REVIEW ARTICLE

Application of Three-dimensional Ultrasound in the First Trimester

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Abstract

The first trimester of pregnancy is the most critical moment for the embryo and fetal development in terms of rapid changes and modification of its internal and external appearance. The modern ultrasound equipment enables us to identify some of these changes as early as 5–7 weeks after the last menstrual period (LMP). The relevance of 3D ultrasound (3D US) in the detection and demonstration of fetal abnormalities has already been proven. Some of the 3D/4D tools have shown some benefits compared to the 2D US when a malformation is present. The 3D images are usually clearer for parents to understand the problem or the normality of the small fetus. There are five main aspects of the 3D/4D US to mention, which are relevant during the first trimester of pregnancy: (1) the multiplanar approach of the embryo and the fetus; (2) the ability to obtain planes that are not accessible with 2D US; (3) the possibility to do an off-line analysis of acquired 3D/4D volumes and telemedicine; (4) the images are usually easier to interpret for parents when displayed with the surface mode; and (5) the increasing amount of tools available to process fetal images and perform different measurements. Answer to the question is it essential to have a 3D/4D ultrasound machine in everyday practice to carry out a first-trimester scan is obviously negative; however, as most of the practitioners do have one nowadays, it is important to point out its benefits and limitations.

Keywords: Embryo, Fetus, First-trimester scan, Pregnancy, Three-dimensional ultrasonography.

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Introduction

The first trimester of pregnancy is the most critical moment for the embryo and fetal development in terms of rapid changes and modification of its internal and external appearance. It is a very complex process that we were not able to see or understand completely. The modern ultrasound equipments and all the available tools enable us to identify some of these changes as early as 5–7 weeks after the last menstrual period.

The relevance of 3D ultrasound (3D US) in the detection and demonstration of fetal abnormalities has already been proven. Some of the 3D/4D tools have shown some benefits compared to the 2D US when a malformation is present in particular to visualize the problem from different perspectives, to obtain other doctors' opinion, to share volumes with colleagues, and as academic or teaching material. In addition, 3D images are usually clearer for parents to understand the problem or the normality of the small fetus. The surface mode and the multiplanar mode of display are the most used in these situations. In summary, we could say there are five main aspects of the 3D/4D US to mention, which are relevant during the first trimester of pregnancy: (1) the multiplanar approach of the embryo and the fetus; (2) the ability to obtain planes that are not accessible with 2D US; (3) the possibility to do an off-line analysis of acquired 3D/4D volumes and telemedicine; (4) the images are usually easier to interpret for parents when displayed with the surface mode; and (5) the increasing amount of tools available to process fetal images and perform different measurements.

The objective of this paper is to briefly explain what are the potential applications of 3D US during the first trimester of pregnancy in the embryonic and fetal periods. The main tools that will be discussed are listed in Table 1. Not all the available tools are useful in the first trimester and therefore we will focus on those applications that are of interest, although some of them are not widely available.

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Surface Mode

The study of the embryo from week 5 to 9–10 after LPM is called sonoembriology and it is based on the observation performed by Carnegie in 1914, when he described 23 different developmental stages of the embryo. In the past, all the studies were carried out with microscopic magnetic resonance that has low resolution and it was time-consuming. As the US machines got better resolution and with the introduction of high-resolution TV probes, it is now possible to perform the so-called 3D US sonoembriology. The images obtained during this period are of great resolution but a learning curve is needed to improve the interpretations of such images. Several studies reported the feasibility of this assessment and its benefits including the use of a novel 3D tool for surface rendering called HD live.[1–8] This approach of the embryo allows the operator to identify with great detail the developmental changes that the embryo experiences everyday during this period. Some may believe this is only science fiction, but thanks to the advance of the technology it is a reality.

The combination of high-frequency TV probes, sonoembriology, and HD live Silhouette is being referred as the "see through fashion."[9]

Table 1: 3D/4D ultrasound tools used in the first trimester of pregnancy

3D/4D ultrasound tool	*Application in first trimester*
Surface mode. Renderization (different settings to display: HD live, dynamic render, Silhouette and Studio)	• Sonoembriology (5th–10th week development of the embryo, decidua, yalk sac) • Visualization of external defects • Provide nice pictures for parents
Multiplanar mode (standard volume manipulation with reference dots, TUI, OMNIVIEW)	• Identification of adequate planes to perform measurements • Volume manipulation • Interpretation of fetal defects
Volume calculation (VOCAL, sonoAVC)	• Calculate volume of any fetal structure, placenta, and amniotic sac
Spatiotemporal image correlation (STIC)	• From 11 weeks onward, better if TV approach of the fetal heart

All the structures in the uterus are seen with this approach including decidua and chorion, yolk sac, embryo, and umbilical cord. There is still difficulty in the visualization of the amniotic membrane since it is too thin to be clearly identified with 3D US (Fig. 1).

Detection or suspicion of embryo abnormalities should be taken with care, since expert opinion is required before counseling the parents regarding abnormal findings in this early stage of pregnancy. The 3D sonoembriology is extremely useful as a research and investigation field that is rapidly increasing our knowledge about such a complex biological process as it is the embryonic period. The reader could refer to specific texts for more detailed information about embryo development and sonoembriology.[1–9]

At the end of the 10th week, the fetal period begins and there is a rapid growth of fetal structures with a great differentiation in several internal organs. The surface of the fetus is also modified due to an increase in fetal movements and its position in the uterus. At 10–12 weeks the fetus lays horizontal, which facilitates its visualization, and by the end of the 13th week it lays more vertical, probably due to the vertical growth of the uterus. At 11–13 + 6 weeks of gestation, the scan is performed for the assessment of markers of chromosomal abnormalities, fetal anatomy evaluation, and screening for preeclampsia[10–12] In the past, this scan was performed with an abdominal approach in many centers but with the introduction of high-frequency TV the combination of both abdominal and vaginal approach provides a remarkable improvement in the visualization of the fetal anatomy. In this respect, images obtained by high-frequency TV probes are of much better resolution compared to the ones obtained abdominally and this is critically important in the acquisition of volume, since the quality of the volume is in direct relation to the quality of the 2D image. The surface mode of 3D/4D US is useful during this scan to show nice pictures and fetal movement to the parents with a spectacular bonding effect. There are a number of different modes of display the 3D renderization. From the classical surface mode to the dynamic rendering or the fetoscopic view that creates a sensation of more depth in the volume; HD live that allows a great modification in term of illumination of the image increasing the facial features and gestures; HD live Silhouette that improves the definition of borders and Studio HD that is a recent introduction in some US brands that combines different algorithms to produce a much more realistic image of the fetal surface with the chance to modify three different parameters of light, background, and focus (Figs 2 to 4).

The skeletal mode of display is the one used to show the fetal bones and it is useful in detection of facial or spine abnormalities. It is possible to describe the development of facial and skull bones in the first trimester in normal and syndromic fetuses[13,14] (Fig. 5).

There are a large number of fetal defects that can be detected at this stage of pregnancy with conventional 2D US by the transabdominal and TV approach.[15]

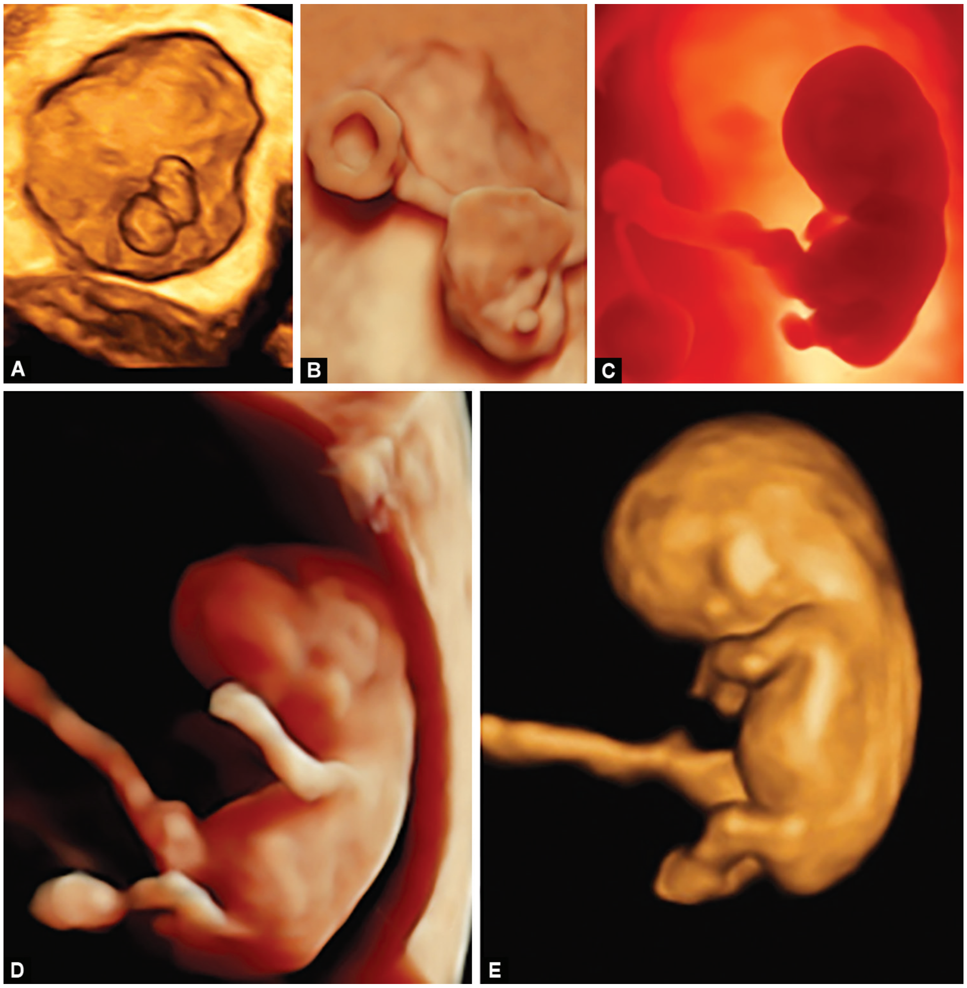
3D ultrasound is also useful to demonstrate these fetal abnormalities using the surface mode as in abdominal wall and facial defects, abnormal extremities, and umbilical cord cysts (Figs 6 and 7). In addition, the multiplanar volume navigation becomes essential for a correct diagnosis in many situations during the first-trimester ultrasound in combination with the surface mode of display, in particular abnormalities of the facial bones have been described.[16–19] Analysis of such volumes is fairly simple and quick and could be done during the live scan on the US machine or as an off-line analysis with the appropriate software in the computer. The multiplanar approach will be discussed later in this paper.

The use of 4D US during the first trimester has not been reported as useful for diagnostic purposes; however, it is of great importance for parents to be able to see the fetus moving. Fetuses at 11–14 weeks show plenty of movements in normal situations, with great jumping and waving hands and due to the size of the fetus, it can be imaged completely on the screen (this is not always possible in the second trimester of pregnancy). There are still not so many facial expressions as seen later in pregnancy and images are of slim funny fetuses. The use of 4D US is mainly dedicated to the cardiac assessment with spatiotemporal image correlation (STIC), a tool that is not used routinely and is mainly reserved to the expert in fetal heart evaluation and in cases of cardiac abnormalities.

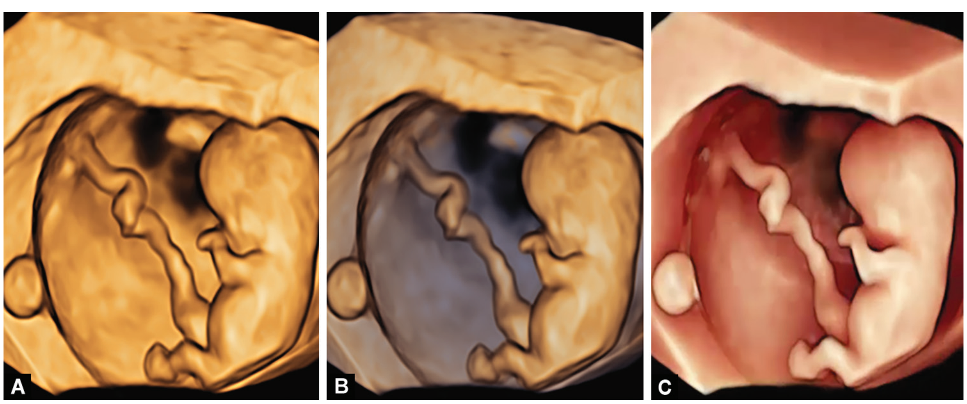
Multiplanar Mode

The multiplanar mode of display a volume is one of the first tools to be developed in 3D US. This mode facilitates the visualization of any fetal structure in the three planes of the space in any desired position. It is useful in its standard or basic mode in which one reference dot can be moved along the volume in the x, y, and z axes; the reference dot represents the single intersection point of the three axes in space. The volume is usually displayed in three panels named A, B, and C in order to visualize all the possible planes simultaneously.

The multiplanar mode of display is widely available in all 3D US machines; it is as useful in live scanning as in off-line analysis. It is fairly easy to manipulate provided the operator is aware of the normal anatomy of the fetus. To remark is the importance of the multiplanar mode in the description of adequate planes in the fetus to perform measurements or anatomical survey, for example, the perfect midsagittal plane (Fig. 8) to ensure the correct plane of the



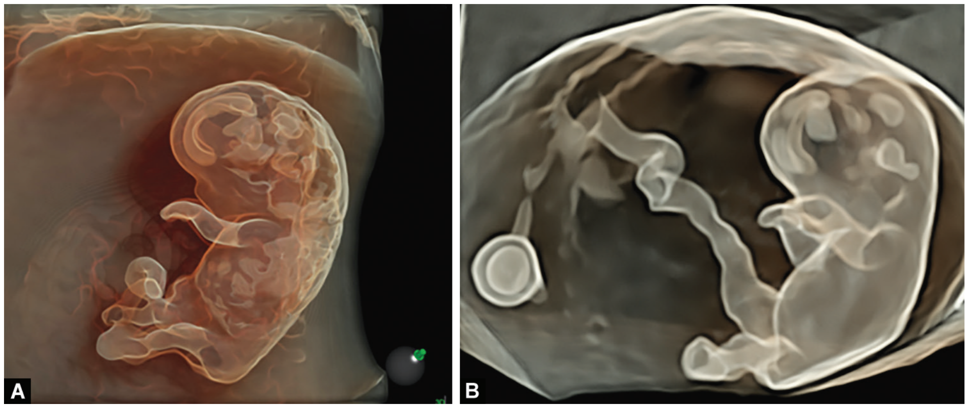
Figs 1A to E: Three-dimensional images of embryos in the first trimester displayed with different surface mode renderization: (A) Embryo at 6 weeks and the yalk sac very close to it with the surface mode; (B) Embryo at 7 weeks and the yalk sac separated from the embryo displayed with HDlive; (C) Embryo at 8 weeks with HDlive; (D) Embryo at 9 weeks with HD live, note the physiologic umbilical hernia; (E) 10-week embryo with the standard surface mode



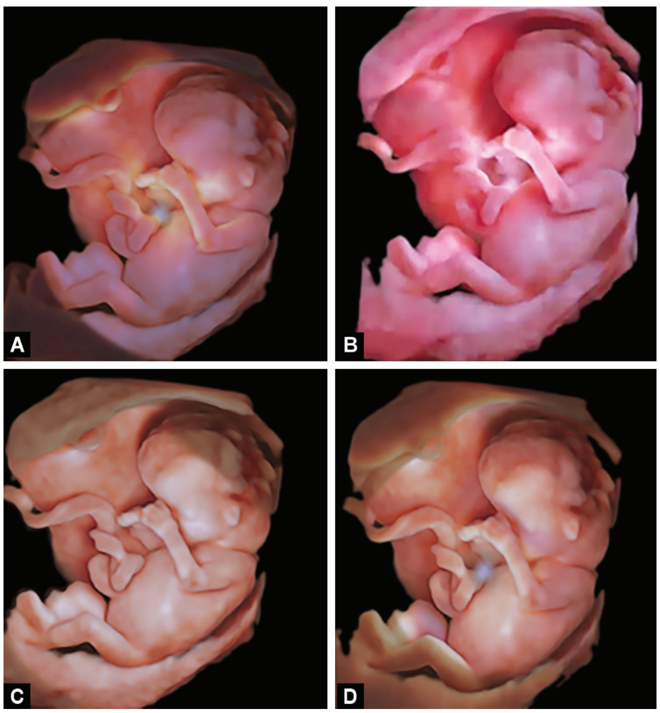
Figs 2A to C: Three-dimensional image of a normal fetus at 12 weeks of gestation displayed with three different renderization surface modes: (A) Standard surface mode; (B) Dynamic rendering (note that structures far from the transducer appear darker, in blue in this case); (C) HDlive that provides a more realistic image with increase in the sensation of volume in the fetus

fetal head to measure nuchal translucency (NT), facial angle, nasal bones assessment, and intracranial translucency (IT) evaluation.[20,21] The same applies to the adequate coronal view to identify the nasal bones in the retronasal triangle[22] (Figs 9 and 10).

There are two main advantages of the multiplanar mode: the possibility to explore the anatomy of the fetus easily and the chance to store the volumes for further analysis or consultation with the expert. The interpretation of images and the understanding of the anatomic



Figs 3A and B: Three-dimensional images of a normal fetus at 11 weeks of gestation displayed with HD live Silhouette



Figs 4A to D: Three-dimensional images of a normal fetus at 12 + 4 weeks displayed with HD Studio. There are many different options for modification that can be applied to this mode

relationship between structures is another advantage of this. For example, the assessment of the presence or absence of the nasal bone can be performed *in vivo* during the scan with a simple acquisition of the fetal profile (well-contrasted 2D image, nasal bone parallel to the probe, small acquisition angle between 30° and 40°). Following this acquisition, the multiplanar is displayed in three planes or with the tomographic ultrasound imaging (TUI) and adequate visualization of the nasal bones can be obtained in the sagittal or coronal view to ensure that both nasal bones are present, or one or both are absent (Figs 9 to 11).

The combination of 2D US with some 3D tools such as multiplanar, TUI, and renderization in the skeletal or surface mode provides a good idea of the normality or the defect in the fetus in the first trimester (Fig. 12). The multiplanar mode is the most used 3D tool in the assessment of fetal defects in the second and third trimester of pregnancy. It is of great importance in the study of central nervous system (CNS) and cardiac malformations.

Other tools such as TUI GE Medical Systems, Zipf, Austria) or the equivalent in other companies, Multi Slice View (Medison, Seoul, Korea) and OMNIVIEW, simplify the navigation and have been used to calculate algorithms for automatization mainly in the cardiac assessment in combination with STIC (see below). These automatic tools are not yet available for first trimester volumes.

The TUI provides of a series of parallel images contained in the volume and in the selected plane and displays them as in a computed tomography (CT). Many images can be analyzed at the same time with no need of further manipulation. It is particularly useful in the first and second trimester for nasal bone assessment if the fetus is in the correct position to obtain a volume (Fig. 11). In contrast, OmniView allows the operator to trace a series of three different types of lines, straight, curved, or of free traced, and displays the correspondent region of the volume (Fig. 13). This mode of navigation is much more intuitive than the one with reference dots.

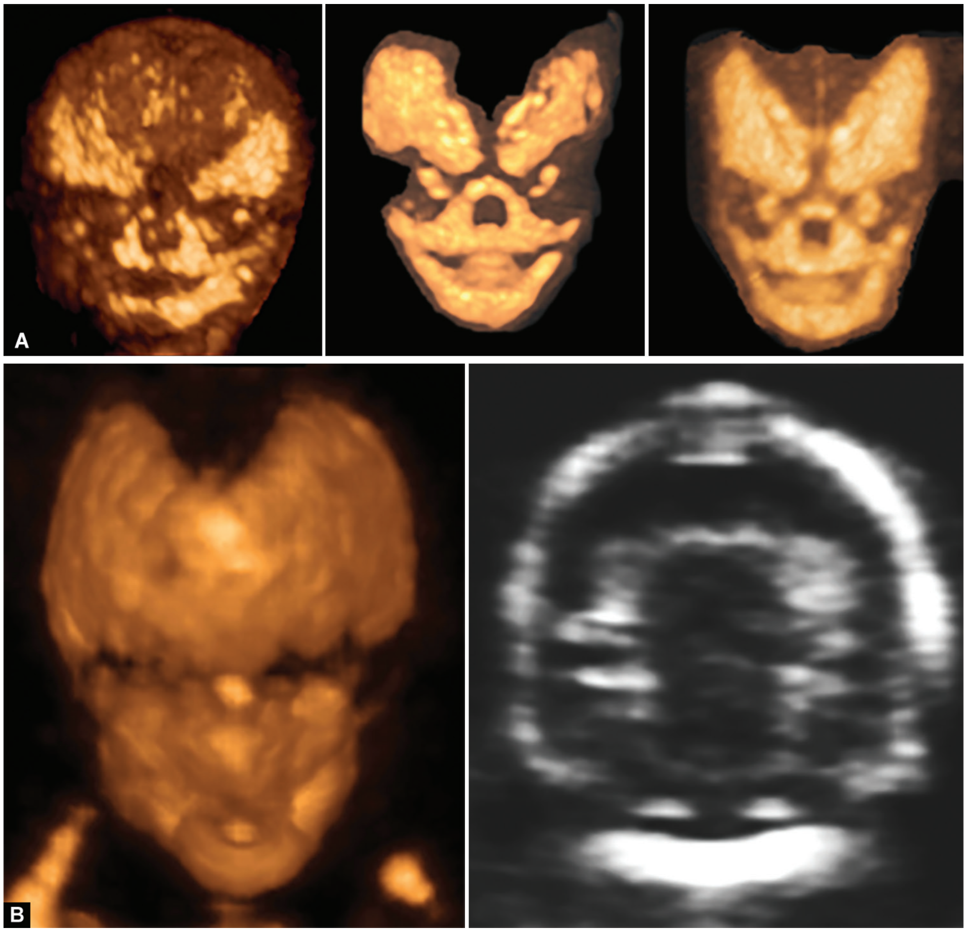
The SonoNT software derives from multiplanar algorithm but in the routine use of automated NT measurement, 3D US is not needed.[23]

These are indirect benefits of the multiplanar mode, because the 3D volumes were used as a research tool to describe many important structures in the fetus and this knowledge has helped many doctors to perform better US examinations in the first trimester.

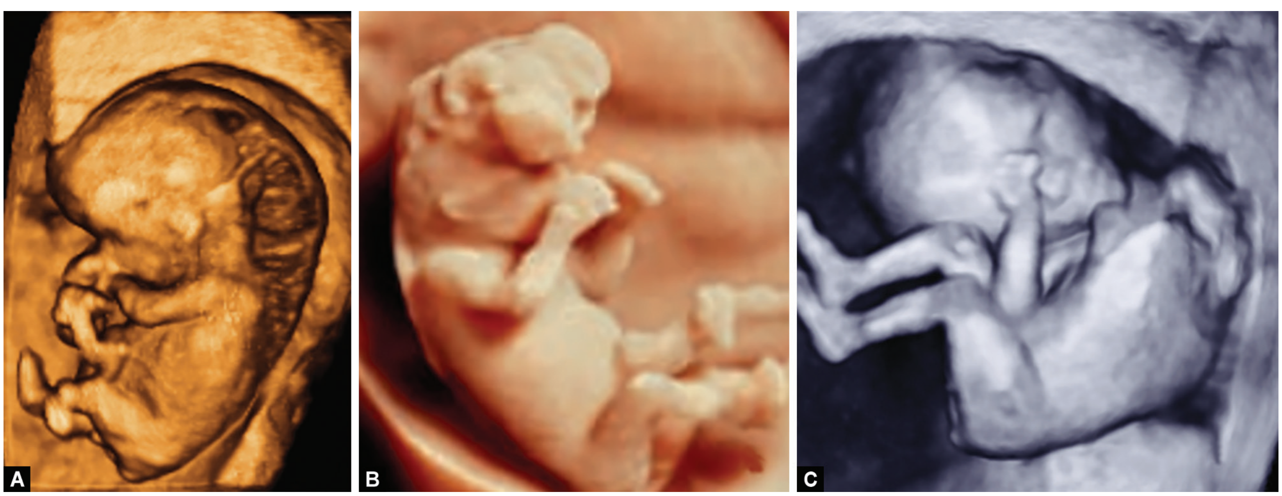
We want to emphasize how useful the multiplanar mode of the 3D US was to understand and describe anatomic aspects of the fetus. In the present, at least some of the detectable abnormalities in the fetus can be suspected or diagnosed with a high-resolution 2D evaluation. In particular, the incorporation of the coronal view in a routine 2D US at 11–14 weeks of gestation is extremely useful and we recommend performing this approach with volume navigation and in real-time 2D US.

Volume Calculation

Volume calculation is possible during the first trimester of pregnancy but its utility is not as relevant in prenatal US. There are many different ways to perform the volume calculation after the acquisition but not all of them are widely available. The inversion mode and virtual organ computer-aided analysis (VOCAL) were the first to be introduced. The virtual organ computer-aided analysis is based on the calculation done on a volume after a series of rotations and tracing of the contour of the selected structure. This technique is fairly precise but is time-consuming and requires

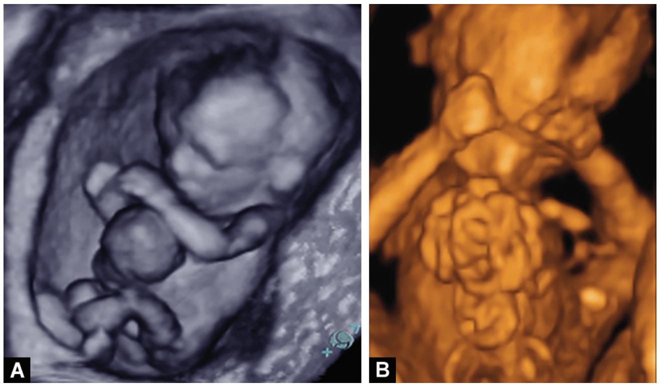


Figs 5A and B: (A) Development of the metopic suture in normal fetuses at 11, 12, and 13 weeks of gestation demonstrated with the skeletal mode of renderization; (B) Abnormal metopic suture in a fetus at 12 + 5 weeks of gestation with holoprosencephaly and trisomy 13



Figs 6A to C: Three-dimensional images demonstrating different fetal abnormalities at 11–13 + 6 weeks that had been diagnosed with 2D US and were displayed in the surface mode after the acquisition of 3D volumes, in order to store them and to show to the parents more clearly the abnormality present in the fetus; (A) Cystic hygroma at 11 + 0 weeks; (B) Anencephaly at 11 + 2 weeks; (C) Body stalk anomaly at 12 weeks (note the abnormal position in which the fetus lies in the uterus; with 4D ultrasound abnormal movements could also be observed)

well-defined borders to ensure that the tracing is correct. At the end of the process, the volume calculation is given and a nice colorful reconstruction can be displayed. It gives the chance to edit the tracing in case of mistakes. To apply VOCAL, the operator has to establish the number of rotation that will be done; when more steps are selected, more reliable the measurement will be, increasing the time spent to achieve such result. If the shape of the desired structure is irregular, the tracing is more difficult and



Figs 7A and B: Three-dimensional images showing abdominal wall defects at 11–13 + 6 weeks; (A) Large omphalocele containing liver in a chromosomally normal fetus at 12 + 6 weeks; (B) Gastroschisis in a fetus at 13 + 4 weeks

less precise. Volume calculation of several fetal structures and the placenta has been reported. But unfortunately, after a decade or more, none of these publications made a great difference in terms of diagnosis of abnormalities or preeclampsia detection in the first trimester[24–30] (Figs 14 and 15). One study reported low intraobserver agreement in the assessment of placenta volume.[31] Studies performed later concluded that the reproducibility of VOCAL is not as good as the reproducibility obtained with a new tool called sonography-based automated volume count (SonoAVC), general or follicle (Fig. 16). Several studies analyzed the relationship between the volume of the placenta in the first trimester measured with VOCAL and the risk of preeclampsia and fetal growth restriction in second and third trimesters. They concluded that the volume calculation is feasible but they could not prove association for clinical use.[29,30]

Sonography-based automated volume count was designed to count the number of follicles present in the ovaries after stimulation in IVF treatments. In addition, the size of each follicle could be independently estimated.[32] Sonography-based automated volume count works by identification of anechoic or hypoechoic fluid-filled structures with a well-define limits and it is a semiautomatic process that requires that the operator obtains a volume and selects the region of interest for the software to make the calculations. It takes only a few second to get the results on the screen. Each follicle gets a color in order to simplify its localization in the ovary and they are counted and listed by size. This tool has been used in prenatal US as well but later the application for general use became available to distinguish from the follicle count that initially was developed (Fig. 17). The new software improved the assessment when hypoechoic structures are involved and limits are not always as clear as in the ovaries. Therefore, the SonoAVC general is the one that should be used in obstetric 3D US. Several studies reported on the volume calculation of fetal structures and gestational sac measurements with this technique[33–40] (Fig. 17). These studies remark that the volume calculation of such fetal structures and gestational sac is feasible with SonoAVC and that the tool is easy to use. Most of these studies concluded that SonoAVC provides a calculation in less time compared to VOCAL when calculating the volume of the fetal stomach, renal pelvis, fetal volume, and gestational sac volume. Moreover, those studies that compared the whole calculation process between VOCAL and SonoAVC concluded that the ability to perform the calculations was similar, but the reproducibility was much better when performed the semiautomated SonoAVC calculation. In one study, SonoAVC was used to assess bladder size and urine production in twin to twin transfusion syndrome. Only a few studies report that SonoAVC requires more editing of the volume compared to VOCAL, but SonoAVC appears to be faster overall.

STIC

The STIC is a 4D tool exclusively designed to assess the fetal heart providing moving or still images. The way it works is with the acquisition of the heart beating followed by the reconstruction of a complete cardiac cycle based on the fetal heart rate. The software asks to the operator to agree with the fetal heart rate estimated before giving the volume images. The series of images that will be

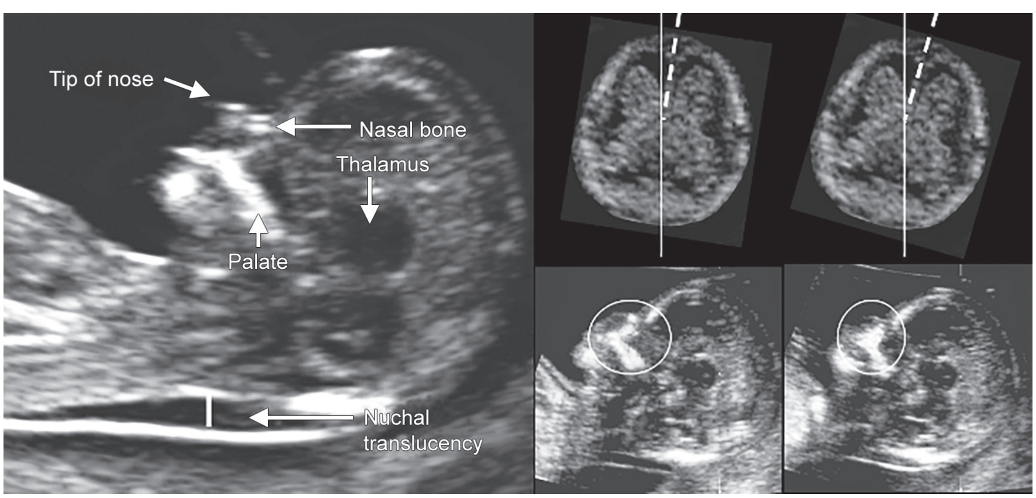


Fig. 8: Effect of the modification of the position of the head in the appearance of the feta profile; rotation of 10° or 15° modifies the aspect of the profile: the visualization of the zygomatic process of the maxilla between the nose and the upper palate and the tip of the nose that is not seen after the rotations

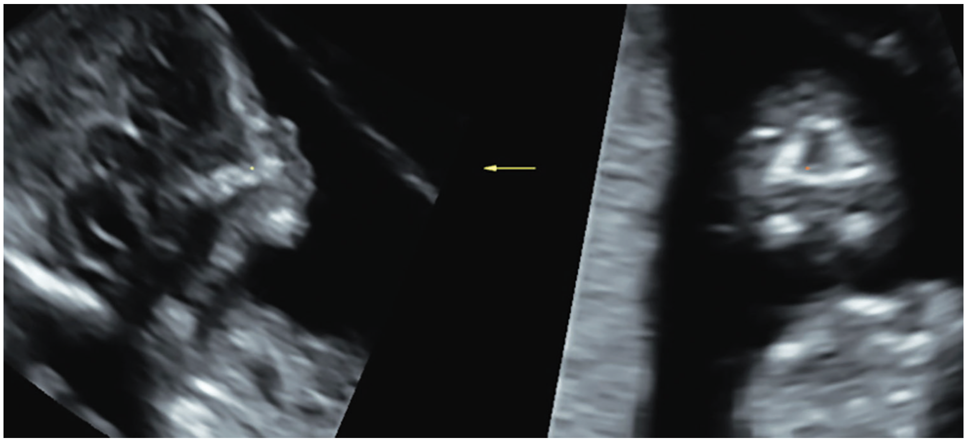


Fig. 9: Image of the fetal profile at 12 weeks displayed with the multiplanar mode showing only A and B planes (sagittal and coronal views, respectively). The acquisition plane is the one recommended for the midsagittal assessment with the transducer parallel to the nose. After rotation of the plane A (fetal profile) in the z axe, a coronal view is obtained in B. In this view, it is possible to assess the retronasal triangle, both nasal bones simultaneously, and the mandibular gap. All these structures appear normal in this fetus

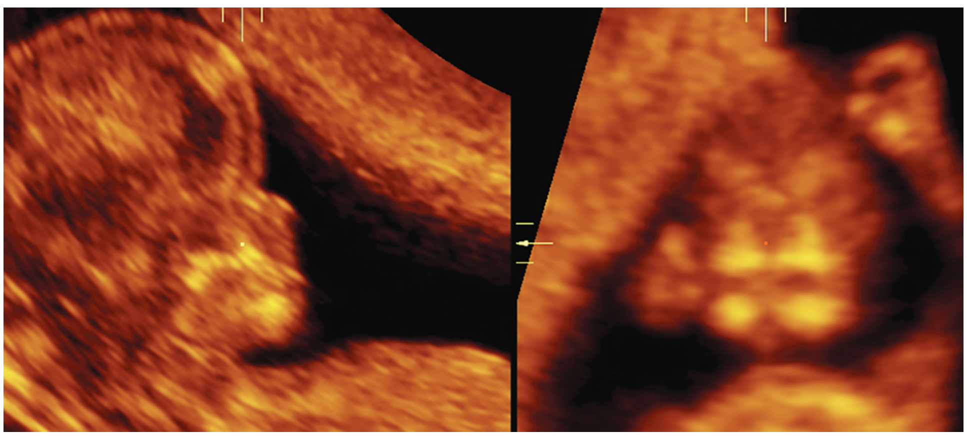


Fig. 10: Image of the fetal profile in a fetus with trisomy 21 at 13 weeks displayed with the multiplanar mode showing A and B planes in a fetus with absent nasal bones. Note in the sagittal view that the line in not thicker or brighter compared to the skin above; in the coronal view, the retronasal triangle is incomplete due to the absence of the nasal bones

available for analysis are reconstructed images from the 2D mode or the color Doppler mode or both. The probe performs a slow sweep over the area of interest selected; depending on the gestational age and the fetal cardiac size, it varies from 7.5 seconds to 15 seconds and the sweep angle from 15° to 40°. It recommends working with a 2D cardiac setting in order to obtain high-contrasted images. Once the STIC is obtained, the volume can be manipulated in the three planes when displayed with the multiplanar mode (standard, TUI, OmniView). The renderization and inversion mode can be useful to demonstrate flow in the cardiac chambers and vessels; volume of the chambers can be analyzed with VOCAL and SonoAVC (Fig. 18).[37,39–41]

Its use in first trimester is recommended always with high-frequency TV probes. Publications report that is not so easy to obtain volumes of high quality, and in certain cases the assessment with 2D US in real time is still of better resolution. However, the experts consider the STIC as a useful 4D tool in the evaluation of cardiac defects in the first trimester of pregnancy.[42–46] The value of the STIC at any gestational age is the possibility to send volumes for second opinion through Internet with no need to send the patient far away for reassurance. Many different algorithms have been published to facilitate cardiac assessment during the second and third trimesters including the automatization of the steps to obtain basic cardiac planes.[47] Other reports combined OmniView with STIC to produce different algorithms to simplify cardiac assessment in the acquired volume.[48,49] Unfortunately, they are not yet available for the first trimester. As in all other 3D/4D tools, a learning curve is needed to acquire correct STIC volume in the first trimester and extra time to learn how to manipulate these particular volumes of the fetal heart. In fact, the manipulation of such volumes also requires at least a minimum knowledge about the fetal heart anatomy.

Telemedicine

3D/4D ultrasound in the first, second, and third trimesters has given the opportunity for doctors to exchange images, volumes, and videos easily. This is called telemedicine and in our opinion is one of

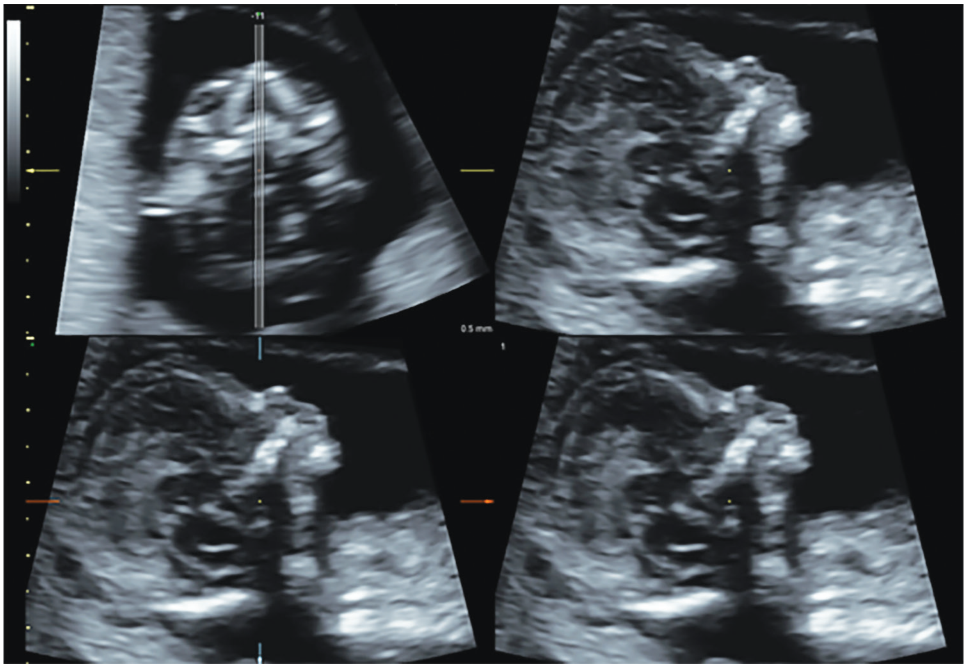
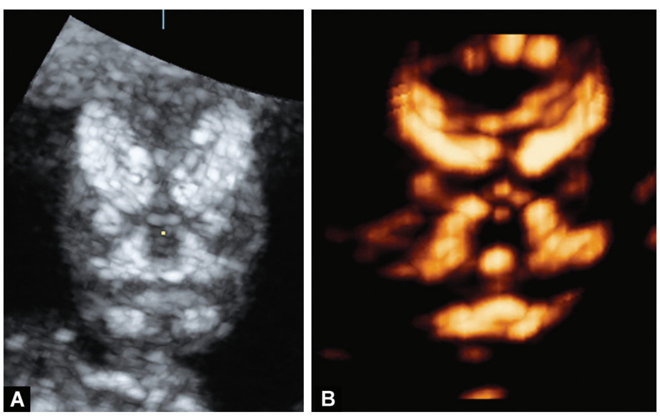


Fig. 11: Tomographic ultrasound imaging in a normal fetus at 12 + 3 weeks demonstrating the presence of both nasal bones at each side of the perfect midsagittal plane of the fetal face. The reference image corresponds to the transverse view of the face so that the parallel sequence of images is displayed in the sagittal view to assess the nasal bones simultaneously. The distance between the lines is 0.5 mm and both pictures on the right side named 1 and −1 correspond the parallel images from the midline. Note that the appearance of the brain is slightly different when moving away from the midline



Figs 12A and B: The multiplanar mode of display set the concept for the renderization of the coronal view of the face, simulating the retronasal triangle but with the renderization mode. A normal fetus at 12 weeks in figure A and a bilateral cleft in a fetus with trisomy 13 at 12 weeks in figure B

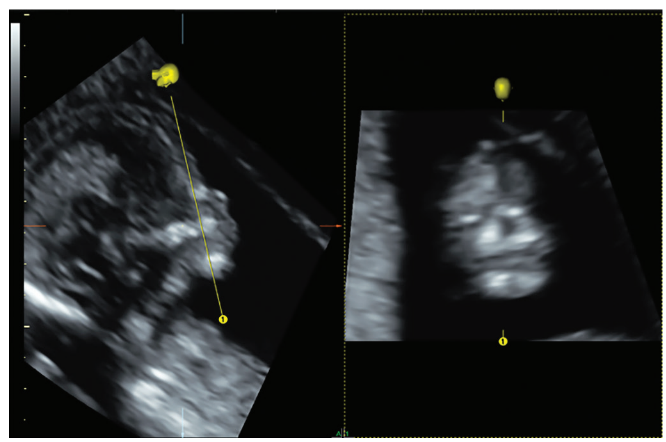
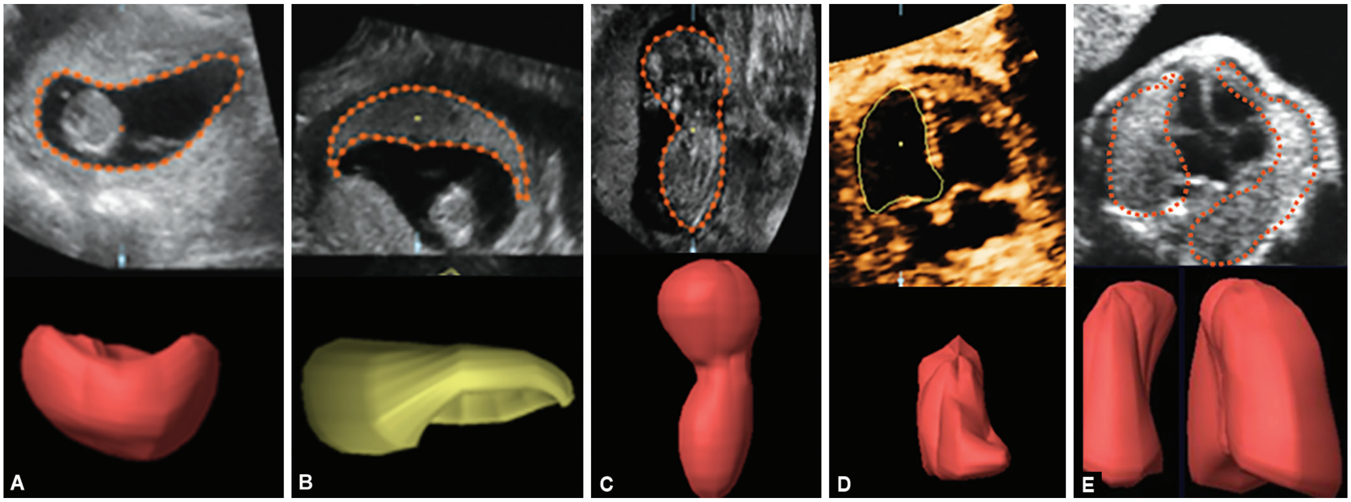


Fig. 13: Retronasal triangle demonstrated with OmniView in a normal fetus at 13 weeks of gestation. The reference image on the right corresponds to the fetal profile in which the OmniView line is drawn as a straight line and the coronal view is displayed on the left showing all the structures that appear on the line; in this case, the retronasal triangle is observed

the most useful applications of the 3D. It is true that there are lovers and detractors of 3D/4D US but the combination of this technology and the Internet is a great advantage compared to the 2D US in the assessment of fetal abnormalities in a distant location without the need of seeing the patient in real-time scanning. However, it is not true that any volume is useful for analysis and care must be taken to acquire adequate volumes in each anatomical area and in particular when a fetal defect is suspected. For this reason, we suggest to obtain more than one volume of the area of interest in more than one orientation to ensure that the whole defect is contained in the information stored. Many studies reported on the benefits of the telemedicine.[50,51] It is clear that in the routine clinical practice, for those with less experience or who do not have the opportunity to work in a medical team, the possibility of sending volumes away to a colleague, asking for a second opinion, is critically important and for teaching purposes as well. Along this line, we believe that learning how to obtain a 3D volume is at least as important as how to interpret the acquired information. We therefore encourage the readers to get adequate training in 3D to improve the results achieved.



Figs 14A to E: VOCAL in the assessment of: (A) Gestational sac; (B) Amniotic sac, and (C) Fetus volumes in the first trimester of pregnancy and (D) Cardiac structures; (E) Lungs volumes in second trimester (*Source*: from the publications mentioned in Ref. 24–27)

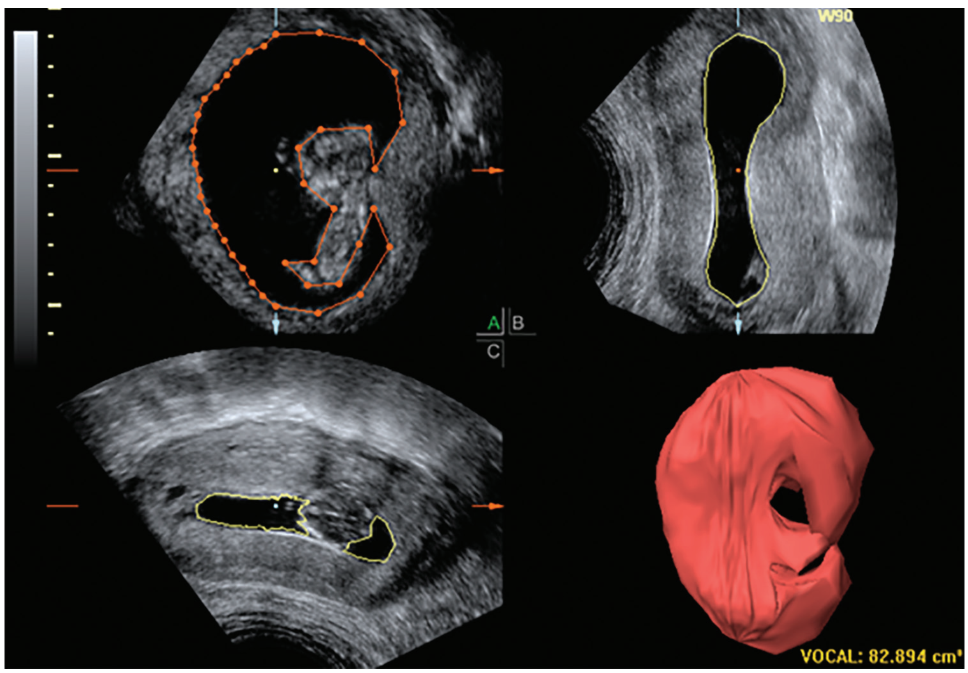


Fig. 15: Gestational sac volume calculated with VOCAL. Note that the irregular shape of the fetus makes the tracing more difficult and need more rotation steps (15° angle) to ensure the accuracy of the measurement

Summary

Is it really essential to have a 3D/4D US machine in our practice to carry out a first-trimester scan? The answer is no. However, as most of the practitioners do have one nowadays, it is important to point out its benefits and limitations.

It is clear that 3D images obtained with TV high-resolution probes to visualize the embryo with all the new renderization modes are spectacular but with little use in medical diagnosis yet. However as the fetus gets bigger, 3D US can show the fetus very nicely and demonstrate some of the abnormalities that affect the fetal surface and that had been previously seen on 2D. Moreover, 4D US in this phase of pregnancy, by visualizing the fetus with constant movements, creates early bonding with the family.

The use of the multiplanar mode of display is extremely useful in its standard mode or with TUI and OmniView in the demonstration of facial abnormalities that are very common in association with chromosomal abnormalities. This 3D mode is essential for teaching in an off-line process that can be carried out in a computer with no patient or US machine, allowing plenty of time for navigation in the stored volume.

The limitations include the less resolution of the 2D US in the first trimester compared to a second-trimester fetus as for example in internal organs and the heart. Therefore, images of good quality

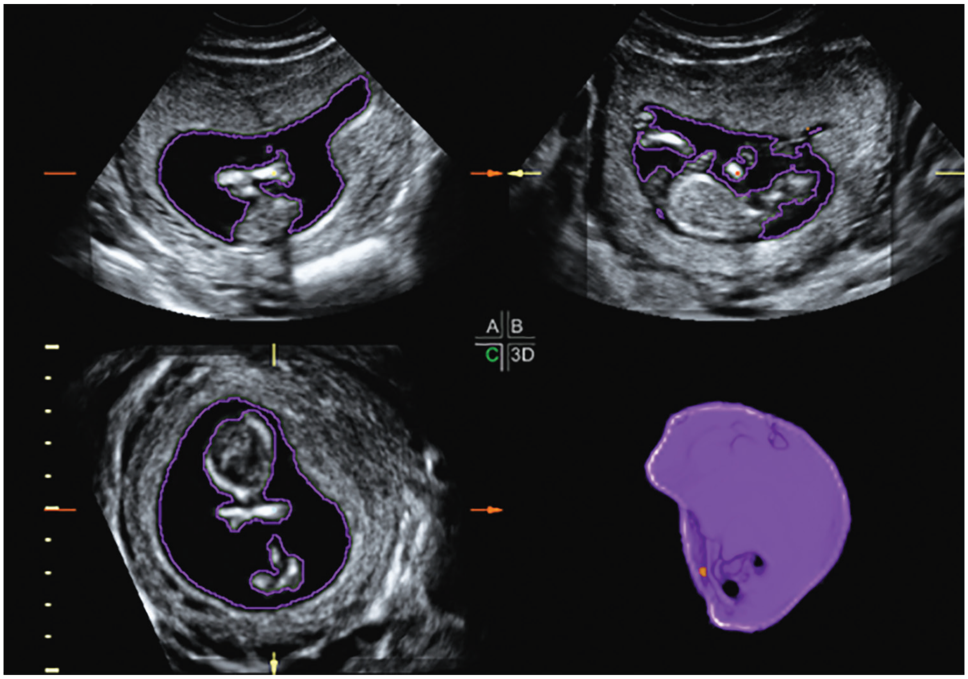
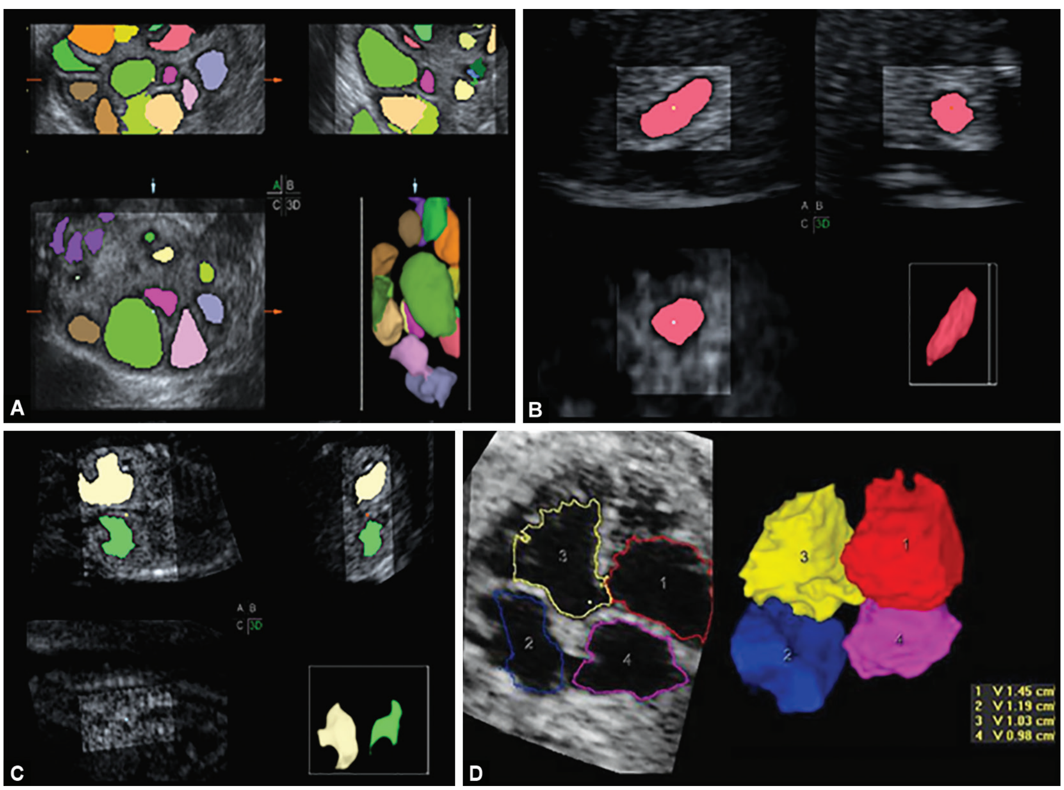


Fig. 16: Gestational sac volume calculated with the SonoAVC follicle. The semiautomatic calculation recognizes very well the borders of the fetus due to the contrast between the anechoic amniotic fluid and the hypoechoic fetus. No further adjustments or editing is needed



Figs 17A to D: Volume calculation with SonoAVC: (A) Ovary with stimulation in IVF; (B) Fetal stomach at 16 weeks; (C) Renal pelvis in a fetus at 15 weeks with hydronephrosis; (D) Cardiac chambers at 18 weeks

and volumes are more difficult to obtain for multiplanar navigation of cardiac assessment with STIC. In some situation, not even with TV approach is possible to store good volumes increasing the scanning time or the need to reschedule the patient for another visit. It is not possible to avoid a learning curve in acquisition and manipulation of volumes, in particular with the surface mode, since new tools became available every year and update of information on how to use them is always recommended.

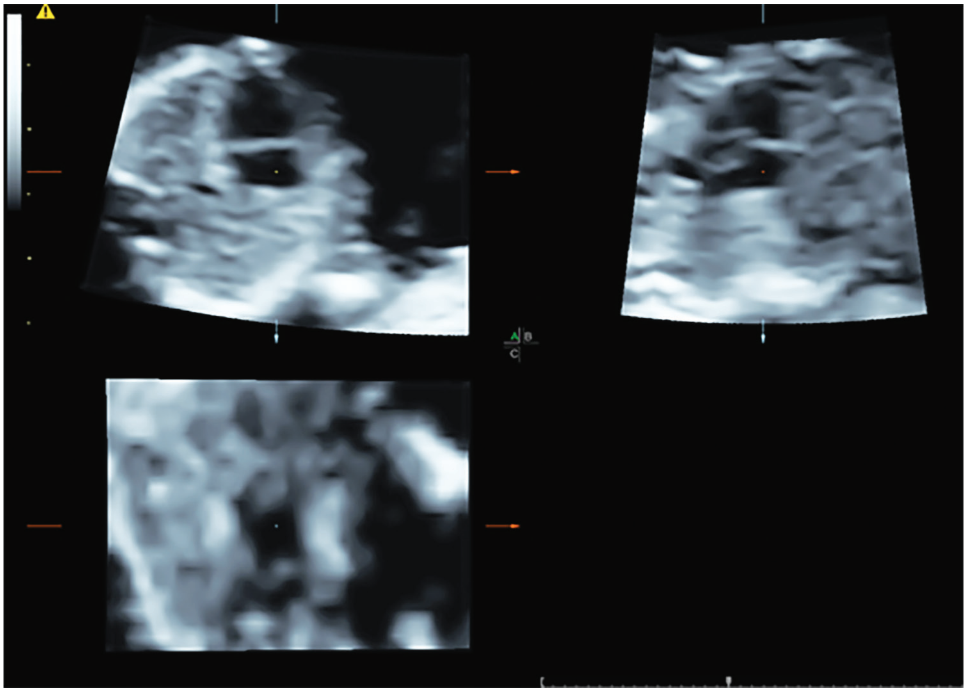


Fig. 18: Multiplanar display of a 4D volume obtained with spatiotemporal image correlation in a fetus at 13 + 5 weeks of gestation. The acquisition plane (plane A) that in this case corresponds to the apical four chambers' view of the heart is the plane with better resolution. In first-trimester spatiotemporal image correlation volumes, this is critically important since the other planes B and C may not be as useful for analysis. Therefore in abnormal cases, more than one volume is needed to demonstrate the defect

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