Biplane mode for more precise intrauterine procedures

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The evolution of ultrasound and the introduction of 3- and 4-dimensional ultrasound techniques led to a shift in the perception and usage of ultrasound in fetal medicine. The biplane mode might help in multiple fetal procedures, including but not limited to basic intrauterine thoracocentesis, thoracoamniotic shunting, amnioreduction, amnioinfusion, cordocentesis, intraumbilical infusion, and umbilical cord coagulation, with a possible reduction in the complication rate. Despite its theoretical usefulness, more studies are required to assess the clinical importance of this technique.

Key words: biplane mode, fetal procedures, ultrasound

Introduction

During the last decades, ultrasonography has evolved markedly with the introduction of 3-dimensional (3D) and 4-dimensional (4D) technique: 3D scans show static images in 3 dimensions, whereas 4D scans show dynamic 3D images with time being the fourth dimension. These new technologies have led to the reconstruction of enhanced images and videos, improving the diagnostic abilities of the ultrasound.[1,2] Furthermore, it has transformed a medical examination into a magical encounter and bonding experience between parents and their child-to-be.[1,3]

Despite the aesthetic aspect, sonographers and obstetricians agree that 3D and 4D imaging cannot replace 2-dimensional (2D) scanning, because evidence supporting the benefit of 3D and 4D imaging are still limited.[4] Recently, the implementation of matrix array probes associated with faster processing and data handling led to the increase in frame and volume rates with high resolution in real-time display and in multiple planes.

The concept of biplane view with the matrix probe allows the simultaneous view of 2 orthogonal planes, in B-mode and in color Doppler or power Doppler modes.

Fetal medicine, fetal therapy, and surgery are innovative fields evolving very fast. The interventions take place in a restricted environment (in utero) with small regions of interest (umbilical vein for example) or targets close to noble and vital organs (eg, pleural effusion next to the heart and big vessels). The margin for error is hence very small, with severe and sometimes fatal consequences. These fetal interventions require a specific training with a learning curve before being able to perform them on patients.[5]

In this clinical opinion, we will discuss the added value of using the biplane mode in some examples of fetal interventions and its contribution to more precision in these delicate procedures (Table).

Basic intrauterine thoracentesis (Figure 1, Video 1)

Fetal pleural effusion is the excessive accumulation of fluids in the pleural space. Thoracentesis is the insertion of a needle in the pleural space to remove the excess fluid. It is usually indicated when this fluid becomes compressive with systemic consequences hydrops, diaphragmatic inversion, and polyhydramnios and can lead to an increased risk of preterm labor and preterm delivery.[6] A basic thoracentesis without shunt insertion is sometimes preferred in pregnancies beyond 35 weeks' gestation, allowing lungs to re-expand, which facilitates postnatal pulmonary ventilation at birth.

In this situation, the use of the biplane mode allows the tip of the needle to be accurately visualized avoiding the injury of intrathoracic structures. In Figure 1 and Video 1, the tip of the needle is identified and visible in both orthogonal planes with precise localization in relation to the right atrium (a couple of millimeters away).

Thoracoamniotic shunting (Figure 2, Video 2)

As with thoracentesis, thoracoamniotic shunting is used with compressive pleural effusions, earlier in pregnancy with excellent results.[6,7] However, shunts are not fixed to the thoracic wall and might be displaced (internally or externally) or become obstructed, with the possible need of an additional procedure.[8] These complications can be secondary to misplacing the drain or to technical difficulties during its insertion. The biplane mode helps bypassing some of these difficulties with easier release of both the intrathoracic and intraamniotic

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TABLE
Intrauterine fetal procedures

Procedure	Explanation
Basic intrauterine thoracentesis (Figure 1, Video 1)	Visual representation of the needle tip in relation to the intrathoracic structures
Thoracoamniotic shunting (Figure 2, Video 2)	Visual representation of the release of the intrathoracic and intraamniotic loops
Amnioreduction and amnioinfusion (Figure 3, Video 3)	Position of the needle in relation to adjacent structures
Cordocentesis and intraumbilical infusion (Figure 4, Video 4)	Adjusting the position of the needle tip in the umbilical vein
Umbilical cord coagulation (Figure 5, Video 5)	Visualization of both jaws of the bipolar forceps grasping the loop

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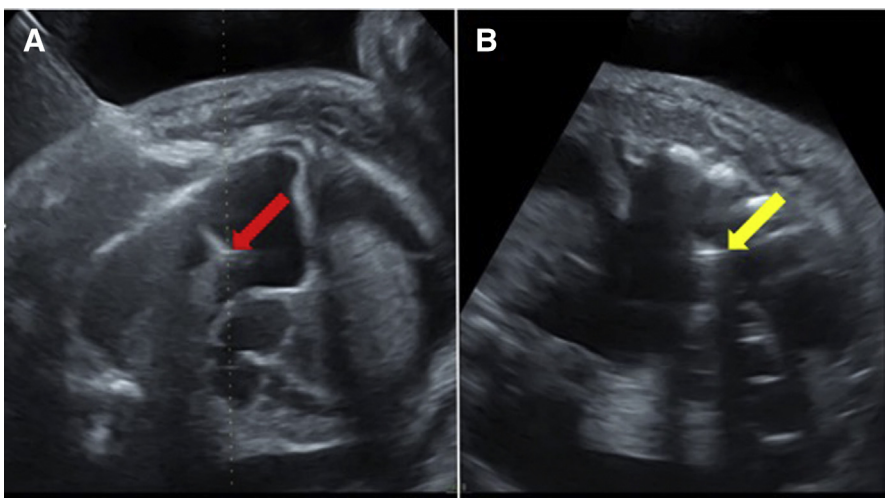
loops. It offers the option to move the orthogonal plane without moving the probe (as illustrated in the video), which allows the operator to follow the release of the loops while keeping the probe in the same position and monitoring the position of the needle relative to the adjacent structures (Figure 2, A–C).

Amnioreduction and amnioinfusion (Figure 3, Video 3)

There are multiple causes of polyhydramnios including viral infection, chromosomal abnormalities, gestational diabetes, and twin-to-twin transfusion syndrome (TTTS). Amnioreduction may be indicated for the symptomatic relief of the mother (dyspnea, uterine contractions) or the need for fetoscopy procedures.[9] In contrast, amnioinfusion may be needed in cases of oligo- or anhydramnios to facilitate normal lung development or during an intrauterine procedure.[10] These procedures may be complicated by prematurity, placental abruption, premature preterm rupture of membranes, intrauterine fetal demise, or chorioamnionitis.[11]

The biplane mode enables the tip of the needle to be precisely visualized in relation to the adjacent structures, making these procedures safer and faster. In the same position, the needle might seem distant from the fetus (Figure 3, A), whereas it might be close on the orthogonal plane (Figure 3, B).

FIGURE 1
Basic thoracentesis without shunt insertion



A, Needle tip seen in 2D in the hydrothorax (*red arrow*). **B,** Orthogonal plane showing the tip of the needle (*yellow arrow*) with a certain distance from the intrathoracic structures.

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Cordocentesis and intraumbilical infusion (Figure 4, Video 4)

Inserting a needle in the umbilical vessels might be needed for cord blood sampling, intrauterine transfusion, or intraumbilical infusion (fetocide, anesthetic, etc).[12] The use of biplane imaging helps in better localization of the needle tip than the classic 2D ultrasound guidance especially in cases of posterior placentae when sampling a free loop might be required. With only one plane of view, needle placement is prone to the phenomenon of lateralization, because the width of the ultrasound beam is wider than the width of the needle tip itself, which allows the needle to be seen anywhere within the imaged tissues.[13] Hence, this imprecision in the procedure can lead to multiple puncture of the umbilical cord with its inherent risk of fetal bleeding and demise.

Umbilical cord coagulation (Figure 5, Video 5)

In contrast to static 3D images, the utilization of 4D technology permits the observation of fetal and umbilical cord movements with more precision during umbilical cord coagulation, because the near real-time technology used in a case of a procedure provides the speed and precision needed to perform advanced and complicated procedures.[14] This has been described in a case of a TTTS at approximately 20 weeks' gestation that was treated with cord occlusion of one

of the twins.[14] The biplane view was shown to be of additional benefit in similar procedures, because it allows better visualization of the umbilical cord loop in relation to the bipolar forceps.[15] In Figure 5, A, we illustrate the localization of the bipolar forceps arriving at the level of the cord without being able to see both jaws of the forceps with their position in relation with the umbilical cord. However, by associating the orthogonal plane, seen in Figure 5, B, we see both jaws of the forceps arriving on both sides of the cord and grasping.

Discussion

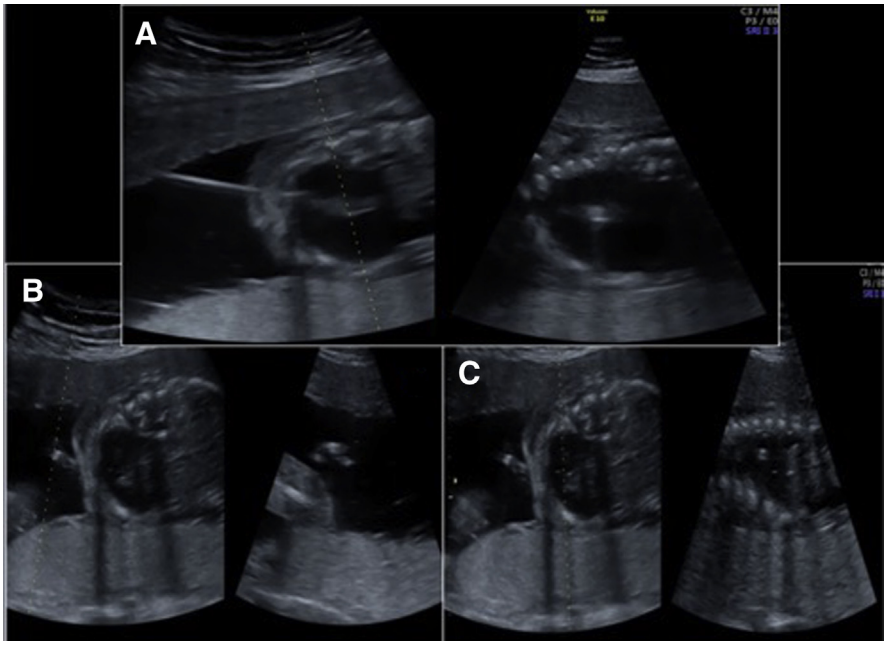
Ultrasonography is an essential tool used in the daily routine of obstetrics and gynecology. Over the past few decades, advances in this field helped expand the diagnostic and therapeutic capacities of this tool in intrauterine procedures. Nowadays, devices help with the acquisition of the static 3D and dynamic 4D images.[4] The concept of biplane view with the matrix probe made it possible to simultaneously view 2 orthogonal planes, in B-mode and in color or power Doppler modes.

Images acquired in 2D modes with their relative resolutions are suboptimal for invasive intrauterine procedures requiring precision using relatively small instruments.[16]

Of note, 3D images present more aesthetic value, but acquiring these images can take up to 15 seconds depending on the size of the field of vision which makes it less useful in invasive procedures.[3,17] The addition of time, as the fourth dimension in 4D ultrasonography, gave it the lead in this field.[3] With these new advancements, movements and structures are visible simultaneously in all directions facilitating orientation during the procedure and minimizing risks of injury to lateral adjacent structures, previously not seen in 2D configuration.

The biplane mode allows high-resolution images to be simultaneously viewed in 2 orthogonal planes in real time without the need to acquire a 4D volume.[17] Image quality is better in the acquisition plane, with the orthogonal plane reconstructed using volumetric data. The Doppler mode can also be used for these acquisitions. The clinical implication of this technology includes fetal ultrasonography with the detailed dynamic view of certain structures, such as the palate, heart, and spinal cord.[17,18]

FIGURE 2
Thoracoamniotic shunting



A, Intrathoracic drain release with the trocar (T) visible in both planes. **B,** Intraamniotic loop (IAL) visible in the amniotic cavity in both planes. **C,** Intrathoracic loop (ITL) visible in the thorax in both planes.

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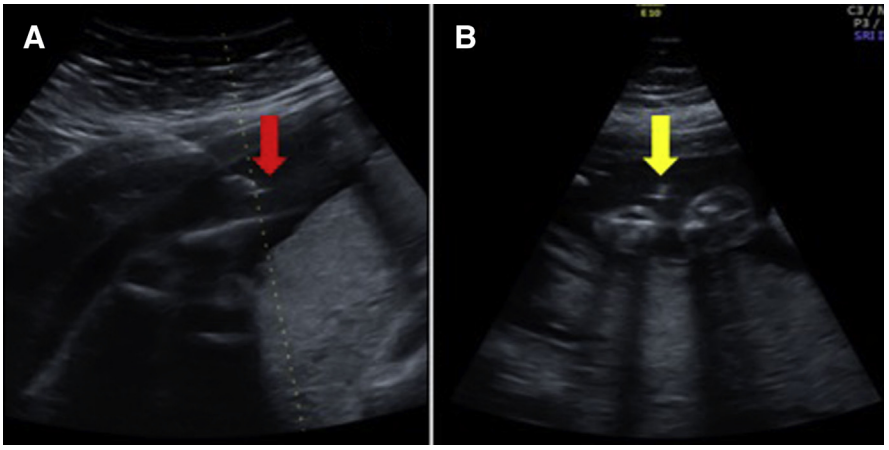
FIGURE 3
Amnioreduction and amnioinfusion



A, Needle appears distant from the fetus (*red arrow*). **B,** Needle tip close to the face of fetus after he moved, visualized in the orthogonal plane (*yellow arrow*).

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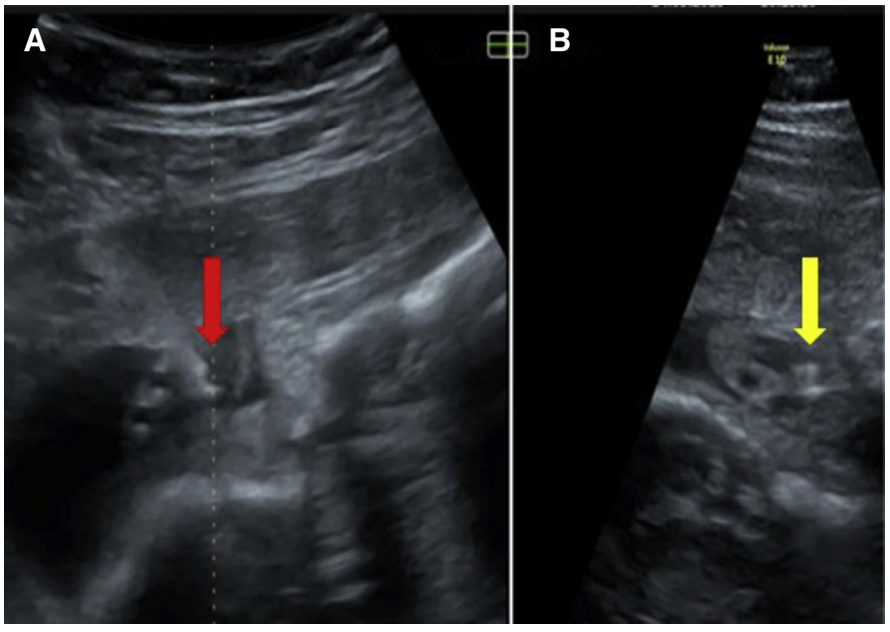
FIGURE 4
Cordocentesis



A, Needle appears reaching the umbilical vein (*red arrow*). **B,** Needle tip visualized inside the vein in the orthogonal plane (*yellow arrow*).

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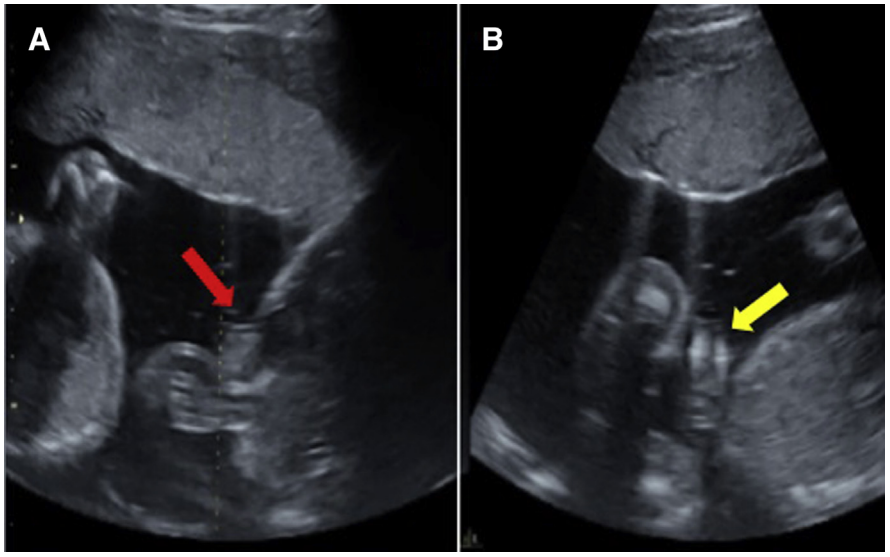
Hence, the biplane mode can also be used for invasive fetal procedures because it can provide the organs' position and relation, in both orthogonal planes, which could not be always visualized using 2D imaging.[15] Following the instruments in both planes allows more accurate manipulation and eliminates the lateralization effect found in 2D scanning.[16] The biplane mode was also shown to be beneficial in other specialties, such as biopsy procedures, in which a reduction in the number of core samples required for a reliable histologic diagnosis was noted.[19–21] The biplane mode offers an advantage without any reporting increase in complications.[13,22] Furthermore, it may require the help of an additional assistant to focus on the studied area.

FIGURE 5
Umbilical cord coagulation



A, Bipolar forceps reaching the cord without proper visualization of the forceps jaws (*red arrow*). **B,** Both forceps jaws identified in the orthogonal plane, grasping the cord (*yellow arrow*).

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Conclusion

Although this technology is very promising, many areas of improvement have yet to be addressed before routine practice use:

- Technically, it needs some improvement, in terms of the number of frames per second and fluidity of the images on both planes. Probably more powerful processor units can easily solve this issue.
- From an accessibility and cost-effectiveness point of view, the cost of the probe and the software behind it needs to be compared with the benefit added to these interventions, as rare as they may seem.
- From a practical point of view, we need to validate the use of such technologies in in utero interventions and afterward establish the necessary learning curve to acquire competence using this innovative technique. ■

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