OBUS – Obstetric Ultrasound Overview

Table of Contents. Documentation for the Global Health Labs Obstetric Ultrasound algorithm development work is organized into the following files, available in the OBUS-GHL GitHub Repository [1]. There are 3 high level files that apply to all algorithms, then 4 feature-specific documents for each of 4 algorithms (thus 16 feature-specific documents). Throughout the documents, the filenames below will be referred to.

Obstetric Ultrasound Introduction

A number of maternal and fetal conditions can put a healthy pregnancy at risk. Ultrasound imaging is a safe and effective tool that gives healthcare providers real-time information they can use to make evidence-based clinical decisions and early interventions over the course of a pregnancy, including referral to higher levels of care.

Obstetric ultrasound is routinely available in high-income countries. It is also recommended by the WHO for pregnancy care [2], and an ultrasound screening device is on the list of essential equipment for primary health care (PHC) clinics in most low- and middle-income countries (LMICs). The WHO recommends one ultrasound scan before 24 weeks of gestation to confirm that the pregnancy is intrauterine; to assess fetal number, gestational age, size, anatomy, and cardiac activity; and to determine the number of placentas and amniotic sacs in the case of multiple fetuses.

Obstetric ultrasound is not routinely available in LMICs [3], however, particularly at the PHC level where pregnant women first seek care. This is because of the high cost of ultrasound equipment, and even when it is available, there is a shortage of personnel with the specialized training needed to perform the scans and interpret the results. Ready access to ultrasound technology in LMICs can also be constrained by regulations to limit its use for fetal sex determination.

In LMICs, pregnant women seeking antenatal care often start at a local PHC facility. Health workers there, such as a midwife or nurse, perform an abdominal exam to assess the well-being of the mother and the fetus. This exam commonly lasts 30-45 minutes and includes assessment of multiple fetal aspects, typically by palpation given the lack of availability of ultrasound. The exam assesses fetal number, orientation, movement, and size. As a proxy for size, fundal height is used, which is the distance from the top of the uterus to the pubic bone, commonly measured as finger widths or with a tape measure if available. Fundal height is then used to estimate gestational age, with 1 cm corresponding to approximately 1 week of gestation. Fetal heart rate is assessed using a fetoscope (a fetal stethoscope).

Women may return for additional exams over the course of their pregnancy but often have limited opportunities to seek care. The accuracy of the initial assessment is thus especially important for early identification of pregnancy risks and complications that can guide subsequent care. These include the presence of more than one fetus, a breech orientation of the fetus, discrepancy between the gestational age estimated by fundal height and by last menstrual period (that could indicate intrauterine growth restriction), and abnormal frequency of fetal movement. In these cases, women are referred from the PHC facility to higher-level facilities for further evaluation that includes ultrasound imaging if available, causing delays and lost opportunities for timely care. Some PHC facilities have handheld Doppler ultrasound equipment used for a limited assessment: confirming fetal cardiac activity and viability. Most, however, do not have the equipment or trained personnel to perform the comprehensive antenatal ultrasound imaging recommended by the WHO, which often results in reliance on results from the palpation-based exam.

Obstetric exams performed by palpation and with simple tools, such as a tape measure and a fetoscope, are much less accurate than ultrasound imaging. They can yield inaccurate gestational age estimates, for instance, due to variability in the health worker's hand and finger size and their level of expertise. This can result in lost opportunities to prevent the consequences of preterm birth or in unnecessary induction of labor for a misdiagnosed post-term pregnancy. They can also miss detecting other types of high-risk pregnancies, and they are labor-intensive and time-consuming, taxing the capacity of PHC facilities whose staff is commonly overburdened.

Obstetric ultrasound can be expected to save and improve the lives of pregnant women and their children. Nevertheless, uncertainties remain around the degree to which it improves morbidity and mortality outcomes in LMICs [4] as well as in high-income countries [5]. A caveat, however, is that there are multiple factors challenging a healthy pregnancy and birth, and broad improvements in antenatal care may be required before the full clinical benefits of ultrasound can be revealed, especially in LMICs.

GH Labs has supported the development of AI-based software that is incorporated into point-of-care ultrasound (POCUS) devices. This enables a broad set of care workers (i.e., non-sonographers), including nurses and midwives, to acquire key obstetric information through "blind sweeps" with the ultrasound probe. These sweeps are unguided, require less than a day of training, do not need real-time feedback and a traditional image display, and they yield data for AI-supported automated analysis without the need for expert medical interpretation. This automated analysis leverages high-quality images collected by the hardware probe to determine key fetal aspects, such as fetal weight and gestational age, the presence of more than one fetus, and whether the fetus is in a breech orientation. This information is used not for definitive diagnosis, but to support clinical decision making, including triage and referral.

There is also ongoing innovation for the hardware components of ultrasound devices and their effective integration with software. This includes different ultrasound probes enabling individual devices to be used for multiple health conditions, obstetric as well as others, such as cardiac and pulmonary conditions. Ultrasound probes contain transducers that convert electric signals to outgoing sound waves and convert incoming sound waves to electrical signals. Transducers can be arrayed in different spatial configurations in the probe, including a convex, linear, or phased array. These arrays confer different capabilities, with convex arrays preferred for obstetrics because they confer a wider field of view useful for imaging deeper structures, such as the fetus during pregnancy. There are also different types of transducers: piezoelectric transducers (PZT) are the most common in existing commercial devices. Piezoelectric micromachined ultrasonic transducers (PMUT) and capacitive micromachined ultrasonic transducers (CMUT) are newer and are being used to facilitate miniaturization and improve integration with electronics, and they have a wide bandwidth enabling a one-probe-solution across multiple use cases.

Technology innovations in both hardware and software are making ultrasound devices more portable, affordable, usable without extensive training, and applicable for multiple health conditions. Combined, these innovations are yielding point-of-care ultrasound tools that could be broadly accessible in LMICs as a core part of antenatal care. A key factor driving increased accessibility of these tools is advances in AI models to support them. An acceptability study in public health facilities in Kenya, for instance, found that care workers and pregnant women patients and their families had positive attitudes towards an AI-enabled ultrasound device for gestational age measurement [6] .

AI model-based automated analysis is demonstrating comparative performance to expert sonographers who manipulate the ultrasound probe through visual feedback to reproducibly identify and measure fetal anatomical features (biometry). Ultrasound image analysis studies found that AI models performed as well as gold standard biometry for gestational age measurement, with the models enabling automated biometric measurement [7] or direct assessment of fetal features without biometry [8] [9]. This latter use case included studies in Zambia, either with trainer sonographers [10] or with care workers using blind sweeps: non-trained nurse midwives [11] and minimally trained operators [12]. AI models also enabled accurate automated ultrasound detection of fetal malpresentation (non-cephalic versus cephalic orientation) based on sonographers performing a single oriented sweep [13] or blind sweeps [12].

References

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