Ultrasound criteria at 8 to 11 weeks of gestation

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Objective

To establish ultrasound criteria for detection and description of fetal and adnexa abnormalities at 8-11 weeks of gestation in prediction of pregnancy outcome.

Methods

We have reviewed 369 pregnancies at 8-11 weeks of gestation and were divided into 4 groups according to their pregnancy outcomes. First group (n=101) comprised pregnancies with normal fetal and adnexa morphology. Second group (n=169) comprised pregnancies with normal fetal scan, with isolated adnexa abnormalities. The evaluation of the adnexa in the third group of pregnancies detected associated abnormalities in fetus. Fetal growth restriction syndrome II-III and damage to placentofetal flow II-III have been diagnosed by ultrasonography at the 18-11 and 30-34 weeks of gestation. Fourth group comprised pregnancies with major fetal malformation that required late termination (up to 22 weeks). Cases of missed miscarriage, pregnancies with major extragenital pathology, multiple pregnancies resulting from in vitro fertilization, and rhesus- sensitization were excluded from the study. The sonography of the fetus and adnexa was evaluated according to the criteria established on the basis of standard changes in the first trimester of pregnancy. Embryonic crown –rump length index was established. This index shows the correlation between embryonic crown –rump length (CRL) and the distance between the crown and the mental protuberance. Ultrasound scanning was conducted at the 8 to 10+6 weeks of gestation. The CRL index 1.6-2.6 proved to be of diagnostic value. The index value 1.6> CRL> 2.6 is a risk factor for congenital fetal anomalies. In addition to the evaluation of fetal and adnexa morphology we recorded the length of the uterine cervix, the state of endocervix, and the presence of the early diastolic caving in screening by uterine artery Doppler, as well as the characteristics of corpus ovarium luteum vascularity. The obtained findings were processed by factor analysis algorithms. The informative importance of each criterion and aspects of excellent prognosis for pregnancy were determined. This method allows detection of differences between examined groups by magnitude comparison f1, f2 and to make mathematical modeling.

Results

To determine the diagnostic value we distinguish the following signs (X-22) with definite criteria (0; 1; 2) which show the level of their visualization. X1- inadiquate differentiation of fetal anatomical structures. Criteria: 0- normal differentiation characteristic of the gestation age; (1) no apparent telencephalon before 9 weeks of gestation; (2) inadiquate cephalic and pelvic pole differentiation before 10 weeks of gestation inclusively. X2 – index of cerebrum- corporal coefficient (CCC). Criteria: (0) normal values ranging between 1.6 and -2.6; (1) index (CCC) < 1.6; (2) CCC values >2.6 X3 – the presence of fetal hydrothorax. Criteria: (0) free fluid in the thoracic cavity is not visualized; (1) bilateral hydrothorax not more than 1mm; (2) echoes of fetal bilateral hydrothorax more than 1mm X4 – umbilical hernia of the fetus. Criteria: (0) visualization of the umbilical hernia up to 6 mm in size; (1) 6-8 mm in size; (2) more than 8 mm in size. X5 – fetal heartrate. Criteria: (0) 60-190 beats per minute; (1) > 190 beats per minute; (2) <60 beats per minute. X6 – umbilical cord cyst; Criteria: (0) normal sonography of the umbilical cord; (1) visualized umbilical cyst 5mm in diameter; (2) visible umbilical cyst >5mm in diameter. X7 – evaluation of the embryonic crown –rump lengths (CRL) and its proportion with the gestation age; (0) complete proportion; (1) significant embryonic crown –rump lengths disproportion (> 30%); (2) embryonic crown –rump lengths deficiency (>30%); X8 - binary contour of the fetus. Criteria: (0) the absent binary contour; (1) doubtful signs; (2) evident binary contour of the fetus. X9 - positive position of the fetus; Criteria: (0) normal position; (1) doubtful signs; (2) positive position of the fetus; X10 – normal differentiation of the telencephalon. Criteria: (0) normal differentiation of the telencephalon at 8th week of gestation; (1) normal differentiation of the telencephalon at 9th week of gestation; (2) abnormal image in the telencephalon area. X11 – inadequate chorion differentiation. Criteria: (0) homogeneous structure ; (1) chorion thickness 5 mm larger than normal; (2) breaking of the chorion- anechogenic irregular structures 5-10mm in size are visible in chorion structure. X12 – evaluation of the yolk sac. Criteria: (0) normal yolk sac diameter (4-6mm); (1) enlarged yolk sac diameter (>6mm); (2) hypoplasia –yolk sac diameter < 2mm. X13 – structure and thickness of chorion.

Criteria: (0) characteristic of the gestation age; (1) mild hypoplasia of chorion – the thickness is 4-6 mm that is not characteristic of the gestation age; (2) evident hypoplasia - hyperechoic structure, dwarfed chorion > 7mm that is not characteristic of the gestation age. X14 – aplasia of yolk sac. Criteria: (0) visualization of yolk sac characteristic of the gestation age; (1) early disappearance - yolk sac is not visible at the 9th week of gestation; (2) yolk sac is not detected as early as at the 5th week of gestation. X15 – echogenicity compensation of amniotic and chorionic cavities. Criteria: (0) normal echogenecity of adnexa cavities; (1) moderately increased echogenicity of amniotic cavity (doubtful test); (2) evident echogenicity of amniotic cavity. X16 – amniotic cavity dimensions. Criteria: dimension characteristic of the gestation age (> 10mm); (1) mild hypoplasia (5-10mm); (2) evident hypoplasia (<5mm). X17 – peculiarities of chorion vascularity; Criteria: (0) adequate vascularity in color flow mapping.(1) interrupted blood flow in chorion; (2) lack of bloodstream in chorion; X18 – visualization of adequate corpus ovarium luteum vascularity. Criteria: (0) annular blood flow around corpus ovarium luteum in Doppler color flow mapping; (1) visualization of unipolar blood flow around corpus ovarium luteum in Doppler color flow mapping. X19- myometrial tone. Criteria: (0) normal tone; (1) local hypersthenia; (2) generalized myometrial tone. X20 – the evidence of early diastolic carving in the uterine artery circulation. Criteria: (0) adequate circulation in the uterine artery; (1) the evidence of early diastolic carving; (2) the evidence of early diastolic carving in screening by uterine artery Doppler. X21 – the length of the cervix. Criteria: (0) the length of the uterine cervix is 30mm; (1) the length of the uterine cervix is < 30mm; (2) the length of the uterine cervix is < 25 mm. X22 - the state of endocervix. Criteria: (0) normal ultrasound image; (1) single endocervical cysts; (2) multiple cysts, heterogeneous walls. We have obtained the following results in each clinical group. In the first group of pregnancies (n=101) such sign as “inadiquate differentiation of fetal anatomical structures” (X1) was not monitored (100%). CCC values were within the normal range (X2). Fetal hydrothorax was not detected (X3). Umbilical hernia of the fetus was visualized within the normal size - up to 6mm (X4). The rate of fetal heartbeat varying between 146 and 175 beats per minute was noted in all pregnancies (X5). Cyst of the umbilical cord up to 5 mm in diameter was visualized in 5 pregnancies (5%) (X6). Crown – rump length (CRL) was characteristic of the gestation age (X7). Binary contour of the fetus was not seen in all settings in the first group of pregnancies (X9). The normal differentiation of the telencephalon was monitored (X10). All pregnancies exhibited homogenous structure of the chorion (X11). In 2 pregnancies (2%) the yolk sac diameter was more than 6mm (X12). In all cases the thickness of the chorion correlated with the gestation age (X13). Yolk sac (X14), normal echogenecity of adnexal cavities (X15), and amniotic cavity of normal size (X16) were visualized in all the pregnancies. Adequate vascularization of the corion in Doppler color flow mapping was visualized (X17) in all pregnancies. Unipolar blood flow around corpus ovarium luteum in Doppler color flow mapping was visualized in 7 women (7%) (X18). Local tone of myometrium was noted in 10 pregnancies (X19). Adequate blood flow in the uterine artery was monitored in all pregnancies (X20). Values of the cervix length were normal ranging from 38 to 45 mm (X21). Endocervix echoes were normal (X22). In the 2nd group of pregnancies (n=169) the normal differentiation of the embryo anatomical structures characteristic of the gestation age (X1) was noted. CCC values were noted to range from 1.6 to 2.6 (X2). Ultrasonographic scanning didn’t visualize free fluid in the thoracic cavity of the fetus (X3). Umbilical hernia of the fetus within the normal size - up to 6mm (X4) as well as the rate of fetal heartbeat was visualized in all the pregnancies (X5). 10 pregnancies (6%) were diagnosed as having a cyst of the umbilical cord 4-5 mm in diameter (X6). All patients demonstrated fetal crown –rump length characteristic of the gestation age (X7). Binary contours of the fetus(X8) as well as positive position of the fetus (X9) were not diagnosed. Normal differentiation of the telencephalon was detected in all pregnancies (X10). Chorion thickening and breaking were noted in 33 pregnancies (20%) (X11). Yolk sac more than 6mm in diameter was visualized in 42 pregnancies, 17(10%) women were diagnosed hypoplasia of yolk sac (d < 2mm) (X12). Chorion >7mm was visualized in 17 women (10%) (X13). 42 women (25%) demonstrated early disappearance of the yolk sac (X14). 17 patients were visualized evident echogenicity of amniotic fluid (X15). Mild hypoplasia of the amnion (5-10mm) was noted in 33 (20%) patients (X16). 42 patients had interrupted blood flow of the chorion in Doppler color flow mapping (X17). Inadequate corpus ovarium luteum vascularity and unipolar blood flow in Doppler color flow mapping were diagnosed in 76 (45%) pregnancies(X18). 25 (15%) patients were detected local tone of myometrium (X19). Screening by uterine artery Doppler revealed present early diastolic carving in 25 (15%) women (X20). Values of the cervix length varied between 35and 42 mm in all examined women (X21). Normal ultrasound image of endocervix was detected in 109 (64%) women; endocervical cysts were noted in 59 (35%) pregnancies (X22). One woman(4%) from the III(n=25) group ultrasonography was revealed free fluid not more than 1 mm thick in the fetal thorax (X3) along with hypoplasia of both chorion and yolk sac. In all cases the sizes of umbilical hernia (X4) as well as fetal heart rate were normal (X5). Cyst in umbilical area 5mm in diameter(X6) along with the reduced amniotic cavity and chorionic breaking were diagnosed in two pregnant women. 23 women (92%) of the given group were visualized crown –rump length (CRL) characteristic of the gestation age; 1 patient presented significant (>30%) crown –rump length (CRL) (X7) along with abnormal Doppler color flow mapping deviation. Positive position of the fetus (X9) was absent in all cases; normal differentiation of the

telencephalon was noted (X10). Thickening and breaking of the chorion along with increased size of yolk sac, equalizing chorionic and amniotic cavities, and hypoplasia of the chorion were visualized in 5 women (20%) (X11). Chorion >7mm that didn't correlate with the gestation age (X13) along with hypoplasia of amniotic cavity and cyst of umbilical cord were visualized in 3 women (12%). In 9(36%) women Doppler color flow mapping visualized interrupted blood flow in chorion (X17); evident increase in echogenecity of amniotic cavity was noted in 4 of 9 women; in 5 of 9 pregnancies we diagnosed evident increase in echogenecity of amniotic cavity along with breaking chorion. Inadequate vascularization of corpus ovarium luteum and unipolar blood flow in Doppler color flow mapping were present in 13 (52%) pregnancies (X18). 6 women were diagnosed as having local tone of myometrium (X19) along with present early diastolic carving visualized in screening by uterine arteries Doppler (X20). In all cases the length of the cervix varied between 35 and 42mm (X21). Endocervix echo was normal in 14 (56%) patients. Endocervical cysts were identified in 11(44%) pregnancies, moreover of 11 cases 4(16%) were visualized multiple cysts. In the 4th group of patients (n=12) inadiquate differentiation of fetal anatomical structures(X1) was identified in 4 pregnant women (33%). In 2 pregnancies (17%) index values of cerebrum-corporal coefficient (CCC) was smaller than 1.6 and in 1 woman this index was more than 2.6 (X2). In 4 (33%) pregnancies ultrasound scanning of the fetus visualized bilateral hydrothorax more than 1mm in thickness (X3). Umbilical hernia of the fetus varying in size between 6 to 8 mm was visualized in 3 patients (25%), umbilical hernia of the fetus more than 8 mm in size was identified in 2 patients (17%) (X4). Fetal heart rate more than 190 beats per minute was diagnosed in 4 women (33%), in 2 patients (17%) the fetal heart rate was <60 beats per minute (X5). Umbilical cord cyst >5 mm in diameter was visualized in 4 (33%) examined women (X6). Embryonic crown –rump lengths deficiency (>30%) was identified in 1 (8%) pregnancy (X7); binary contour of the fetus was evident in 5 (42%) pregnancies (X8). Ultrasound scanning visualized positive position of the fetus (X9). Differentiation of the telencephalon was not characteristic of the gestation age in 2 (17%) fetuses(X10). The breaking chorion was diagnosed in 3 women (25%) (X11). The diameter of the yolk sac < 2mm was visualized in 1 pregnancy (8%) (X12). Evident hypoplasia of the chorion was visualized in 5 pregnancies (42%) (X13). The absent yolk sac at the 5th week of gestation was diagnosed in 1 female patient (8%) (X14). Evident echogenicity of amniotic fluid was visualized in 5 (42%) patients (X15). Hypoplasia of the amniotic cavity (5-10mm) was diagnosed in 5 pregnancies, at the same time of 5 patients 1 (8%) had evident hypoplasia of the amniotic cavity (the size< 5 mm) (X16). In 4 (33%) pregnancies Doppler color flow mapping identified interrupted blood flow in chorion, in 1 patient (8%) blood flow in chorion was absent (X17). In 4 pregnancies we identified inadequate corpus ovarium luteum vascularity (X15). Local tone of myometrium was identified in 3 pregnancies (25%) (X 16). 2(17%) patients demonstrated evident echogenicity of amniotic fluid (X15). Mild amnion hypoplasia was noted in 3 pregnancies (25%) (X16). Doppler color flow mapping determined 4 cases (33%) of interrupted blood flow in chorion (X17). Inadequate corpus ovarium luteum vascularity was visualized in 4 pregnancies (X18). Local tone of myometrium was identified in 3 pregnancies (25%) (X 19). Doppler ultrasonography determined early diastolic carving of the uterine arteries (X20). Values of the cervix length varied between 18 to 35 mm (X21). Ultrasound image of the endocervix was normal in 5 (42%) patients; endocervical cysts were visualized in 4 (33%) patients, of 4 examined women 2 (17%) were visualized multiple cysts. Using mathematical modeling with special algorithms we have determined the value of different signs and have worked out the following prognostic algorithm

$$S=X1\times0.45+X2\times0.43+X3\times0.39+X4\times0.33+X5\times0.25+X6\times0.22+X7\times0.41+X8\times0.42+X9\times\times0.30+X10\times0.28+X11\times0.42+X12\times0.32$$

in which X1 denotes inadequate differentiation of fetal anatomical structures,X2 denotes index of cerebrum- corporal coefficient (CCC), X3 – the presence of fetal hydrothorax, X4 – umbilical hernia of the fetus, X5 –fetal heart rate, X6 – umbilical cord cyst, X7 – evaluation of the embryonic crown –rump lengths (CRL) and its proportion with the gestation age, X8 - binary contour of the fetus, X9 - positive position of the fetus, X10 – normal differentiation of the telencephalon, X11 – incorrect chorion differentiation, X12 – evaluation of the yolk sac, X13 – structure and thickness of chorion, X14 – aplasia of yolk sac, X15 – echogenicity compensation of amniotic and chorionic cavities, X16 – amniotic cavity dimensions, X17 – peculiarities of chorion vascularity, X18 – visualization of adequate corpus ovarium luteum vascularity, X19- myometrial tone, X20 – the evidence of early diastolic carving in the uterine artery circulation, X21 – the length of the cervix, X22 - the state of endocervix. Values of each criterion stipulated for its prognostic significance. Each sign was assessed by three-point system: 0 corresponded to optimal characteristic of the sign; 2 meant unfavorable characteristic, 1 meant intermediate value of the sign assessment. The overall ranging between 0 to 09 viewed as minimal risk of failure; 3.1-5.0 viewed as complications hazard. The overall ranging between 1.0 to 3.0 denoted mild complications hazard. Such values as 5.1-7.0 indicated the unfavorable pregnancy outcome at the check up. As a result the overall in the first group was within the range 0-0.9, in the second group -1-3, in the third group-3.1- 5.0, and in the fourth group- 5.1-7.0. It should be noted that there were a combination of signs in the 3rd and 4th groups of patients. In the 3rd group the combination of 2 signs accounted for 65 %; the combination of 3 signs accounted for 25% of pregnancies. In the 4th group the

combination of 2 signs accounted for 82% of pregnancies and the combination of 3 signs accounted for 65% of pregnancies. Thus, based on the factor analysis we have determined the importance of ultrasound scanning in diagnosing many structural abnormalities of the fetus and adnexa. We have worked out the matrix useful in predicting pregnancy outcome and identify risk groups of population with prenatal pathology.

Conclusion

Based on the factor analysis we have determined the significance of given criteria. The aplasia of yolk sac is the most important criterion of fetal and adnexa development in the first trimester of the pregnancy with the value 0.50. Dysplasia of yolk sac accounted for 100% of undeveloped pregnancies. Isolated adnexa abnormality is of minimal diagnostic value. Associated pathology was diagnosed in the group with high risk of unfavourable pregnancy progression and pregnancy failure. Both inadiquate differentiation of fetal anatomical structures and index of cerebrum- corporal coefficient (CCC) are considered to have significant value in prediction of unfavourable fetal development, their informational weight being 0.45 and 0.43 respectively. These criteria depict the progression of embryogenesis as well as photogenesis, their abnormality cause disproportion in the size of the fetal head and body. Tone of the myometrium, inadequate corpus ovarium luteum vascularity, and echo morphological assessment of the endocervix proved to be less significant. The informational weight of these criteria is 0.12, 0.18, and 0.18 respectively.