INFERTILITY: 3D Ultrasound and a New User-Friendly Ultrasound System

An Introduction to Voluson SWIFT

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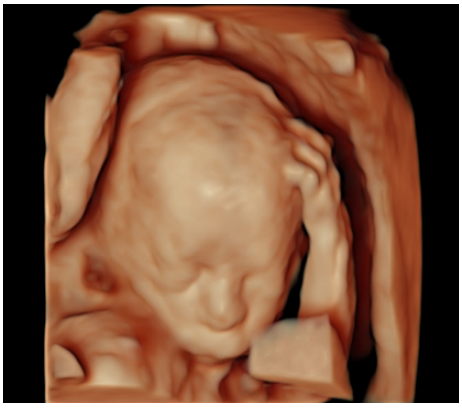
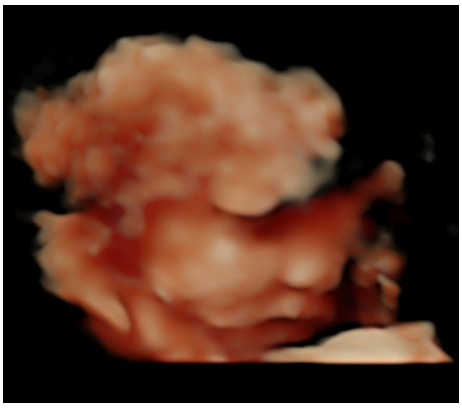
Ultrasound imaging is of paramount importance in Obstetrics and Gynecology. The annual gynecologic visit is often accompanied by an ultrasound examination, which allows evaluation of the ovarian cycle, uterus, endometrium, ovaries and other pelvic structures as well as diagnosis of adnexal/uterine pathology. In Obstetrics, ultrasound allows precise dating of pregnancy, non-invasive prenatal diagnosis, anatomic evaluation of the fetus and evaluation of fetal growth as well as follow up and timing of delivery in pathologic pregnancies. In reproductive medicine, ultrasound is key to diagnosing causes of infertility, monitoring follicle growth and procedural guidance for treatment.

Over the past 15 years, technology has allowed dramatic improvements of ultrasound devices and image quality and three-dimensional ultrasound has gradually been introduced in clinical practice. While obstetrical 3D scans have initially focused on obtaining “pretty pictures” of the baby, especially the face (Figure 1), new applications have more recently emerged, which improve the diagnostic precision of ultrasound examinations.



1a: 18 weeks



1b: 35 weeks

Figure 1: Baby’s face illustrated with HD*live*™ technology.

Introduction

In Gynecology and Reproductive Medicine in particular, 3D has gradually emerged as an important, and we would say essential, diagnostic tool. Numerous tools are now available that enable easy acquisition, post-processing and rendering of acquired volumes resulting in improved diagnostic precision. Software packages for evaluation of tubal anatomy with Hysterosalpingo Contrast Sonography (HyCoSy)*, ovarian reserve assessment with automated, rapid and precise antral follicle counts as well as automated follicle monitoring to determine optimal timing for oocyte retrieval for IVF have all helped to enhance efficiency and accuracy in Reproductive Medicine.

Figure 2: Patient examination room with Voluson SWIFT.

Recently, a new system was introduced by GE Healthcare, the Voluson™ SWIFT (Figure 2), which was designed with the infertility specialist in mind. The new system combines all the advanced features and dedicated reproductive medicine packages with a very user-friendly design.

This paper will focus on the clinical benefits of 3D ultrasound and automation using the Voluson SWIFT and includes images highlighting the software packages, technologies, tools and image quality that we routinely use in Reproductive Medicine.

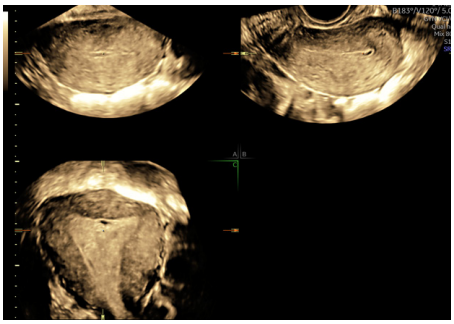
Benefits of 3D Ultrasound in Reproductive Medicine

We believe that 3D ultrasound plays a pivotal role in infertility workup and in *in vitro* fertilization. For years, we have included 3D ultrasound not just for our infertility workup and follicle monitoring, but also for pregnancy confirmation and early pregnancy assessment.

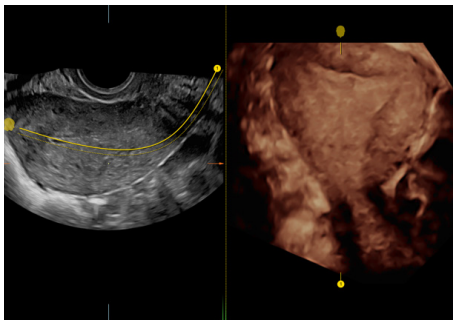
The use of 3D has become essential for us during a patient's first visit for the evaluation of ovarian reserve, uterine morphology, and the fallopian tubes. Most often, we also include 3D sonohysterography to complete the study of the uterine cavity and tubal patency/anatomy. We refer to this as the "One-Visit Infertility Workup."

We will now provide a few examples of ultrasound images obtained using the Voluson SWIFT illustrating its image quality, and the advantages of 3D and of the different tools and software packages.

Uterine Morphology

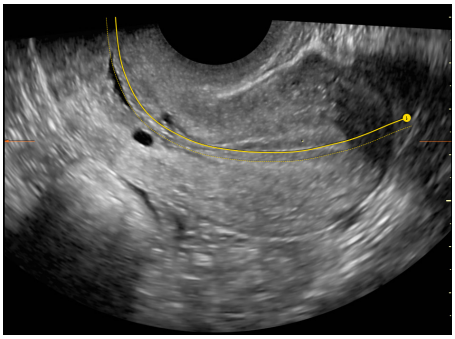


3a: 3D Multiplanar Reconstruction (MPR)



3b: OmniView with VCI

Figure 3: Normal uterus – menstrual phase. 3D ultrasound allows visualization of the coronal plane, which is essential to evaluate the shape of the uterus; VCI (Volume Contrast Imaging) increases contrast and improves image quality. OmniView is a useful tool that allows delineation of the uterus with improved image quality.

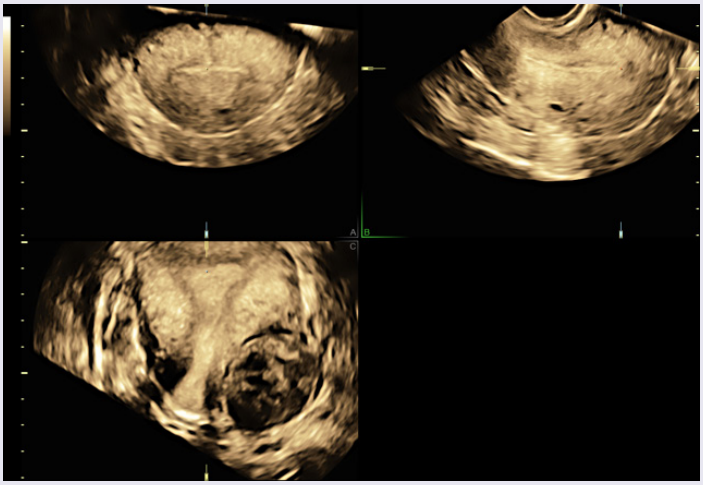


4a: Sagittal uterus with trace line

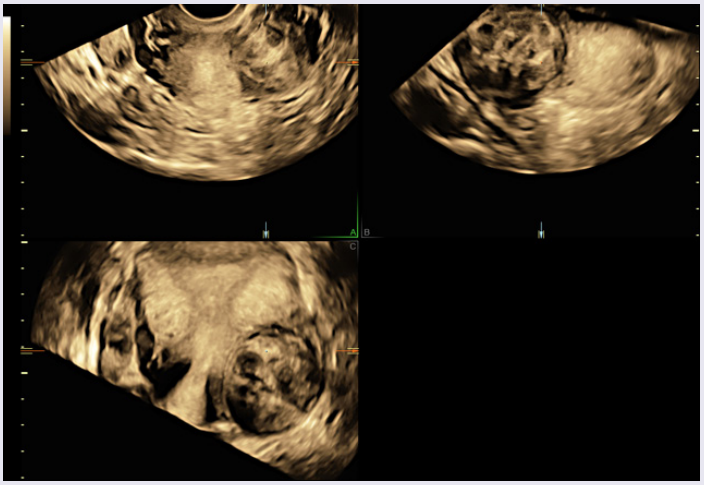
4b: Automatically acquired coronal plane

Figure 4: Normal uterus acquired using Uterine Trace, a new feature that enables easy visualization of the coronal plane of the uterus. From a standard sagittal view, the endometrium is traced on the touch screen and the system acquires the volume, automatically displaying the coronal plane.

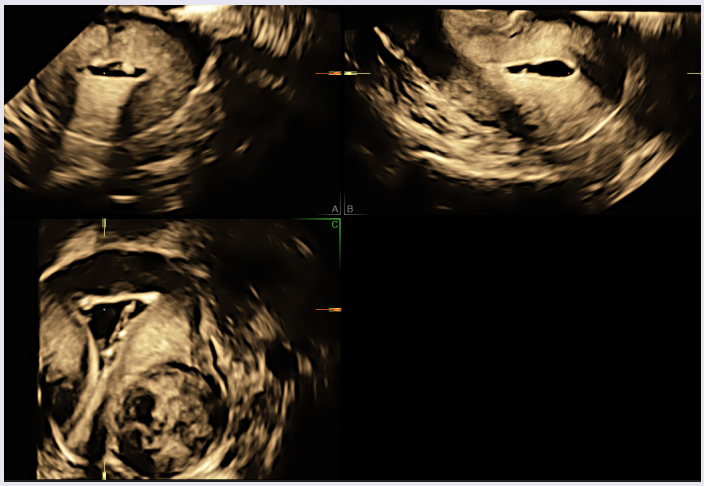
* Hysterosalpingo Contrast Sonography (HyCoSy) is not cleared in the United States and may not be available in all countries.



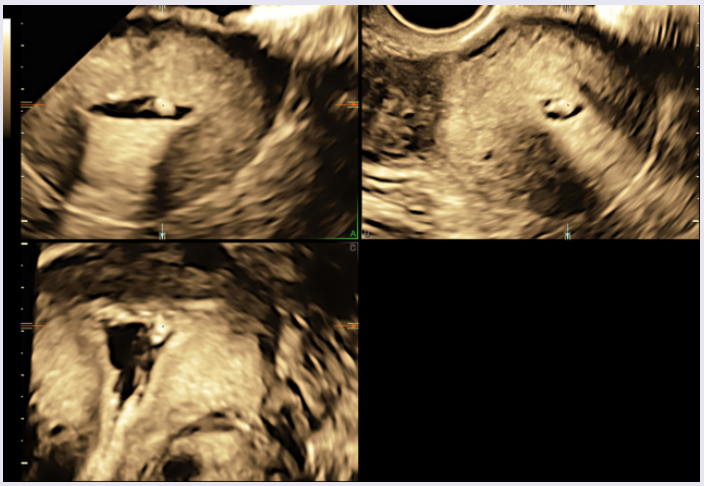
5a



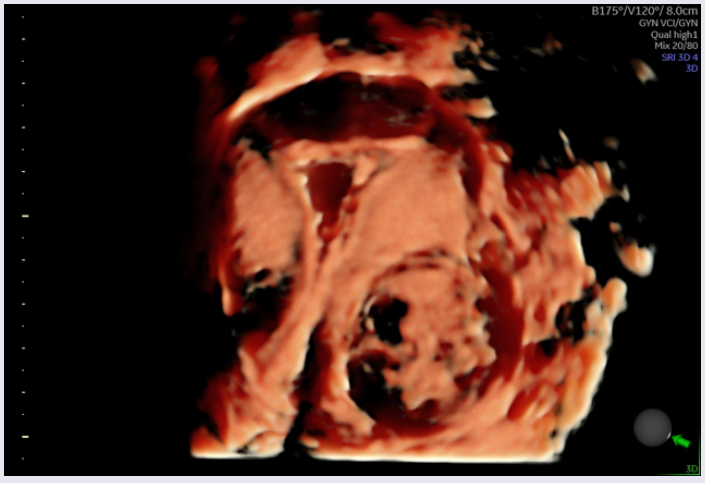
5b



5c



5d

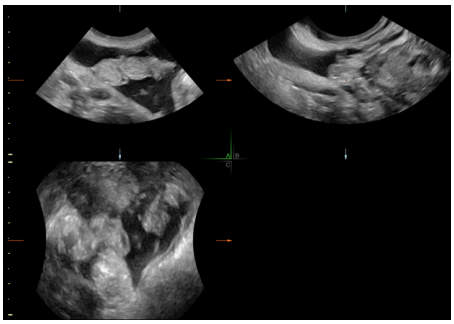


5e

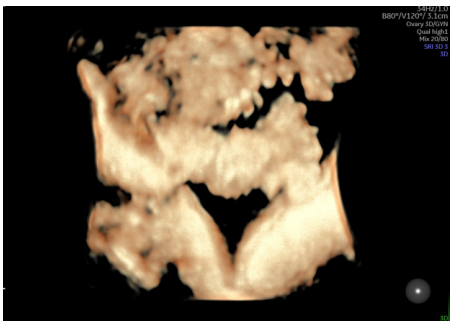
Figure 5a, b: Uterus with a 4 cm isthmic fibroid. The coronal plane allows accurate preoperative localization/mapping of the fibroid. In this case, 3D ultrasound gives information comparable to MRI, while being more accessible and cost effective. c, d: 3D sonohysterogram (same patient) allows better definition of the distance between a fibroid and the uterine cavity as well as identifying intrauterine lesions and micropolyps. e: Rendered 3D image of the same uterus using HD*live*.

Fallopian Tube Assessment

6a: 2D image fallopian tube



6b: 3D Multiplanar Reconstruction (MPR) of fallopian tube



6c: HD*live* rendered image

Figure 6: Sonohysterogram of tortuous fallopian tube with thickened wall evaluating tubal patency. Peri-adnexal fluid facilitates visualization of the tube in 2D and acquired volume.

Assessment of the Ovaries at Baseline

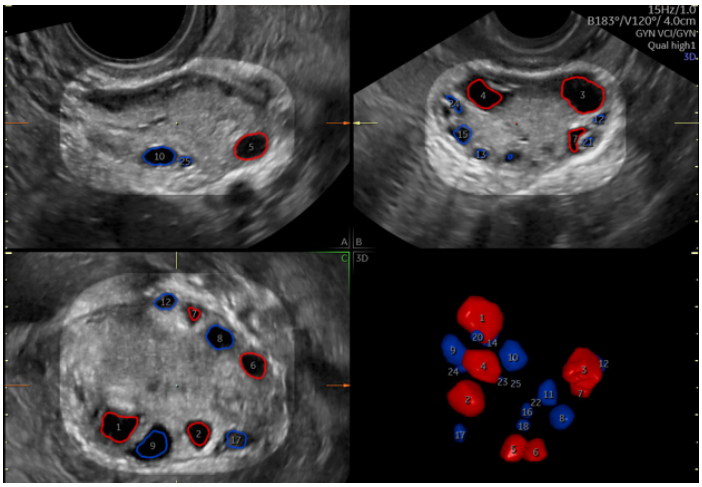
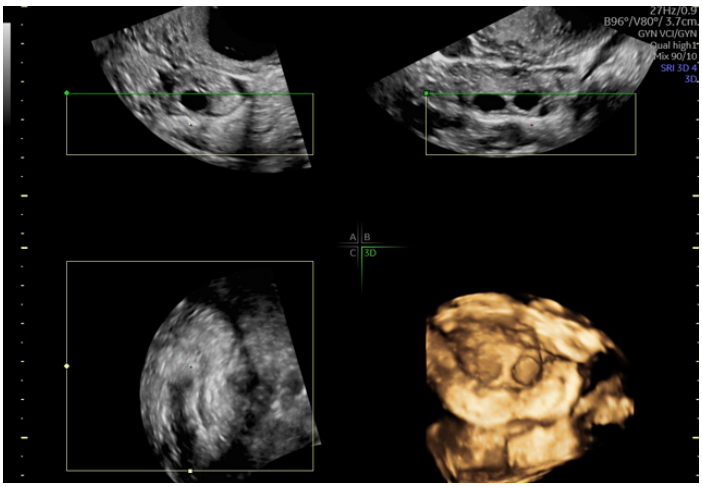
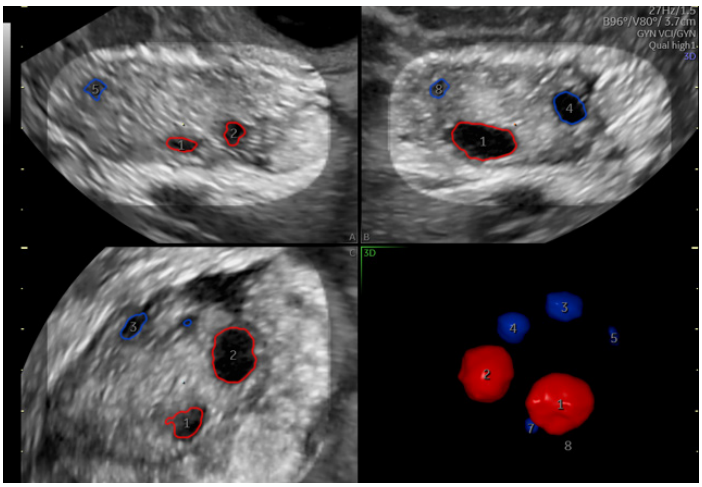


Figure 7: Antral follicle count using the SonoAVC™*antral* (Sonography-based Automated Volume Calculation *antral)* tool. This tool allows for a quick and precise automatic identification and count of antral follicles and their volumes and reduces inter-observer variability.



8a: 3D with volume rendering

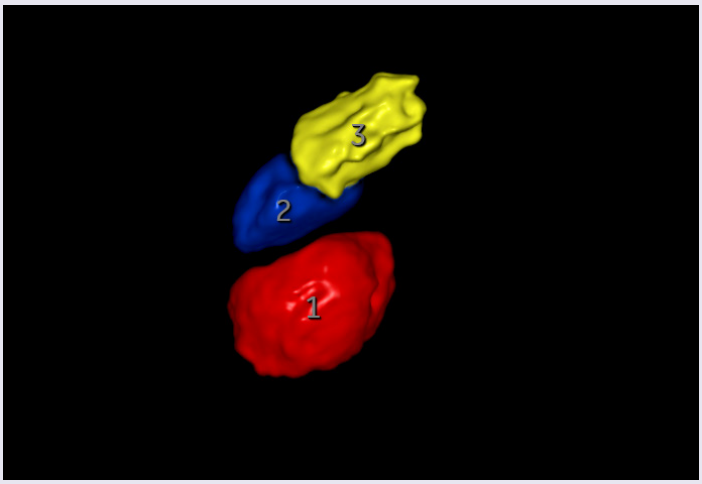


8b: SonoAVC*antral* tool

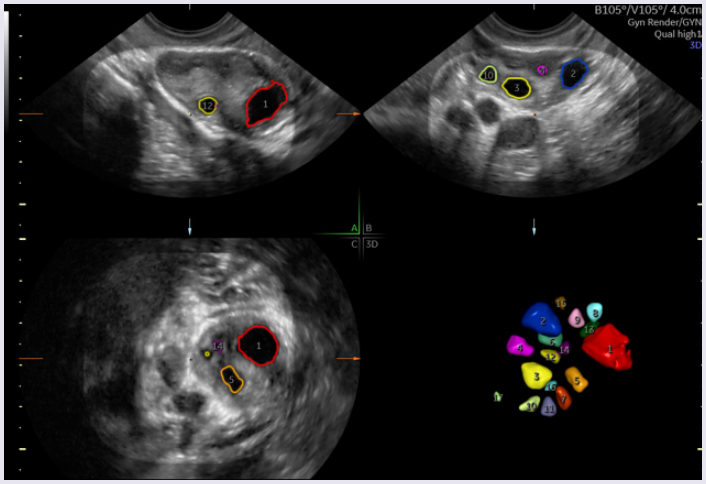
Figure 8. Rendering of a fallopian tube and automated follicle count of the same ovary using the SonoAVC*antral* tool.

During Stimulation

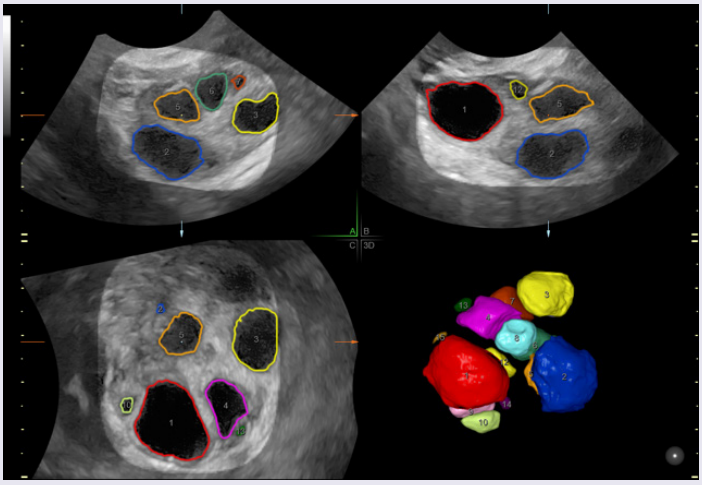
Monitoring follicle growth with 3D has become an essential part of our practice. SonoAVC*follicle* (Sonography-based Automated Volume Calculation *follicle*) is a very useful software, which allows quick and precise automatic measurements of follicle diameters and volumes. Since follicles have irregular shapes and are not perfect spheres, measurement of the third dimension during follicular monitoring makes the overall measurement more precise. Moreover, follicular volumes have been demonstrated to have a better correlation with the retrieval of mature oocytes (Rodrıguez-Fuentes A., et al. 2019). Studies in our laboratory have shown that follicles with volumes greater than 0.7 cc are associated with mature oocytes, and this information can be helpful to decide the day of trigger (Hernandez et al. 2009; Hernandez J. et al. 2016). We further tested the SonoAVC*follicle* software in egg donors, comparing manual and automatic measurements and found that SonoAVC*follicle* is a more accurate and efficient method to monitor ovulation induction in this population (Hernandez J. et al, 2009; Sanabria V. et al, 2009).



9a



9b



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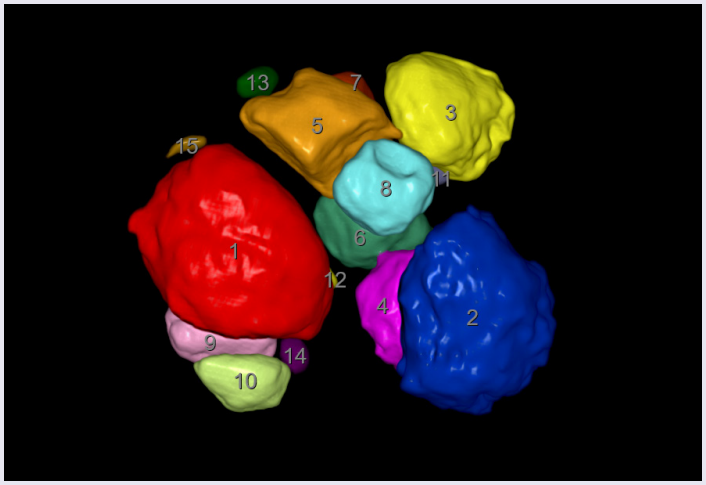
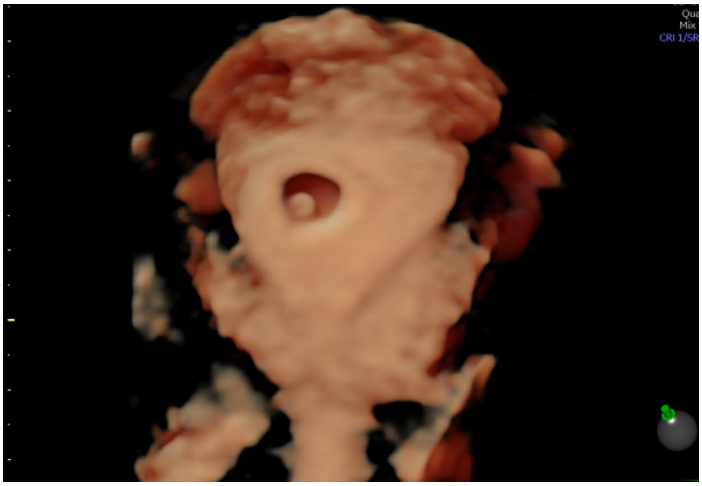


9d

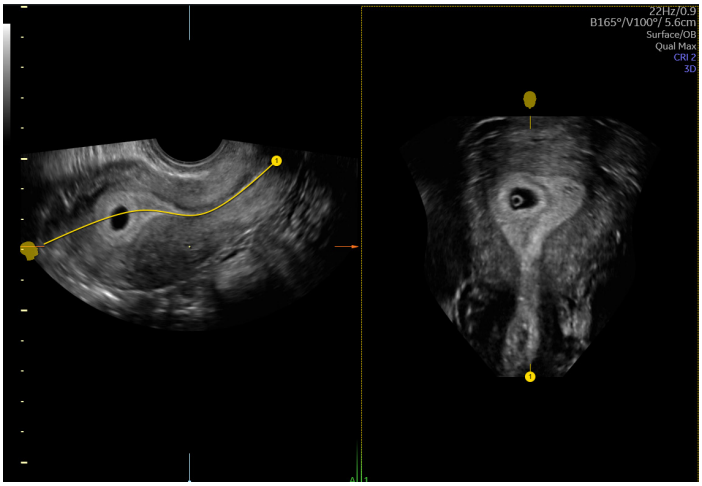
Figure 9: SonoAVC*follicle* automates follicle measurements eliminating the need for time-consuming manual measurements.

Pregnancy Confirmation

Utilizing 3D during pregnancy confirmation has also become part of our practice protocol. The first ultrasound, where parents are able to visualize a viable pregnancy is very emotional for many patients undergoing fertility treatment. A 3D rendered image adds a unique perspective and can make it seem even more real.



10a: HD*live* rendered image



10b: OmniView

Figure 10: Early IVF pregnancy (5+3 weeks).

11a

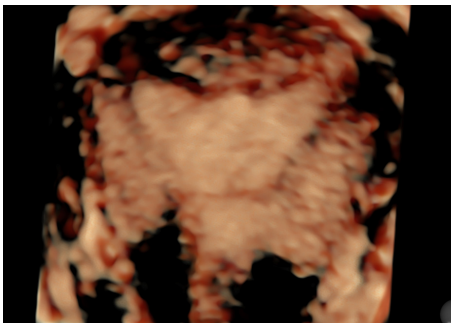
11b

Figure 11: HD*live* rendered image of a 9-week pregnancy.

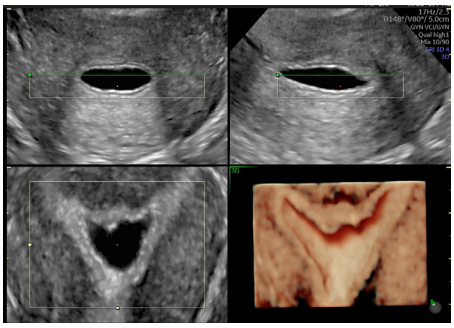
Patient Case Studies

Case 1

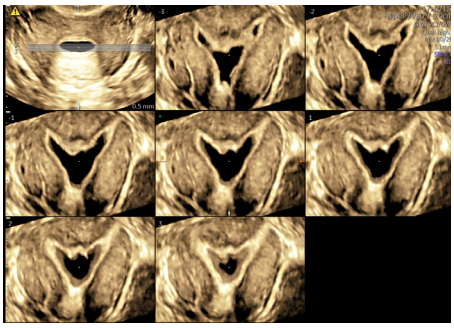
45-year-old patient who desired egg donation. After a telemedicine consultation, the patient came to the office for a 3D ultrasound and 3D sonohysterogram.



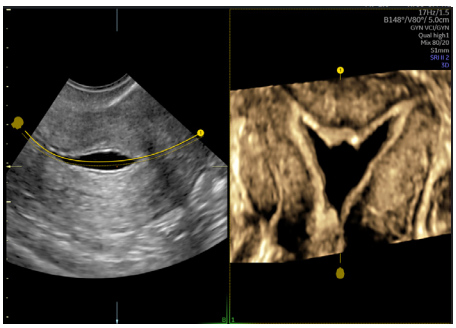
12a: HD*live* rendered image**



12b: 3D sonohysterogram



12c: TUI (Tomographic Ultrasound Imaging) displaying multiple slices



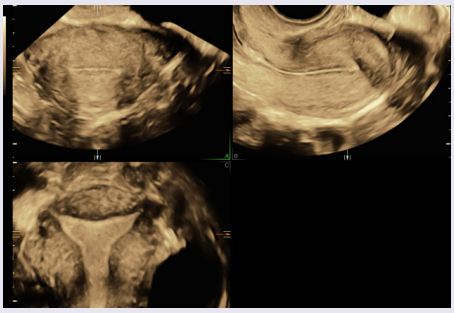
12d: OmniView

Figure 12: An arcuate uterus with fundal synechiae and polyps was diagnosed. The patient was referred to her gynecologist for operative hysteroscopy.

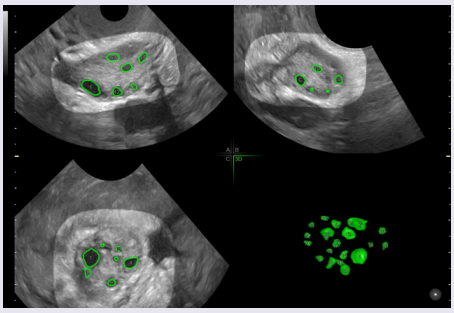
** It is important to note that the coronal plane was essential to visualize this pathology.

Case 2

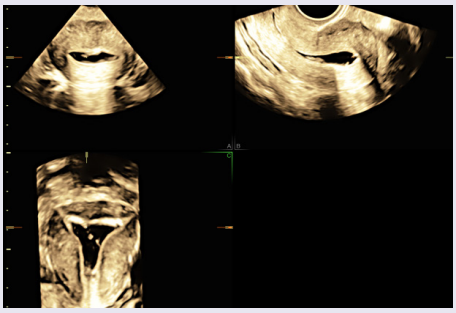
28-year-old patient with history of right salpingectomy for ectopic pregnancy.



13a: MPR uterus with VCI

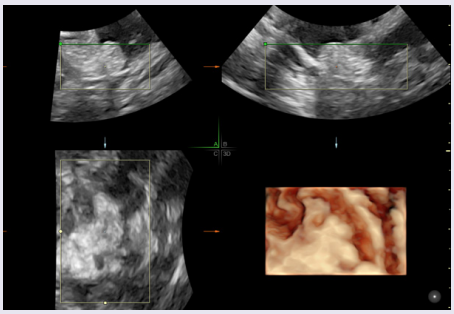


13b: Antral follicle count



13c: Sonohysterogram

13d: Coronal view micropolyps



13e: MPR and volume rendering

Figure 13: 3D ultrasound demonstrating a: normal appearing uterus. b: ovaries with good ovarian reserve. 3D sonohysterogram demonstrating c,d: a micropolypoid endometrium, suggestive of chronic endometritis. e: tortuous but not dilated left fallopian tube with hyperechogenic walls that showed slow passage of contrast media.

An endometrial biopsy was performed, and pathology confirmed diagnosis of endometritis. A follow up hysteroscopy with directed biopsies was scheduled after completion of antibiotic treatment.

Adapting to a Changing Environment: COVID-19, Telemedicine and 3D Ultrasound

In March 2020, due to the COVID-19 pandemic, we introduced a protocol to minimize interpersonal contact and optimize social distancing, conducting the initial consult via telemedicine appointment. We then schedule a visit in the clinic where we practice the "One-Visit Infertility Workup," as previously described.

During the ultrasound assessment, the use of 3D allows us to shorten time with the patient, and minimize contact times, another way of practicing social distancing. During "in vivo scanning," we simply acquire "volumes" of the anatomy to be investigated. These datasets can then be evaluated after the patient leaves the ultrasound room, which can lead to shorter examination times and reduced exposure times. Figure 15 demonstrates examples of the image volumes acquired during such a visit.

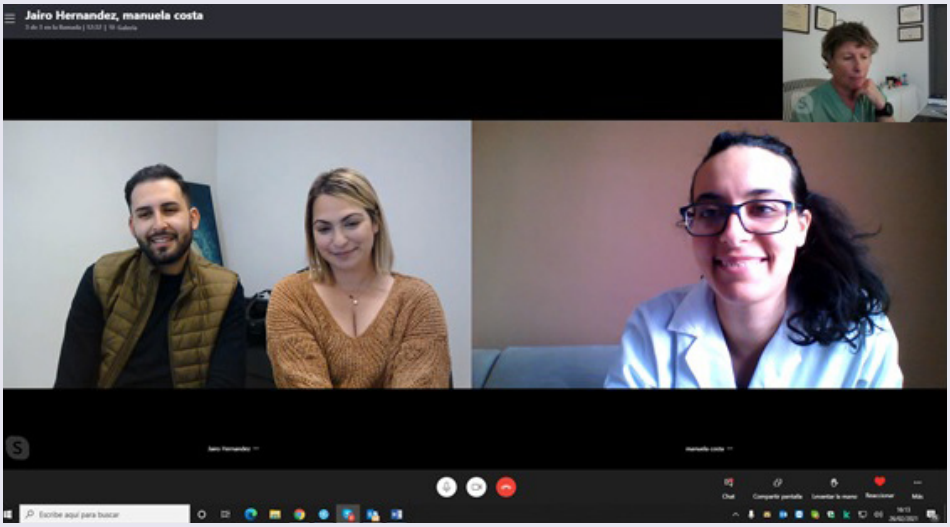
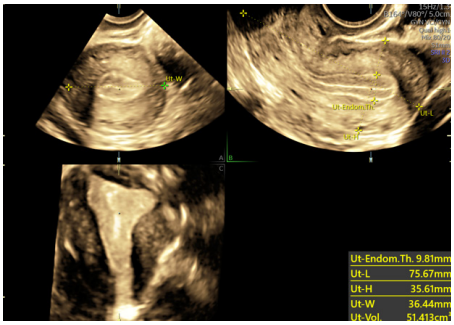
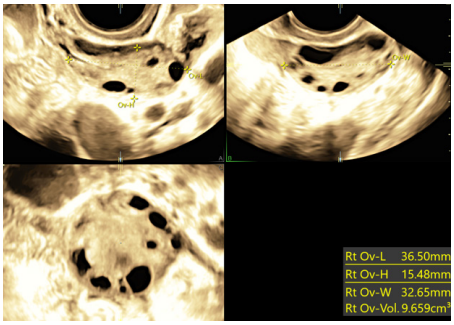


Figure 14: Example of a telemedicine consultation***

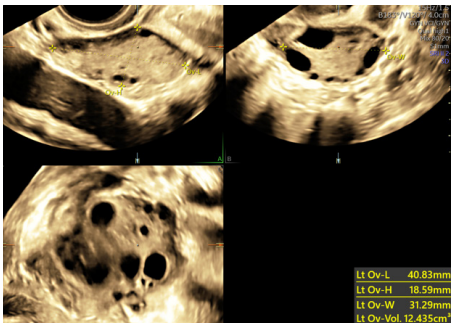
*** To ensure patient privacy models have been used in this example.



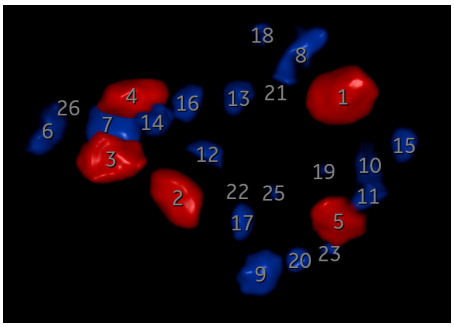
15a: Uterus



15b: Right ovary



15c: Left ovary



15d: Antral follicle count

Figure 15: 3D ultrasound of the uterus and the ovaries with the applicable measurements, respectively, and an antral follicle count (AFC). Acquisition of the 3D volumes took approximately two minutes. All measurements and the AFC were performed at a later time.

Conclusions

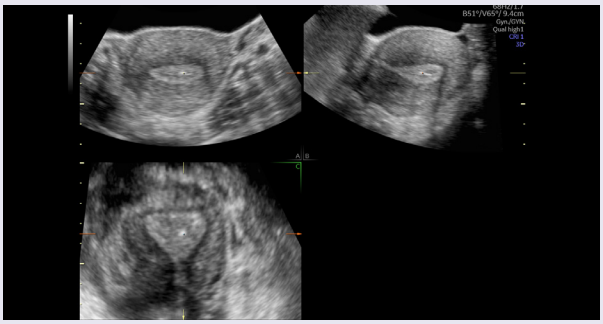
During the past few years, the use of 3D ultrasound in Reproductive Medicine has grown and thanks to technology improvements, the benefits it has to offer have increased. The availability of 3D ultrasound in our clinic allowed us to adapt our practice during the COVID-19 pandemic and continue to care for our patients in a new and safer way. For our practice, this is now standard of care. With advances in technology, incorporating 3D ultrasound into a Reproductive Medicine practice has not only become easier, but also more cost effective. Until recently, many of the above-mentioned options were only available on higher-end ultrasound devices. However, with the launch of the Voluson SWIFT, now a small, ergonomic ultrasound system includes all these features. It is very user-friendly, easily moveable between offices, ORs and patient rooms and battery operation allows for uninterrupted operation.

The system's large touch screen and minimal hard keys make it very easy to clean and ideal for procedures like sonohysterograms and egg retrievals, where systems can be exposed to splashes. In addition, the easy cleaning and simple export of reports to PDF/USB have helped significantly, aiding in disinfection and minimizing patient contact during COVID-19 (Figure 17).

In summary, 3D ultrasound and 3D sonohysterograms provide invaluable tools in the diagnosis and treatment of infertility. Moreover, automation tools such as SonoAVC*antral* and SonoAVC*follicle* are very useful additions for a more precise diagnosis and treatment monitoring.

The Voluson SWIFT provides excellent imaging, simplified operation and is loaded with tools and features to enhance efficiency. This new ultrasound device combines image quality with a full range of tools and software options that are useful for infertility workup and treatment. Key advantages are easy cleanability, mobility through battery operation, intuitiveness, and improved efficiency. In conclusion, the new Voluson SWIFT can be a real asset to IVF clinics.

16a: Operating room



16b: MPR uterus post embryo transfer

Figure 16a: The Voluson SWIFT in our operating room, just after an embryo transfer procedure. b: The embryo flash is clearly visualized.

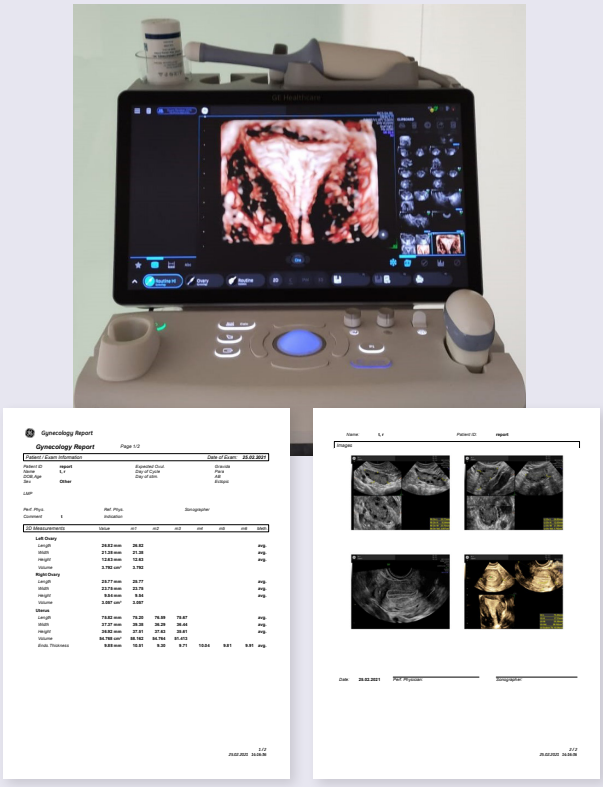


Figure 17: Voluson SWIFT system and a report.

Authors

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Dr. Palumbo is a board certified obstetrician gynaecologist (Yale-New Haven Hospital, Yale University, 1988-1992) and infertility specialist (Brigham and Women´s Hospital, Harvard University, 1992-1994), and the founder and medical director of Centro de Asistencia a la Reproducción Humana de Canarias (FIVAP) in Tenerife, Spain. Major research interests are in ovarian physiology (ovarian renin-angiotensin system, ovarian sirtuin expression), and clinical interests are in the field of 3D ultrasound in Reproductive Medicine, early pregnancy and hysteroscopic surgery.

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Dr. Rouleau is the director of the IVF program at Centro de Asistencia a la Reproducción Humana de Canarias (FIVAP). Following his residency in Obstetrics and Gynecology, he specialized in Reproductive Endocrinology and Infertility with a particular interest in 3D ultrasound and Reproductive Surgery. In 2018, he obtained the ESHRE Certification in Reproductive Endoscopic Surgery and is currently pursuing a PhD at the Universidad de la Laguna in Tenerife. The focus of his thesis is the hysteroscopic treatment of spontaneous abortion and genetic studies on products of conception.

References

1. Hernández J, Rodríguez-Fuentes A, Puopolo M, Palumbo A. Follicular Volume Predicts Oocyte Maturity: A Prospective Cohort Study Using Three-Dimensional Ultrasound and SonoAVC.Reprod Sci. 2016 Dec;23(12):1639-1643. doi: 10.1177/1933719116671003. Epub 2016 Sep 29.PMID: 27688243.

2. Hernández J, Sanabria V, Rodríguez-Fuentes A, García-Guzman R, A. Palumbo. Comparison of automated measurements of follicular volume and manual measurements of follicular diameter to time HCG administration: a prospective study in egg donors. 64th Annual Meeting of the American Society for Reproductive Medicine. Fertil Steril, September 2009 Vol. 92, Issue 3, page S47.

3. Hernández J, Rodriguez A, Palumbo A. Is it possible to establish new criteria for hCG administration based on follicular volume as measured by three dimentional ultrasound and SonoAVC? 25th Annual Meeting of European Society of Human Reproduction and Embryology. Free Communications. Human reproduction, June 2009 Vol. 24, Supplement 1, page i85.

4. Mora-Guanche P, Sparacino L, García-Guzman R, Bennett R.A, Hernández J, Palumbo A. Three-dimensional sonohysterography (SHG) has improved diagnostic accuracy for intrauterine pathology compared to two-dimensional SHG: a prospective pilot study in infertility patients. 64th Annual Meeting of the American Society for Reproductive Medicine. Fertil Steril, September 2009 Vol. 92, Issue 3, page S119.

5. Rodrıguez-Fuentes A., Hernández J., Rouleau J.P., Palumbo A. (2019) SonoAVC (Sonographic-Based Automated Volume Count). In: Stadtmauer L., Tur-Kaspa I. (eds) Ultrasound Imaging in Reproductive Medicine. Springer, Cham. https://doi.org/10.1007/978-3-030-16699-1_17.

6. Rodríguez-Fuentes A, Hernández J, García-Guzman R, Chinea E, Iaconianni L, Palumbo A. Prospective evaluation of automated follicle monitoring in 58 in vitro fertilization cycles: follicular volume as a new indicator of oocyte maturity. Fertil Steril. 2010 Feb;93(2):616-20. doi: 10.1016/j.fertnstert.2009.02.058. Epub 2009 Apr 18.PMID: 19376513.

7. Sanabria V, Hernández J, Rodríguez A, García R, Palumbo A. Three-dimensional ultrasound with SonoAVC can be used with accuracy and efficiency to monitor ovulation induction in egg donors: a prospective study. 25th Annual Meeting of European Society of Human Reproduction and Embryology. Human reproduction, June 2009 Vol.24, Supplement 1, Abstract P-334.

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