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Histogram Tissue Characterization of the Fetal Lung as a Noninvasive Indicator of Fetal Lung Maturity

Thesis

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Introduction

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Determination of fetal maturity continues to be a crucial factor in obstetric management of the non-routine patients. Reliance on history (last menstrual period, quickening) and physical examination (fundal height) have in large measure been supplanted or at least heavily augmented by laboratory determinations. The prevailing gold

standard is currently the estimation of lecithin/sphingomyelin ratio (L/S ratio) and the presence, both qualitative and quantitative, of phosphatidylglycerol (PG) in amniotic fluid. Each separately and both in concert are taken to be indicators of fetal lung maturity, which in turn a major determinant of the neonate's course.

In experienced hands and guided by sonography, amniocentesis is a relatively safe procedure with only a minor degree of associated discomfort. Nevertheless, amniocentesis is an invasive procedure with finite risks and non-universal patient acceptance. The incidence of fetal demise and/or spontaneous abortion secondary to amniocentesis is generally believed to be less than 1%, even with mid-trimester procedures, with reports ranging from 0.2% to 1.4%.

Therefore, interest persists in finding a noninvasive means of determining fetal lung maturity chiefly by sonographic methods. Reports of echogenicity of the fetal lung as it relates to maturity of that organ are scant and variant.

In 1985, Fried AM et al. conducted a study to determine if any correlation between fetal age and/or lungmaturity and echogenicity could be determined in a clinical setting. Studies were performed with either linear array or mechanical sector real-time devices. Echogenicity of the fetallung was compared with that of the fetal liver in the same longitudinal (parasagittal or coronal) sonogram. Lungechogenicity was judged to be hypodense, isodense, slightly hyperdense, or markedly hyperdense as compared with the liver texture. One hundred eighty-five cases were evaluated; of these, some 37 cases also underwent amniocentesis for determination of

lecithin/sphingomyelin ratios (L/S) and presence of phosphatidylglycerol (PG).

Linear regression analyses were performed to determine if lungechogenicity would serve as an indicator of fetalmaturity. They found out that there was no clinically applicable relation between fetallungechogenicity and gestational age, L/S, or presence of PG in amniotic fluid with current methodology. The possibility persists that tissue characterization techniques may find application in such an investigation.

In 1992, Sohn C et al. Using the fetal liver as a reference-organ and avoiding the known pitfalls which made it impossible in the past to standardize the fetallung changes depending on the age of gestation. They examined 104 cases between week 27 and week 41. In one ultrasound section cut they depicted as well lung and liver. According to the known A-mode they registered frequencies in both organs. The registered frequencies were entered digitally into a computer and checked for f(mean), f(max) and f(min). Afterwards the frequencies of the lung were divided by those of the liver. Of all weeks of gestation the mean value and standard deviation were calculated. They found the liver as an adequate reference-organ, since there is no change of the reflection pattern between the different weeks of gestation, while there are significant changes to be registered in the fetallung, a cutting line being week 35. A quotient of f(mean) lower than 1.1 hints to lungmaturity, while values over 1.1 point to immaturity. This was confirmed by several cases of analysis

of amniotic fluid (L/S-ratio). Further comparisons with amniotic fluid results will have to validate these findings.

In 2004, Tekesin I. et al, performed a study to evaluate the quantitative ultrasonic tissue characterization of the normal fetallung development by using acoustic raw data captured after preprocessing. They gathered one hundred and sixty-two cases with completed gestational ages between 22 and 37 weeks and were enrolled in this study. Longitudinal and transverse sections of the fetal thorax and upper abdomen were imaged. A region of interest of constant size was defined and the tissue-specific gray scale was determined by using interactive software. In their results, a total of 162 cases met the inclusion criteria. The echogenicity of the fetallung showed a particular changing pattern during pregnancy: the mean gray value of the fetallung (MGV) is almost the same as the MGV of the fetal liver at 22 and 23 weeks, decreases between 22 and 31 weeks and increases between 31 and 37 weeks. The MGV of the fetal liver decreases significantly from 24 weeks to 31 weeks and increases significantly again toward 37 weeks. They stated that the MGV of the lung is smaller than the MGV of the liver during 31 weeks of gestation and the relation reverses in late gestation. At term, the MGV of the liver is greater than the MGV of the lung. The lung-to-liver ratio is <1 between 24 and 29 weeks and >1 between 30 and 35 weeks. Their study concluded that, echogenicity of the fetallung showed a particular changing pattern during pregnancy, which corresponds to morphologic changes of the fetallung development.

In 2010, Serizawa M. and Maeda K. aimed to noninvasively predict fetal lung immaturity with the ultrasonic gray level histogram width (GLHW), a form of clinical tissue characterization. Their study included 22 fetuses in which infant respiratory distress syndrome (IRDS) developed post-delivery and 25 fetuses without IRDS development. Independent receiver operating characteristic (ROC) analysis of the fetal lung-to-liver GLHW ratios, fetal weights, gestational ages and the product of GLHW ratios by gestational ages of this cohort indicated that optimal thresholds for these parameters to differentiate immature from mature were 0.94, 1.750 g, 31 weeks and 29, respectively. With the optimal decision threshold of 0.94, the GLHW ratio provided sensitivity and specificity of 0.86 and 0.72, respectively. The corresponding values of gestational age were 0.77 and 0.68, 0.77 and 0.60 for fetal weight versus 0.96 and 0.72 for the product of GLHW ratios by fetal age, which was comparable with invasive amniotic fluid tests. The areas under the ROC curve for these parameters were 0.82, 0.82, 0.70 and 0.91. They found that GLHW is a noninvasive, stable and reliable measure of fetal lung maturity.

Aim of Work

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The aim of the current thesis is the study of mathematical measurement of thepixel histogram tissue characterization of the echogenicity of the fetal lung in comparison to pixel histogram tissue characterization echogenicity of the fetal liver in third trimester (34 weeks to 38 weeks) fetuses as non-invasive predictivemethod of lung maturity.