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3D volume ultrasound assessment of the caesarean section scar

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Objective

To evaluate the caesarean section (CS) scar features using transvaginal three-dimensional (3D) volume ultrasound in pregnant women with previous advanced labour or full dilatation CS and their predictive performance for spontaneous preterm birth (SPTB) or late miscarriage (LM).

Methods

This is a single centre prospective cohort study of pregnant women with previous CS at ≥ 8 cm cervical dilatation undergoing PTB surveillance in a specialist prematurity clinic (University College London Hospital, UK, 2019-2023). Transvaginal 3D ultrasound volumes were acquired between 14-24 weeks of gestation. SPTB prophylactic interventions (cervical cerclage and/or vaginal progesterone) were offered to women identified with short cervical length (CL ≤ 25 mm) or in women with a history of SPTB/LM following the index CS. Sonographic volume processing used virtual organ computer aided analysis (VOCAL) function on 4D View 18 Software (GE Healthcare). Two-dimensional (2D) cervical length, niche measurements (length, depth, width), residual and adjacent myometrial thickness and CS scar distance to internal os were recorded. Niche and cervix volumes were calculated using manual contouring in 6 reference planes, at 30 degree angles from each other using a reproducible method. Primary outcome was prediction of SPTB < 37 weeks of gestation. Statistical analysis was performed using IBM SPSS Statistics v29. Multivariable logistic regression analysis was used to develop prediction models based on ultrasound features. Goodness of fit was determined using the area under the receiver-operating-characteristics curve (AUC) and sensitivity at a fixed false-positive rate (FPR) of 25%.

Results

CS scar was visualised in 89.8% (132/147) 3D volumes; 44.2% (65/147) women had a CS scar niche present. Overall SPTB rate was 6.8% (10/147). Short CL was identified in 10.2% (15/147); all had a prophylactic intervention; 20% (3/15) delivered SPTB. Individual niche measurements (length, depth and width) were correlated with niche volume (Pearson correlation coefficients of 0.71, 0.71 and 0.73 respectively, $p<0.001$). In screening for short CL, the predictive model using 2D scar measurements on the 3D volumes had AUC of 0.76 (95% CI, 0.59 - 0.92). Addition of 3D scar characteristics, niche and cervical volume improved the model predictive ability to AUC of 0.81 (95% CI, 0.70 - 0.92); the sensitivity of the model was 57.1%. Prediction of SPTB based on 2D scar measurements on the 3D volumes had AUC of 0.86 (95%CI, 0.73 - 0.98). Addition of 3D features also improved the model predictive ability to AUC of 0.91 (95%CI, 0.83 - 0.98); the sensitivity of the model was 77.8%.

Conclusion

Multiparameter screening models based on 2D scar measurements in 3D volumes predict a high proportion of women who will develop a short cervical length or SPTB following late stage of labour or full dilatation CS. Incorporating 3D scar features into prediction models obtains a marginal improvement in performance but may not currently be clinically useful in PTB surveillance.