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3D/4D/HD live Imaging; Increasing Fetal Anomaly and Gynaecological Abnormalities Detection in Africa

Oluwasegun Titilade[1*], Adebusola Titilade [2], Adebimpe Bello [3]

[1] Department of Radiology, University College Hospital, Ibadan, Nigeria/ Window to the Womb Burscough and Liverpool United Kingdom
[2] General medical Practitioner Nigeria and United Kingdom
[3] Consultant Radiologist/Lecturer 1 Department of Radiology Unimed/UNIMEDTHC, Ondo, Nigeria
[*]Corresponding Author Email: [1] titiladetolf@gmail.com

Abstract

Background and Purpose*: Three/four Dimensional/High definition live (3D/4D/HDlive) ultrasound images are recent advancements which have aided and increased diagnoses of gynaecology abnormalities, detailed evaluation of normal and abnormal findings across pregnancy trimesters. Although, 2D ultrasound has played significant role in the field of medicine with its use spanning across almost all the systems of the body since inception, these recent advancements have gained practical usefulness by increasing the diagnosis rate of fetal anomalies and gynaecological disorders in the western world.*

In most teaching Hospitals in Africa using Nigeria as a case study, Radiologists perform most of the ultrasound imaging including fetal anomaly and gynaecological scans. It is therefore imperative for the Radiologists in Africa to master and employ the use of the 3D/4D/HDlive to improve the sensitivity of detecting various abnormalities.

Aim: *There are limited studies on 3D/4D/HD images in Africa, the aim of this article to give illustration to the role of these ultrasound imaging in clinical medicine and the importance of engaging them in Obstetrics evaluation, as well as the diagnosis of the gynaecological abnormalities in Africa's tertiary institutions.*

Keywords

3D ultrasound, 4D/HDlive ultrasound, Gynaecology, Obstetrics, tertiary hospitals in Africa.

INTRODUCTION

In 1952, Wild and John Read published the first 2D images which focused on characterisation of tissue mainly breast tumours[1]. 2D ultrasound has played significant role in the field of medicine with its use spanning across almost all the systems of the body. However, 3D/4D/HDlive ultrasound have increased the sensitivity of diagnosing fetal anomalies and gynaecological disorders[2], [3]. In 2005, 3D ultrasound was proven to be useful in imaging myriads of medical problems especially in fetal medicines and gynaecological conditions during a conference held by the American institute of Ultrasound in Medicine[2], [4], [5]. In recent times, 3D/4D/HDlive ultrasound are not only useful in obstetrics and gynaecology but also in breast ultrasound and cardiac imaging[6], [7], [8], [9], [10], [11].

In most African teaching Hospitals (using UCH Ibadan, UNIMEDTHC Ondo, OAUTHC Ile-Ife, LASUTH and LUTH Lagos, BUTH Ogbomoso, OSUTH Osogbo etc. as case study), Radiologists perform most of the ultrasound imaging including fetal anomaly and gynaecological scans[12], [13]. It is therefore imperative for the Radiologists to develop proficiency in the use of the 3D/4D/HdLive to improve the sensitivity of detecting various abnormalities that this recent advancement has brought.

SCIENTIFIC AND TECHNICAL FEATURE

Three Dimensional (3D) images are obtained when the ultrasound machines acquire many 2D images from various angles within a brief timeframe and process them together. Each of the 2D images from different depths of the tissue creates different view which are then reconstructed by the machine's mathematical algorithms to form the 3D images[14] (fig 1A).

4D ultrasound is 3D images displayed in motion (real time)[15]. Many 3D images are put together in a frame rate to form a video[14]. The state of the art in this regard is the HDlive (fig 1B) which are found in many GE machines (GE Voluson E8, GE Voluson S10, GE Voluson Signature 18 etc.) and some Mindray machines specifications. It provides vivid picture of the fetus and organs by using an adjustable light source that causes panoramic illumination and enhancement of images.

Images in 3D/4D/HDlive involves data acquisition, visualization, volume imaging processing and manipulation, storage and rendering of image sequences[5], [16], [17].

Transvaginal volume probes (5-9 MHz) are used for 3D/4D/HDlive image acquisition in early pregnancy and in

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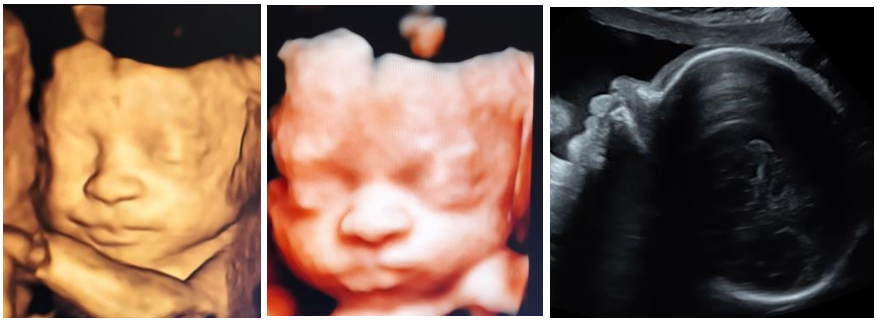
gynaecology scan for assessment of the uterine and ovarian abnormalities as well as automated follicular count. Abdominal volume transducers (4-8 MHz) are employed in later pregnancy especially from the late first trimester to the third trimester[5].



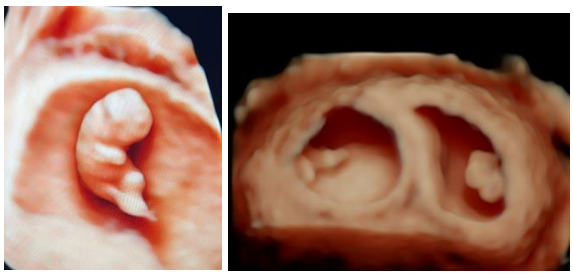
A B C

Figure 1. A and B are the 3D and HD images of a 25weeks fetus. C. 2D image of a 28weeks 3day fetus

THE IMPORTANCE OF 3D/4D/HDLIVE ULTRASOUND IN OBSTETRICS

The recent advancements play major roles in increasing diagnosis across all pregnancy trimesters as well as highlighting normal findings (fig 2 and 3A, 3B, 3C). Acquiring a good quality 3D/4D/HDlive images requires the following

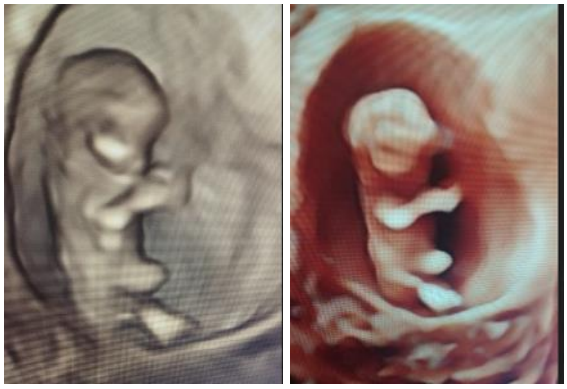
1. An adequate amniotic fluid around and in the front of the body parts
2. Proper positioning of the area of interest and the sensitivity line as depicted in the image below (fig 4)
3. Adequate processing of the images based on the x, y, z coordinates, the smoothening and other post processing analysis[16], [18], [19].



A B

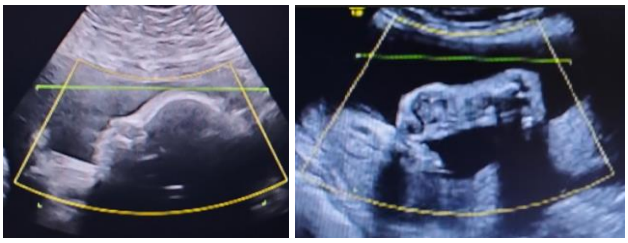
Figure 2. A. HD image of an 8weeks 5days. B. HD ultrasound image of a set of twins in different gestational sac at 7weeks 2 days

A



B C

Figure 3. A, B, C. 2D, 3D and HD ultrasound images of a 10weeks 4days fetus showing physiological herniation.



A B

Figure 4. The images demonstrating the acquisition process of 3D/4D image. A. Fetal face is in profile with amniotic fluid in the front. The area of interest (yellow box) and the sensitivity line are shown B. Fetal foot

3D assessment of the true mid sagittal section necessary for proper measurement of the Nuchal translucency (NT) can be done in the first trimester[5], [20]. Normal brain or facial structures can be displayed in a multiplanar view with the use of 3D/4D ultrasound (fig 5). Also, pathological brain structures like partial or complete corpus callosum agenesis or abnormalities of the ventricles can be seen in the multiple planes display mode of the 3D/4D scan mode[21], [22], [23].

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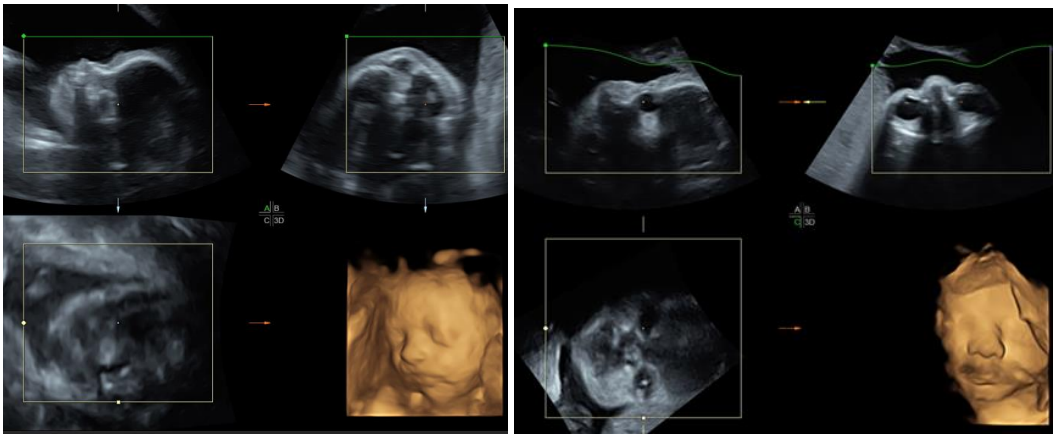
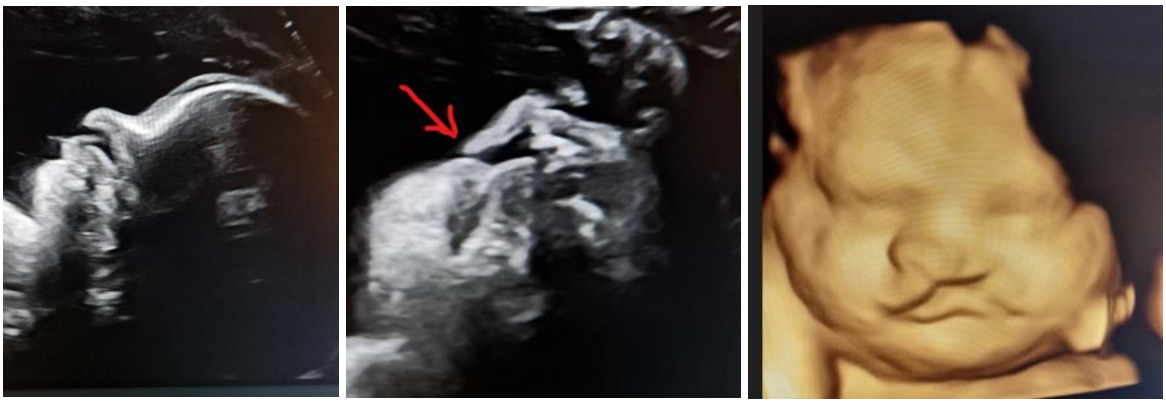


A B

Figure 4. A. The multiplanar display of a 25weeks 2days fetal face in anterior oblique plane B. Multiplanar display of 31weeks 5days face. Note the display of the fetal orbit in the sagittal, axial and coronal planes.

3D/4D spatiotemporal image correlation (STIC) fetal echocardiography technique allows the complex evaluation of the fetal heart anomalies[24], [25], [26], [27].

Abnormalities of the facial, limbs, abdominal, spinal defects and external genitalia[5], [28], [29] can be properly evaluated with the surface rendered images (Fig 6-13)



A B C

Figure 6. A, B Sagittal and axial 2D images C. 3D image of a 31weeks 2days fetus with upper cleft lip.

Figure 7. 32 weeks 2days fetus with a very subtle cleft upper lip.

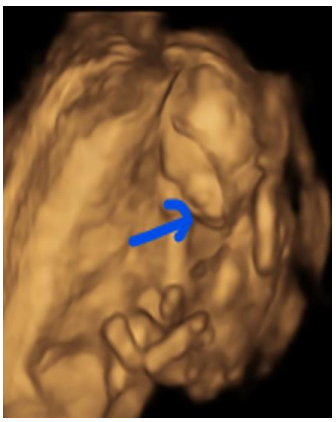


Figure 8. 15weeks 6days fetus with a subtle upper lip cleft (blue marker) later confirmed in the subsequent scans (later scans not shown)

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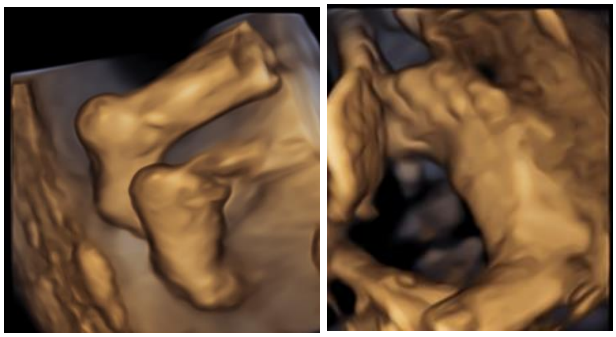
A



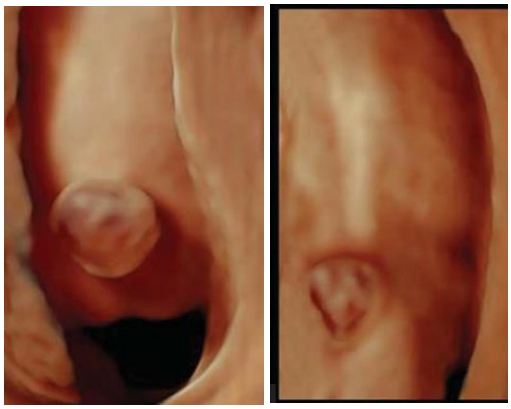
B C

Figure 9. A. Normal HD and B. 3D ultrasound images of a 25weeks old fetal's feet. C. Normal foot in a 29weeks 5days fetus

A B

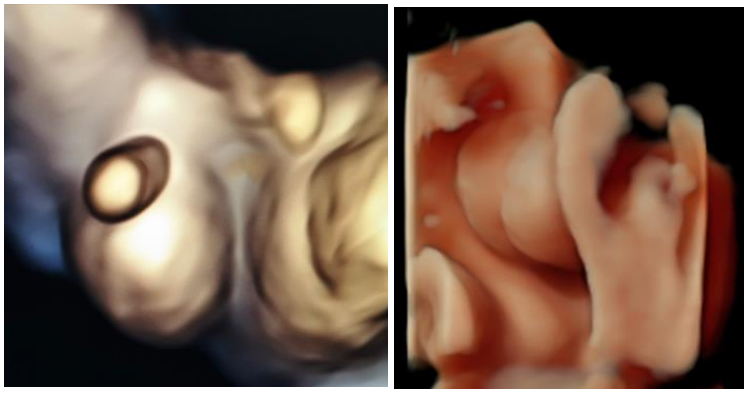
Figure 10. A. 2D image of a clubfoot. B. HDlive image of 24wks fetus with talipes (right image adapted from DSJOUG

A



B C

Figure 11. A. HD (surface view) of a 21-week fetus with gastroschisis. B. HD (surface view) image of fetus with lumbar dysraphism 23weeks gestation (middle image) and 18weeks gestation (right image). Images are adapted from DSJUOG.



A
30weeks 3day male genitalia in 3D

B
HD image of 34weeks 4days male genitalia

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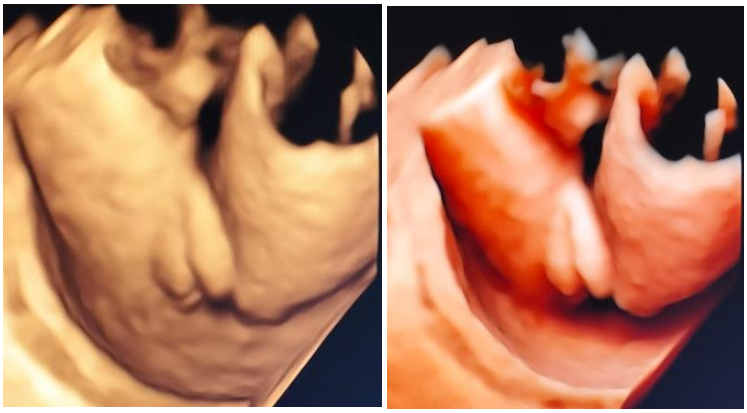


C D

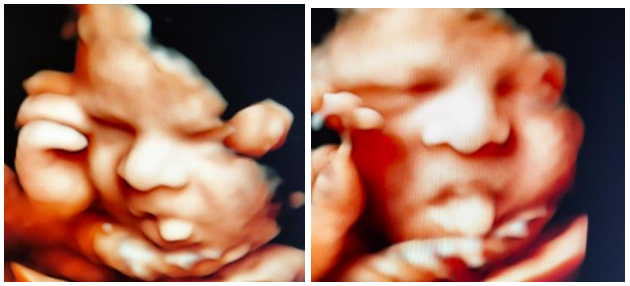
3D and HD images of 28weeks 1day female genitalia

Figure 12. 3D and HD ultrasound images of male and female external genitalia

Figure 13. HD ultrasound image of a 23-week female fetus with clitoromegaly (adapted from DSJUOG)

Different fetal grimaces can also be observed such as smiling, sticking out of the tongue by the fetus, crying and others during the 4D/HDlive ultrasound [30](fig 14 A - E).

A. 27wks 2days fetus yawning B. Smiling



C. Licking the cord D. sticking out tongue

E. 21 weeks 4 days crying.

Figure 14. A – E show various fetal grimaces across different gestational age

THE ROLE OF 3D/4D/HDLIVE IN GYNAECOLOGY

The Transvaginal and transabdominal volume probe makes it possible to obtain the axial sections of the lower pelvis with additional sagittal and coronal sections[5].The images can be evaluated by looking through the stored volume in slices in all the three planes and the images can be rotated in the three planes. This allows exact localization of lesion in all the three planes [31], [32], [33].

3D ultrasound enables clear display of the endometrium in the coronal plane, which allows clear diagnosis of

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abnormalities of the uterus [34], [35], [36]. The 3D display shows vivid outline of the inner and outer contour of the myometrium when compared to hysterosalpingography which only shows the cavity of the uterus[5], [37] (fig15-16). Some variant fold of the cervix can be seen properly on the 3D scan (fig 17).

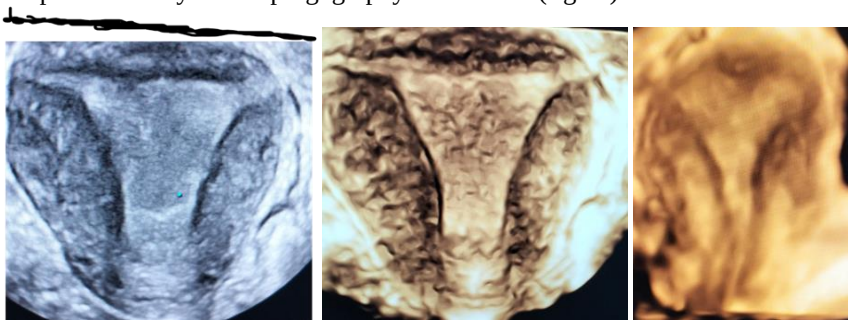
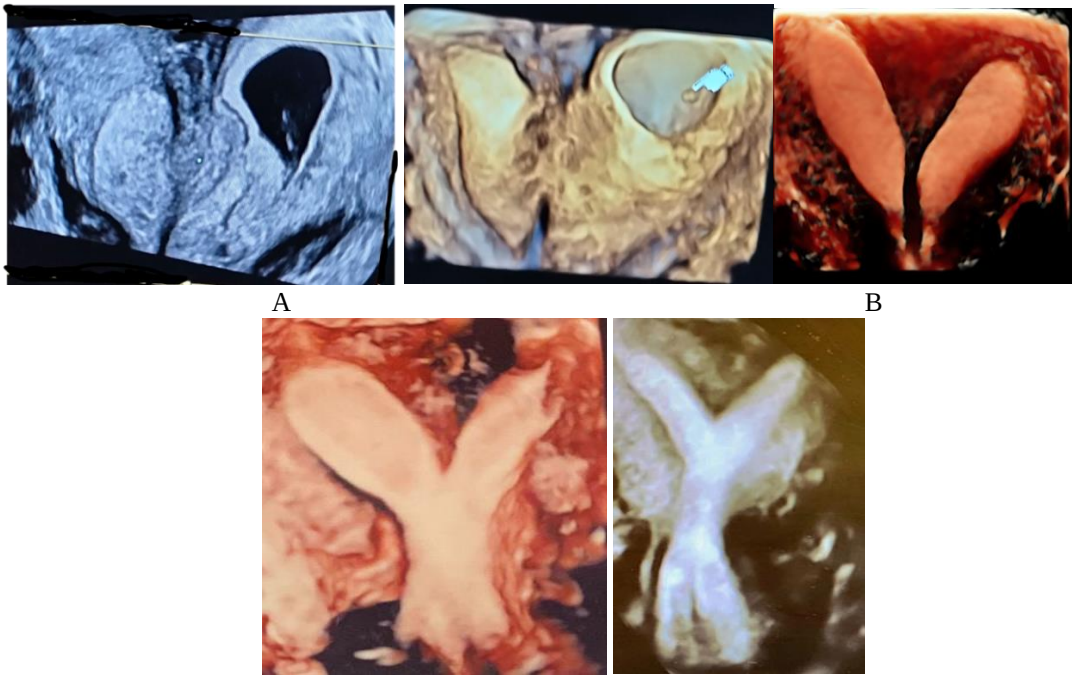
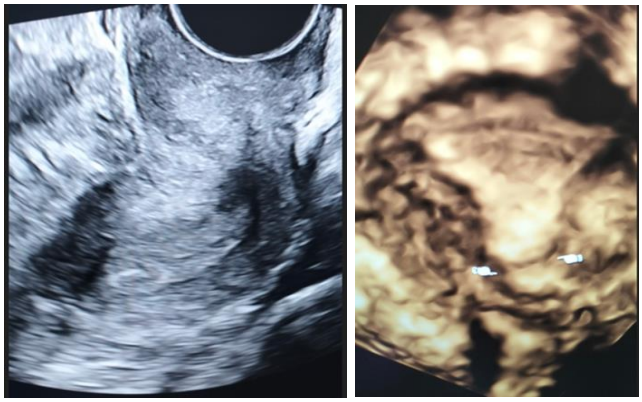


Figure 15. Transvaginal A. coronal B. 3D and C. Transabdominal 3D ultrasound images of the uterus.



A B C D

Figure 16. A. coronal B. 3D ultrasound images of uterine didelphys with ongoing early pregnancy (hand pointer), HD uterine Didelphys (left image) C, D. HD and 3D ultrasound images of bicornuate uterus.

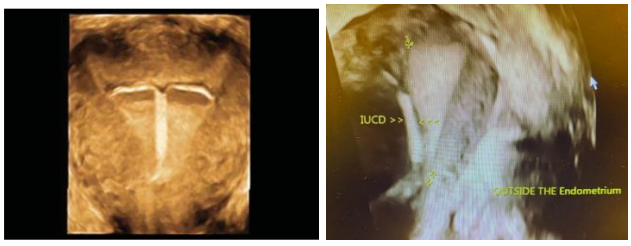


A B

Figure 17. A. 2D ultrasound showing exaggerated uterine cervical fold and which is well delineated on the corresponding 3D image (B hand pointers)

Exact coronal view makes localization of the intrauterine device very easy (fig 18)[37], [38], [39].

The volumetric analysis and accurate localization of uterine endometrial nodules (fig 19), fibroids and other uterine tumors can be done on the multiplanar display of the 3D images[40], [41], [42].



A B

Figure 18. A. correct intrauterine device positioning (adapted from DSJUOG). B. Intrauterine device outside of the endometrial cavity.

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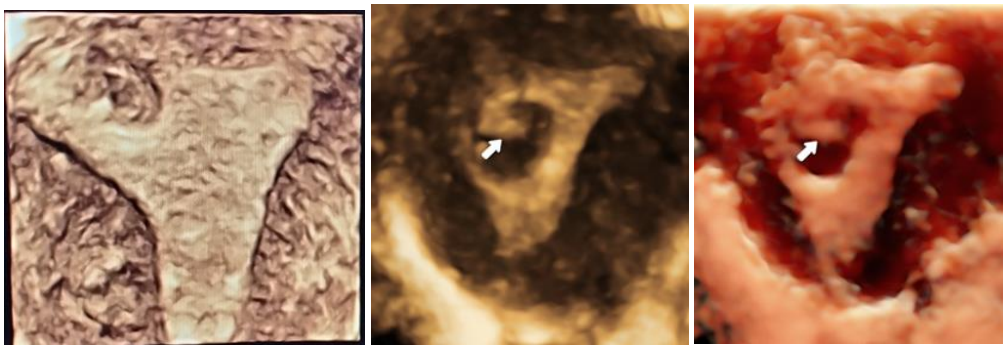


A B C

Figure 19. A. 3D ultrasound image of a sub endometrial endometriotic nodule. B, C. 3D and HD ultrasound images of endometrial polyp.

The ovaries can be displayed and evaluated in multiple planes. Automated volumetric analysis and follicular count can be performed through the 3D analysis (fig 20).

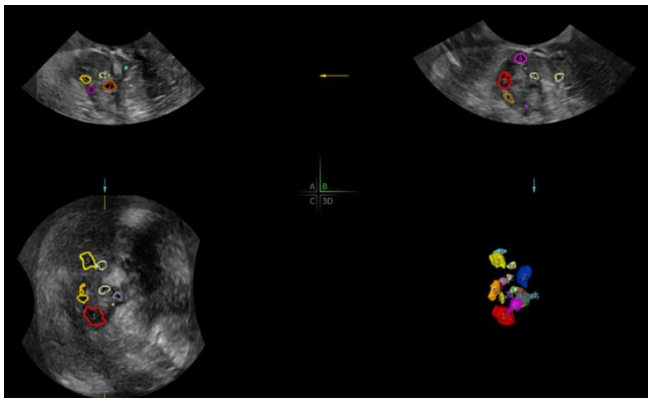
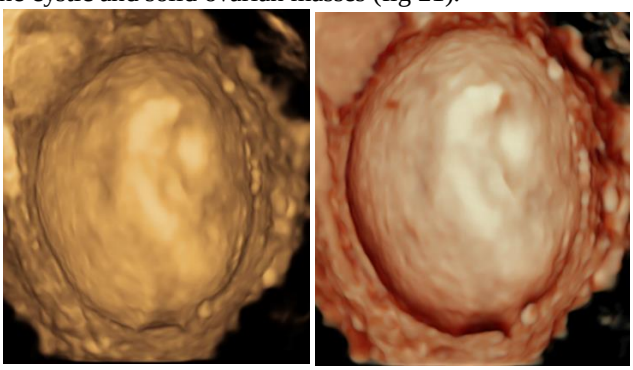


Figure 20. Automated follicles count and volume analysis. The follicles are illustrated in different colours.

The surface mode can be used to demonstrate the ovaries, the cystic and solid ovarian masses (fig 21).



A B

Figure 21. Surface rendered 3D and HD images of simple ovarian cyst

Sonographic evaluation of the normal and abnormal pelvic floor can be performed on the 3D ultrasound[43], [44] Fig 22.

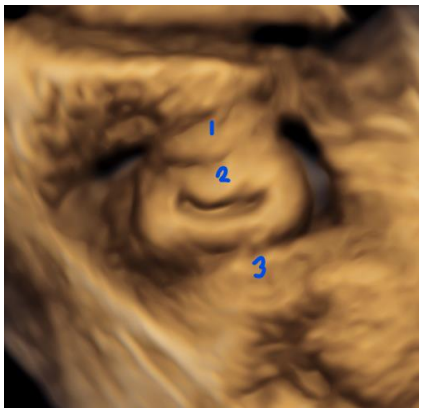


Figure 22. 3D image of the pelvic floor shown from below 1. The urethra 2. The vaginal 3. The rectum.

CHALLENGES FACED BY MOST AFRICAN INSTITUTIONS.

One of the main challenges in the use of 3D/4D/HDlive ultrasound images is poor hospital funding by the government[45], [46]. Most ultrasound machines that come with fully 3D/4D/HDlive options are quite expensive but proper and consistent advocacy can help solve this. Training of personnel is another challenge but with availability of proper machines, the knowledge can be properly passed down among the professionals that employ the use of the 3D/4D/HDlive scans.

CONCLUSION

3D/4D/HDlive ultrasound are gaining more use around the world due to their useful application in Obstetrics, gynaecology, breast and fetal cardiac imaging. The easy technique and many display modes possible from this imaging justify its use and application in African Hospitals.

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