Enhanced grading system for monitoring fetal well-being

John Ryan, Fionnuala McAuliffe, Mary Higgins, Marie Stanton, and Patrick Brennan

Quantifying placental calcification and infarction aids the obstetrician in assessing these well-established indicators of potential complications.

In the western world, almost all women are offered at least one ultrasound examination during pregnancy. The Euronatal audit study\(^1\) demonstrated that accurate detection of growth retardation in utero, which is linked to placental calcification (calcium deposits), can result in better management of babies, further assessment of intrauterine development using Doppler (ultrasound) techniques, and interventions that reduce perinatal death.\(^2\) Calcifications of the placenta are well associated with fetal distress in labor, poor perinatal outcome, maternal smoking, first-time mothers, and subsequent development of a toxic disorder known as preeclampsia, which carries an increased risk of neonatal morbidity and mortality.\(^3\text{-}^6\)

Grannum classification, based on a subjective observation of the placenta, is the currently employed method for describing this abnormality. Depending on their presence and location, calcifications are given a score of I, II, or III, in order of importance. But the method lacks objectivity, precision, and reproducibility, which at least in part contributes to the persistent difficulty in identifying a high-risk fetus in a low-risk population.

We have developed a software tool that takes 2D ultrasound images of the placental area as input. Using the C++ programming language, and the ITK (Insight Toolkit) and FLTK (Fast Light Toolkit) libraries, we have developed a user interface that allows the clinician to select a region of interest (ROI) to assess. After the clinician has finished drawing the ROI, a reference map is automatically created. Figure 1 illustrates the process. First, a flood-filling algorithm is used to saturate the image (blue) apart from the red-defined ROI and its contents. Once this image is created, any pixels that are blue are turned black, and any other pixels (i.e., within the confines of the ROI) are turned white. This image now acts as a reference. The clinician has two sliders that alter the intensity threshold for defining placental calcification and infarction (tissue death) within the ROI (see Figure 2). Output metrics are in the form of pixel counts for both calcification and infarction as well as the respective percentages in reference to the total number of pixels within the ROI.

Note that the clinician constitutes the key input in defining the ROI and the intensity threshold. Considering the current semi-quantitative eyeballing approach to Grannum scoring, our quantitative technique aims to minimize subjectivity and maximize reproducibility with an image acquisition protocol that includes optimal location and orientation specifications. Indeed, preliminary clinical evaluations have proven successful. A prospective study is currently being performed to fully evaluate this tool.

Individual infarction selection is enabled by implementing a circular ROI. The clinician selects a central point within the infarction and grows the circle until the borders of the infarct are included (see Figure 3, left). The intensity threshold slider is then used until the clinician is satisfied the tissue in question is fully segmented (see Figure 3, right). This function has potential value in monitoring the progress of existing abnormalities on an indi-
In summary, we have created a software tool that measures the percentage of placental calcification and infarction within a user-defined ROI. This provides a more precise metric than the current grading methods. A prospective study with a large patient population is currently being performed. The tool will then be further developed to demonstrate automatic quantification of other indicators of fetal development, such as biparietal diameter (head size), crown rump length (length from head to base of spine), and abdominal fat content. We are also implementing a similar approach to 3D ultrasound imaging of the placenta.

Author Information

John Ryan, Marie Stanton, and Patrick Brennan
Biological Imaging Group
School of Medicine and Medical Science
University College Dublin
Dublin, Ireland
http://www.ucd.ie/diagnosticimaging/html/johnryan
http://www.ucd.ie

Fionnuala McAuliffe and Mary Higgins
National Maternity Hospital
Dublin, Ireland

References