

FETAL UMBILICAL CORD INSERTION–GENITAL TUBERCLE DISTANCE (UCI–GT): COMPARATIVE ULTRASOUND AND FETOPATHOLOGICAL STUDY WITH ALGORITHMIC MODELING PROPOSALS

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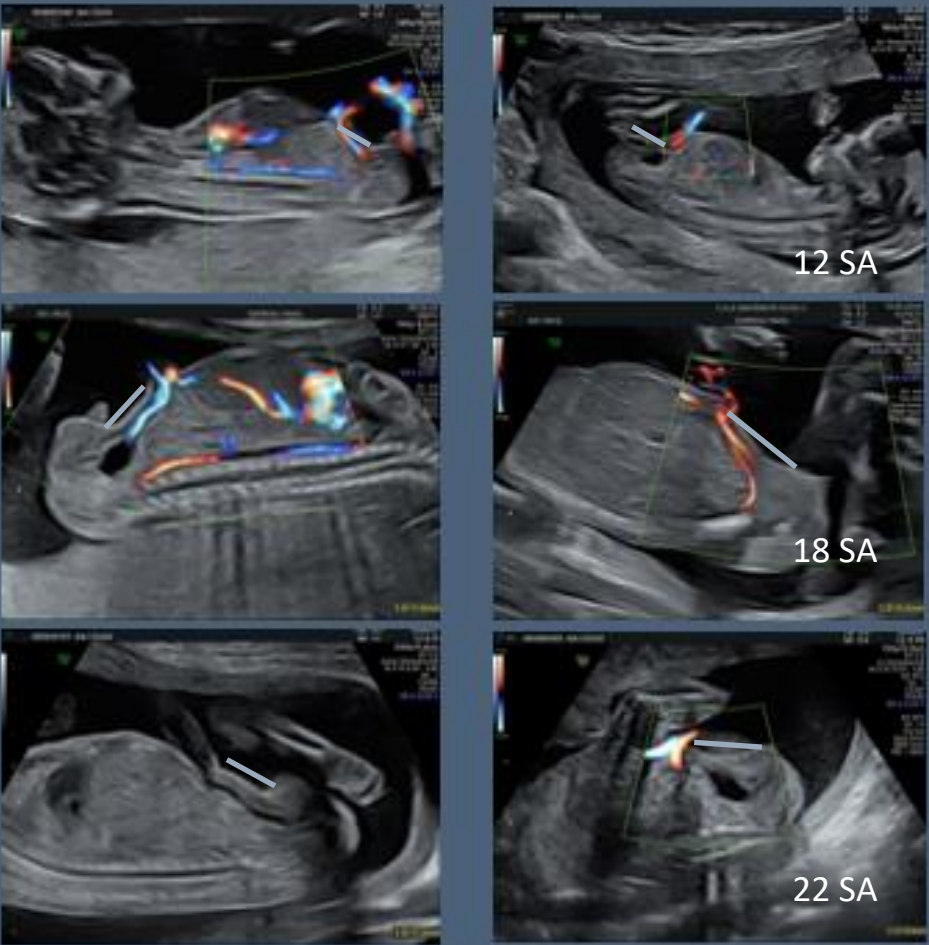
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INTRODUCTION

Objective of this study was therefore to evaluate objectively fetal umbilical cord insertion–genital tubercle distance (UCI-GT) according to gestational age and fetal sex, and to compare ultrasound and anatomical measurements in order to explore potential predictive models.

MATERIALS AND METHODS

This observational multicenter study consisted of 102 structurally normal fetuses examined by ultrasound between 11 and 24 weeks of amenorrhea from March 1, 2024 to June 20, 2024, and 100 fetal autopsies performed between June 15, 2023 and December 31, 2023. In cases of intrauterine fetal demise, gestational age was estimated using fetal bone maturation. Ultrasound measurements were obtained under strict technical conditions.: in a strict midsagittal plane with a neutral dorsal position, between the lower limbs in order to clearly identify both the inferior origin UCI and the beginning of GT. Fetal sex determined during the first trimester scan was confirmed during the second trimester examination. During autopsy, UCI–GT distance was measured prospectively. Additional biometric data including femur length, fetal weight, vertex–heel distance, and vertex–coccyx length were collected.

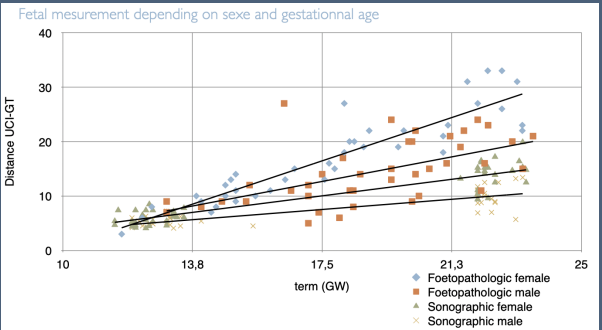
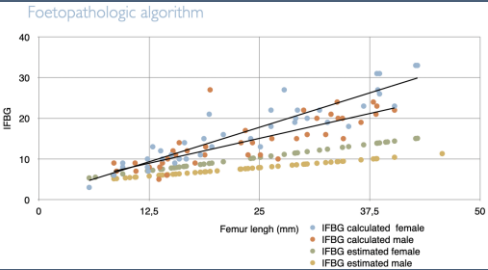
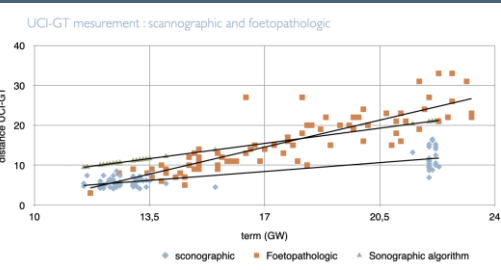
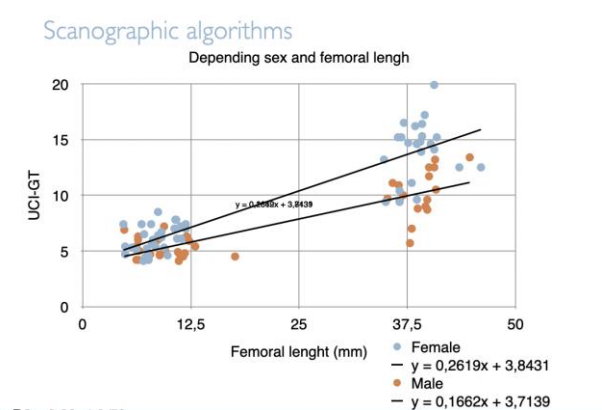
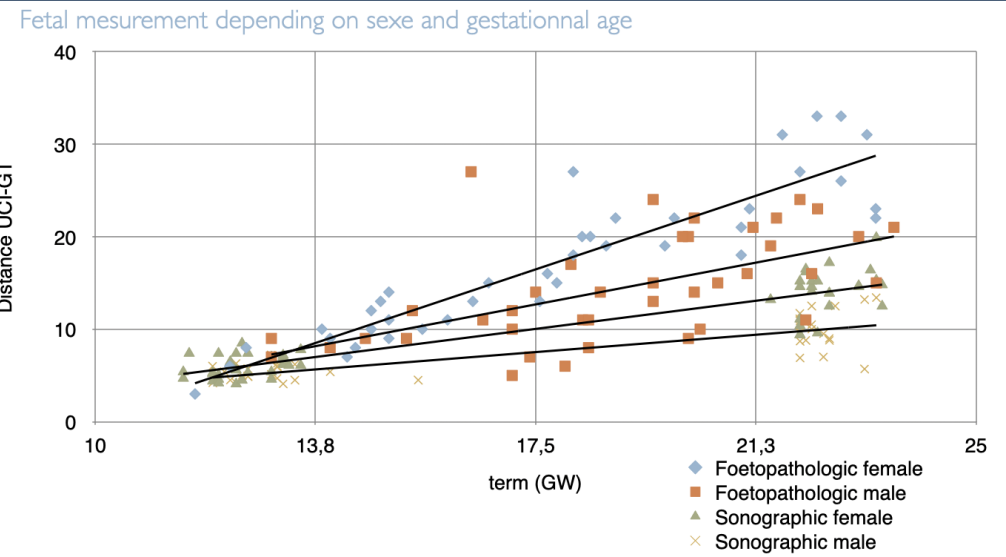


ALGORITHMIC MODELING PERSPECTIVES

Given the observed growth pattern, a linear gestational age model may be proposed in which UCI–GT distance is expressed as a function of gestational age. Preliminary slope estimation based on ultrasound female measurements suggests an approximate increase of 0.7 mm per week. A sex specific linear model may also be considered by introducing a binary variable for fetal sex in order to account for the systematic offset observed between males and females.

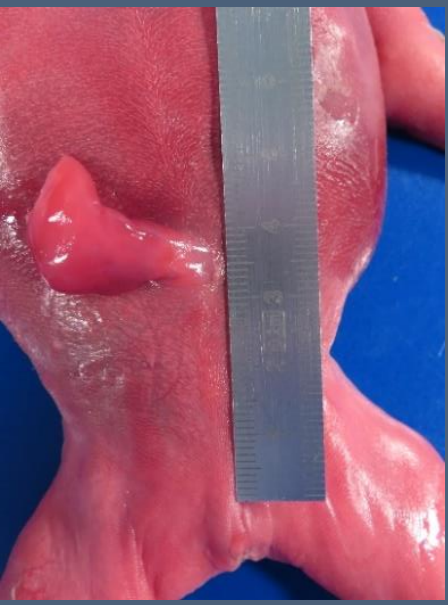
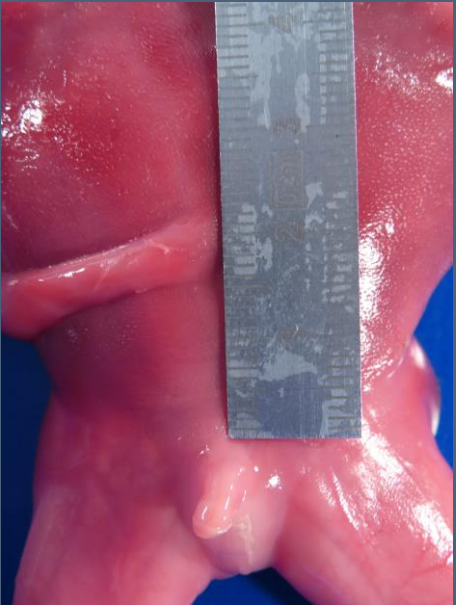
Normalization strategies could improve comparability across gestational ages. In the first trimester, an index calculated as the ratio of UCI–GT distance to crown–rump length may reduce the effect of global fetal growth. In the second trimester, normalization to femur length may provide a more stable comparative parameter.

A multivariate predictive model integrating gestational age, crown–rump length, femur length, fetal weight, and fetal sex could further refine prediction.



MALE

FEMALE



CONCLUSION

This study did not demonstrate a direct correlation between ultrasound and anatomical UCI–GT measurements, likely because of physiological and methodological differences between in utero imaging and postmortem assessment. However, a consistent sex related difference was observed, with female fetuses demonstrating larger UCI–GT distances at all gestational ages. Further prospective studies with larger sample sizes are required to validate these findings, develop sex specific reference curves, and construct predictive multivariate algorithms. Quantitative evaluation of fetal cord insertion may represent a subtle but clinically relevant parameter in early detection of congenital anomalies and could potentially be integrated into extended first and second trimester ultrasound protocols.

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