see Fig. 4).

Fig.4:
Slice thickness is selectable (2 mm – 10 mm with small parts probe, up to 15 mm with abdomen probe, left hand side), depth position and angulation adjustment (right hand side).

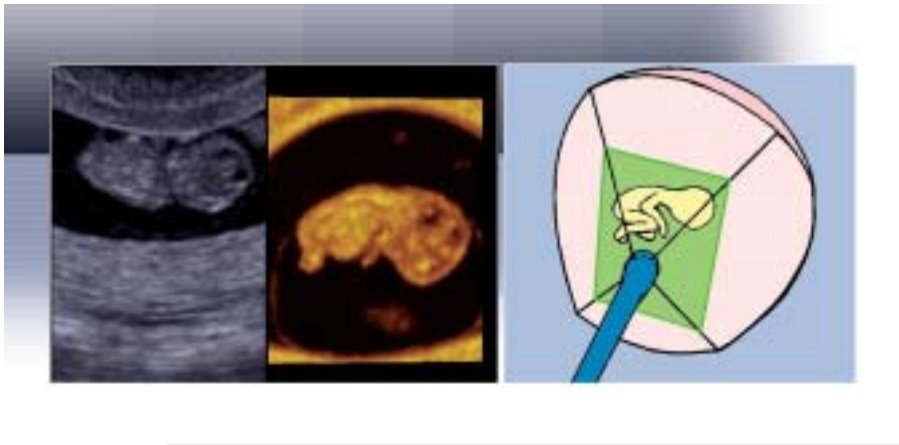


CLINICAL APPLICATIONS

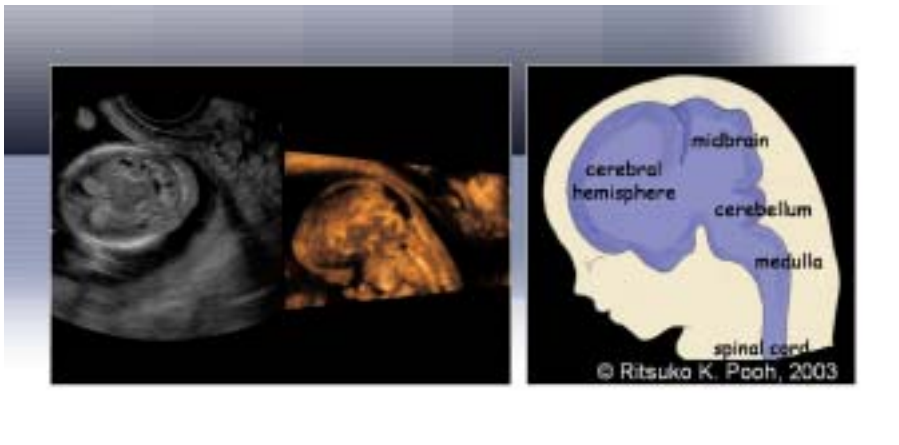
VCI-C displays a coronal slice as a 2D plane with the extra advantage of better tissue contrast compared to conventional 2D. The ability to image difficult-to-scan regions, otherwise impossible to reach, is greatly facilitated. Volume Contrast Imaging in the coronal plane (VCI-C) has many applications in a variety of diagnostic fields.

OBSTETRICS

VCI-C offers great potential in OB imaging, providing diagnostic images in situations where fetal position obscures anatomy otherwise not obtainable in any 2D exam.



Routine measurement of the Crown Rump Length in a first trimester scan. Due to limited freedom of movement with transvaginal probes it sometimes is difficult to scan a true median-sagittal section to perform a correct measurement. By proper placement of the VCI-C slice, accurate measurements are possible.



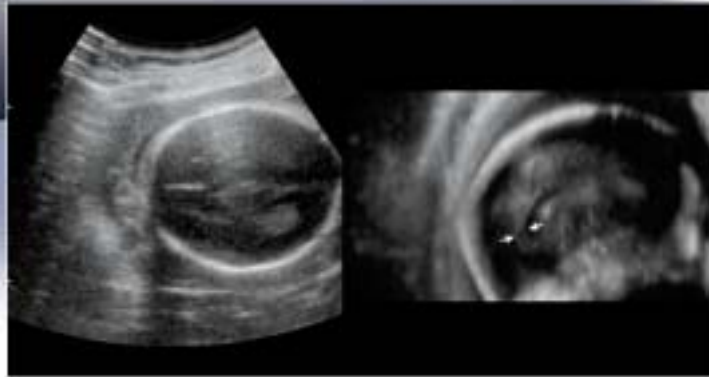
Fetal brain at 15 weeks gestation. VCI-C allows tomographic scrolling through the essential scan planes for accurate assessment of the brain development.

Ritsuko K. Pooh, MD, Japan:



"Recent advances of 3D/4D ultrasound technology have enabled us to demonstrate thick-slice images. By this technology of Volume Contrast Imaging, real-time images with increased contrast resolution can be obtained not only in longitudinal plane but also in vertical plane of the 2D scanning section. This novel unique VCI technology provides additional information simultaneously with conventional 2D imaging, without the process time of off-line 3D reconstruction."

Scan conditions such as an unfavorable position of the fetal skull as well as a small amount of amniotic fluid make assessment of brain structures difficult. The strong tissue contrast resolution of VCI-C allows a display of the corpus callosum.



Gary Pritchard, MD, Brisbane, Australia:

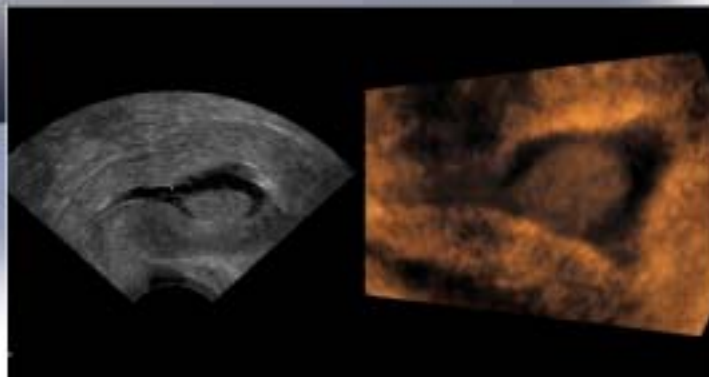


"The corpus callosum is an important part of the brain. It is difficult to see in the usual case because of the difficulty obtaining the correct plane. It has been necessary to infer its presence by imaging the cavum septum pellucidum, since the normal corpus callosum forms the roof of this structure. VCI-C has an ability to directly view it, to confirm its presence. The adequacy of VCI-C in assessing this important structure is still to be determined."

GYNECOLOGY

One of the main applications in gynecology is the uterine scan. The position of the organ makes it difficult to examine the uterine cavity respective to the endometrium. VCI-C enables the user to exactly position a scan plane along the axis of the uterus.

This is a case of hystero-sonography that presents the fluid-filled cavum uterus and the endometrial polyp in the sagittal plane (see left hand side). The VCI-C image (right) impressively demonstrates the location and width that occupies most of the entire cavity.





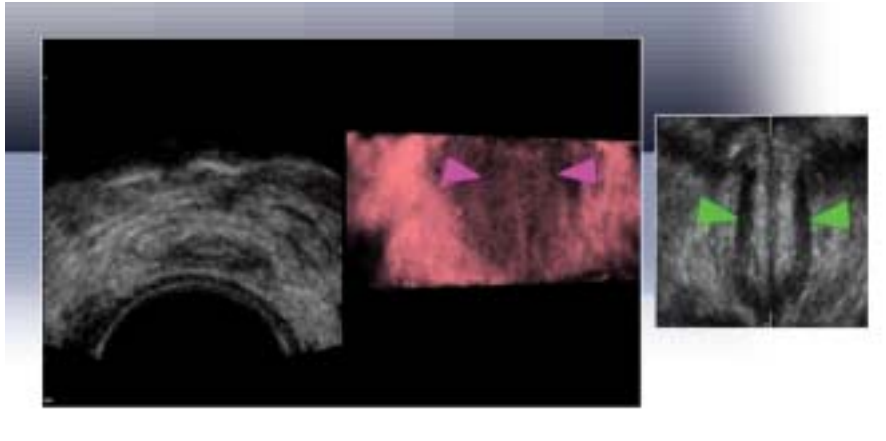
Bernard Benoit, MD, Monaco, France:

"The VCI-C plane allows obtaining automatically the coronal view of the uterus and so you get the exact display of the shape of the cavity. It is absolutely impossible with conventional 2D and a standard endovaginal probe."

UROLOGY

Another growing environment for utilizing this new technique is in urology. An increasing number of aged females suffer from different forms of incontinence. Accurate imaging of the structures involved helps to establish a beneficial therapy plan.

Ultrasound is a safe and effective imaging method to display the morphology of the female urethra and the rhabdosphincter. The problem is the approach of the structures using conventional ultrasound techniques. The left image shows the transverse and frontal section (pink = VCI-C) of the urethra presenting atrophic musculature of a patient suffering from incontinence. No muscles are seen at the position of the pink arrows. The far right image presents a normal, intact rhabdosphincter (green arrows).



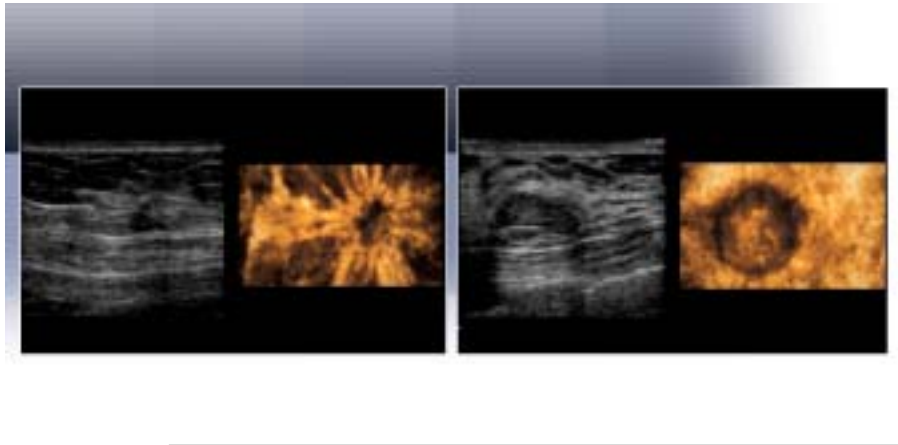
Alfred Kratochwil, Prof., MD, Vienna, Austria:

"Contrast Imaging in plane A and C excellently improves the demonstration of anatomical structures of the genito-urinary tract, for instance, the rhabdosphincter muscle in incontinent females. Another promising application of this new tool is the examination of the prostatic gland in cases of a cancerous disease."

BREAST ULTRASOUND

There is clearly a different appearance between the two cases, exclusively presented in each of the coronal sections (gold colored image portions). The retraction pattern in the left case is highly suspicious for malignancy in contrast to the right case presenting a compression pattern, regular boundary and no invasion of the surrounding tissue – signs suggesting a benign finding. (Stavros AT, Thickman D, Rapp CL, Dennis MA, Parker SH, Sisney GA., Solid breast nodules: use of sonography to distinguish between benign and malignant lesions. Radiology. 1995 Jul;196(1):123-34.)

Ultrasound is the most widely used imaging method in addition to mammography for breast diagnosis. The coronal plane demonstrates the architecture of the lesion and the adjacent breast tissue. Enhanced contrast resolution improves the display of subtle tissue changes, increasing the probability of pathology detection. VCI-C is a very beneficial tool for the detection and specification of breast lesions, and is being studied for use in differentiating malignant from benign nodules.



Christian F. Weismann, MD, Salzburg, Austria

"In my routine diagnostic and interventional breast work I use VCI in the coronal plane combined with 2 mm thickness to study the margins of a breast lesion to get additional information about the dignity of the lesion. In the axial, transversal and coronal plane VCI helps me to study, e.g., the arrangement of intraductal micro-calcifications of a DCIS. If VCI offers me this information I am able to perform an ultrasound guided vacuum-assisted- or large-core needle biopsy to confirm or rule out the underlying malignant intraductal breast disease."



Summary: Volume Contrast Imaging (VCI-C) improves the tissue contrast resolution and facilitates the detection of suspicious and inhomogeneous areas.

Acknowledgement

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