Investigation regarding the feasibility of early neurosonogram in open spina bifida detection

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Abstract

Objective. *To investigate the feasibility of recently described markers of fetal neurosonogram, in first trimester detection of open spina bifida (OSB).* ***Methods.*** *We retrospectively assessed the dates from September 2007 - September 2010 of fetuses that underwent routine 11-13 weeks' scan. Accessibility to stored neurosonogram parameters was evaluated in 3D dates from 1149 normal fetuses. Dates from 2 studied fetuses diagnosed with SB during this period were used to evaluate the parameters.* ***Results.*** *IT was considered an accessible parameter (95.51% rate of retrospective satisfactory-considered images); mean values increased with crown-rump length and abnormal values were found in both OSB cases. The measurements are repeatable and show no significant differences between 2D and 3D evaluation.* ***Conclusions.*** *In our knowledge studies regarding the comparative analysis of first trimester OSB markers have never been published. Preliminary results suggest that posterior brain measurements may offer the possibility of first trimester diagnosis of open SB. In normal neurological fetuses the measurements correlates with gestational age, are reproducible and the results obtained by 3D and 2D ultrasound are similar.*

Keywords: *neurosonogram, spina bifida, first trimester screening, mid-sagittal view, intracranial translucency, three-dimensional ultrasound*

Introduction

The introduction of an early marker for open SB is important because of the possibility to diagnose this condition at 11-13 weeks, along the majority of all major fetal abnormalities[1]. Presently the SB diagnosis is usually missed at this age of gestation[2]. Recent research shows that fetal spinal abnormalities diagnosed in the first trimester are usually severe, frequently associated with other major defects and the diagnosis of small defects is difficult, requiring second-trimester scan to detect most cases of spina bifida[3,4]. The large prevalence of indirect signs for SB during second trimester encouraged the research for such indirect sonographic markers of associated caudal displacement of the brain in the first trimester. Retraction of frontal bones and parallel cerebral peduncles has been proposed[5], and also measureable abnormalities in the posterior brain: intracranial translucency (IT), brain stem/brain stem-occipital bone distance ratio[6,7]. The 11-13-weeks' scan became an important tool in evaluation of gestational age, chromosomal risk[8-12] and diagnosis of major morphologic abnormalities[3,13,14] and consecutively many national health-care systems has offered this sonographic evaluation to all pregnant women. Studies confirm the possibility of evaluate the indirect sonographic markers mentioned above in routine ultrasound examination at 11(+0)–13(+6) weeks' scan, on the standard planes of the fetal head, therefore with little/no investment in additional time.

The aims of this study were: to determine the accessibility to these markers in stored 2D and 3D dates and second and to investigate retrospectively the affected cranial and cerebro-spinal features in the cases of spina bifida diagnosed in our center between September 2007 and September 2010 in order to evaluate the benefits of the new-suggested markers.

Methods

We retrospectively studied the stored acquisitions from the first trimester screening programme during September 2007 - September 2010. In this study sonographers had not been specifically instructed to search for cranial signs of spina bifida, and we used 2D images database illustrating obligatory planes of examination in the center's routine and 3D volumes stored of fetal head. All examinations were carried out transabdominaly, using RAB 4-8L probe on Voluson 730 Pro and Voluson 730 Expert, GE Medical Systems Kretztechnik ZIPF Austria.

Approval for the study was obtained from the hospital Ethics Committee.

We considered relevant to evaluate the accessibility to satisfactory images of the stored early neurosonogram parameters in the perspective of a study meant to investigate retrospectively their presence in the group of affected fetuses from our clinic, based on the reevaluation of the stored markers.

The rate of retrospective satisfactory-considered images were calculated using dates from 1149 fetuses examined

at 11(+0) to 13(+6) weeks, which subsequently had a detailed ultrasound examination at 20 to 24 weeks that showed no fetal abnormalities. The cranial markers were assessed using the 3D volumes of the fetal head and the spine aspect was evaluated on the section used for the measurement of crown-rump length (CRL). The standard planes used for evaluation were: sagittal view of the face, transverse planes of cranium at the level of choroid plexus and cerebral peduncles, oblique-transverse plane of cranium at the level cerebellum and sagittal planes of spine. The targets of evaluation consisted in: brain stem (BS), choroid plexus of the fourth ventricle, occipital bone, cranium shape with special care for dolichocephaly and narrowing of the frontal bones at the level of coronal sutures, choroid plexus aspect and median septum, cerebral peduncles aspect (angulations/parallelism), cerebellum aspect with special care in curvature, regularity/irregularity of spine and the presence of cystic masses. Figure 1 shows normal aspects of structures in early (11-13 weeks) neurosonogram.

In all cases with satisfactory visualization of the fourth ventricle, the widest antero-posterior diameter (IT) was measured in 2D, in the same sagittal section used for the measurement of nuchal translucency and for evaluation of the nasal bone, as shown in Figure 1. All examinations were carried out transabdominally by sonographers with extensive experience in first-trimester scanning and who had obtained the Fetal Medicine Foundation Certificate of Competence in the 11 to 13 weeks scan.

We searched our 2007-2010 database to identify cases of spina bifida diagnosed intrauterine or at birth. Consecutively, the images from the first trimester ultrasound exams were retrospectively evaluated in order to assess recently described markers of fetal neurosonogram, in detection of the fetuses with spina bifida diagnosed in our clinic and examined during the first trimester of pregnancy.

Statistical analysis. Regression analysis was used to determine the significance of the association between the measured parameters and CRL. Each measurement of IT was expressed as a difference (delta value) from the expected normal mean for CRL. The normal distribution of the calculated delta values was confirmed using Kolmogorov-Smimov test.

Results

Retrospective accessibility to stored CNS parameters at the 11 to 13+6 weeks scan

The retrospective study involved a total of 1149 pregnancies with the median gestational age of 12+5 (11+0 to 13+6) weeks, median CRL 68.2mm. Table 1 contains the standard planes and targets of evaluation in the retrospec-

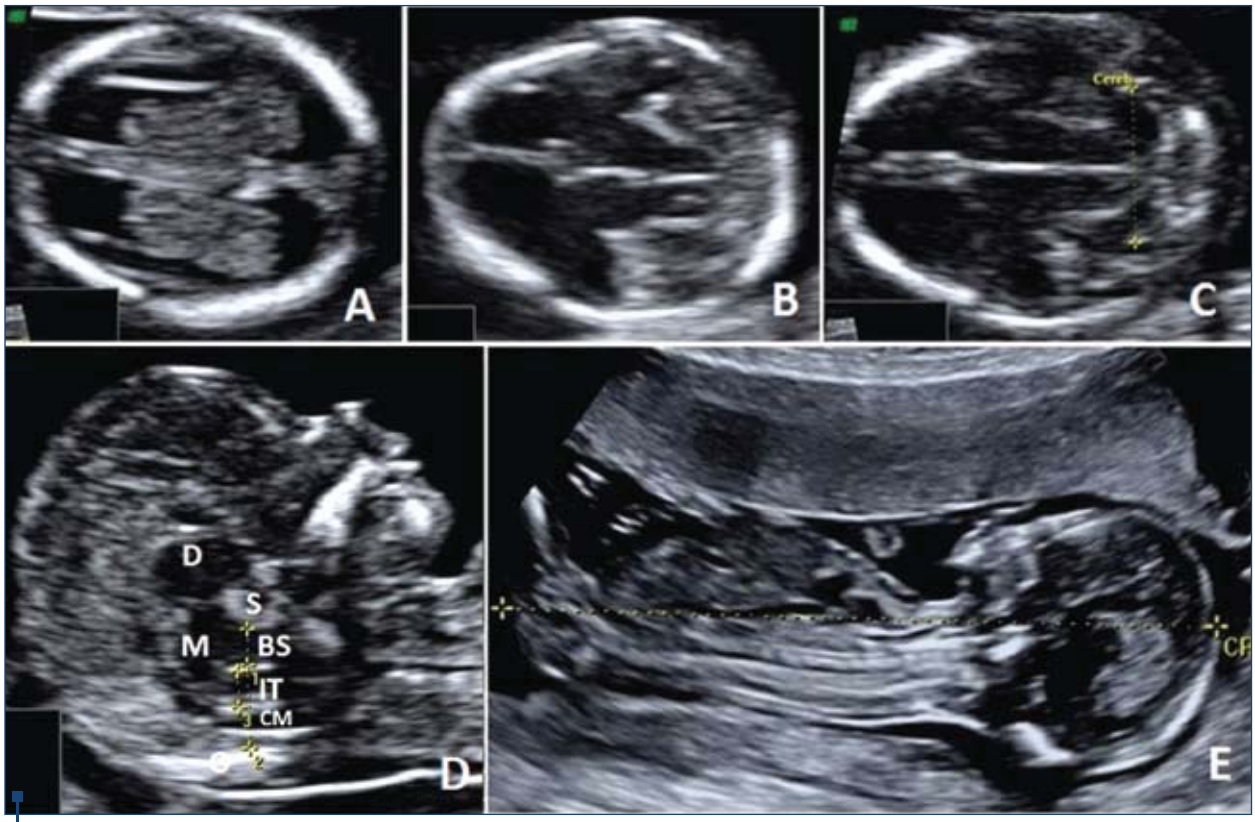
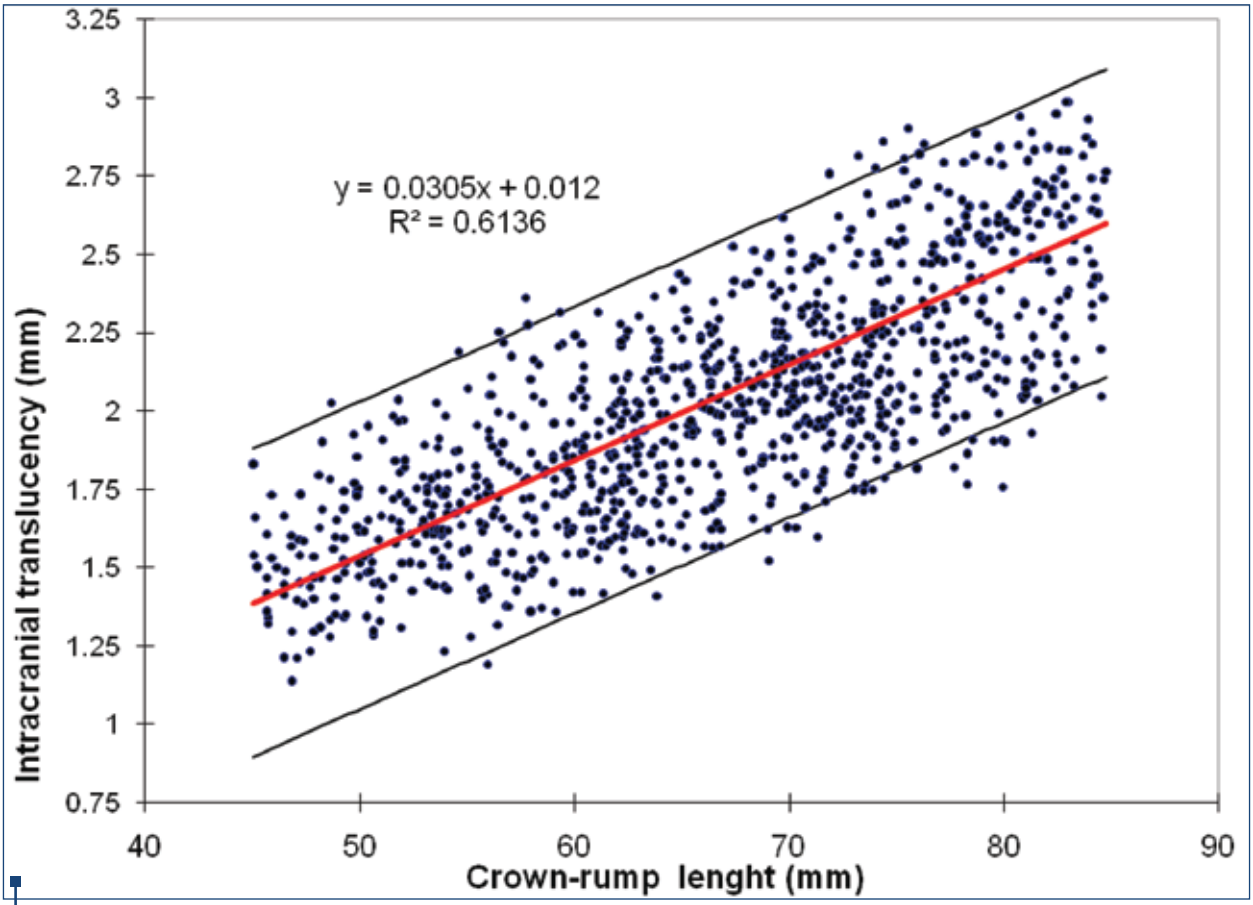


Figure 1. Normal aspects in early (11-13 weeks) neurosonogram. Cranium shape, choroid plexus aspect and median septum (A), cerebral peduncles aspect (B), cerebellum (C), sagittal view of the fetal face (D), sagittal plane of spine (E). In the sagittal view of the face are noted: diencephalon (D), midbrain (M), brain stem (BS), intracranial translucency (IT), cisterna magna (CM), sphenoid bone (S) and occipital bone (O) and measurements in posterior brain: intracranial translucency, brain stem antero-posterior diameter and the distance form brain stem to occipital bone

Table 1 Standard planes and targets of evaluation in the retrospective neurosonogram. Rate of retrospective satisfactory-considered images obtained from 3D volumes of the fetal head and 2D CRL measurements stored at 11(+0) - 13(+6) weeks

Standard planes	Targets of evaluation	Rate of retrospective satisfactory-considered images - % (number)
Sagittal view of the face	Sagittal visualization of sphenoid bone, brain stem (BS), choroid plexus of the fourth ventricle, occipital bone and measurement of IT	95.47 (1097)
Transverse plane of cranium at the level of choroid plexus	Cranium shape with special care for dolichocephaly and narrowing of the frontal bones at the level of coronal sutures; Choroid plexus aspect and median septum	98.43 (1129)
Transverse plane of cranium at the level cerebral peduncles	Cerebral peduncles aspect (angulations/parallelism)	85.81 (986)
Oblique-transverse plane of cranium at the level cerebellum	Cerebellum aspect with special care in curvature	56.31 (647)
Sagittal plane of spine on the CRL section	Regularity/irregularity of spine Presence of cystic masses	22.10 (254)



Graph 1. Intracranial translucency measured in 1097 normal fetuses vs crown-rump length

tive study, with the corresponding rates of retrospective satisfactory-considered images.

We found that the incidence of some sonographic markers is gestational age-dependent. The cerebellum was best visualized in fetuses of 13+ weeks of gestation, and the spine parallelism and suprajacent cutaneous layer - in fetuses over 12 weeks of gestation.

1097 fetuses (95.47%) presented satisfactory retrospective images of the fourth ventricle; IT was measured in 2D, in the same sagittal section used for the genetic markers assessment (nuchal translucency, nasal bone, facial angle).The mean IT in the entire studied lot of pregnancies increased with CRL from 1,39 mm a at CRL 45 mm to 2,59 mm at CRL 84 mm. (IT = 0,0305 x CRL + 0,012, r^2=0.6136) (Graph 1).

Retrospective evaluation of fetuses with OSB

We had seven diagnosed SB in our clinic during 2007-2010 and two of them underwent first trimester scan in our clinics. The stored images were examined by a sonographer with extensive experience in first-trimester scanning who had obtained the Fetal Medicine Foundation Certificate of Competence in the 11 to 13 weeks scan. Both fetuses presented associated abnormalities.

The cranial signs of the first case are presented in Figure 2: not measurable intracranial translucency on the sagittal view of fetal face, normal aspect of choroid plexus with normal but rather acorn contour of cranium, also parallel peduncles were suspected. A reassessment was suggested for suspicion of heart abnormality and persistent exomphalos, but we didn't perform an extensive exam, because the pregnancy was interrupted at request for familial reasons. However, after medical abortion, the requested pathologic exam confirmed open neural tube defect of sacral spine. The retrospective image show a slightly parasagittal view of the fetal face, but, as demonstrated by Chaoui and Nicolaides[15] this cannot impair the visualization of a normal fourth ventricle.

The second case came from a dichorionic twin pregnancy and images from first trimester scan are presented in Figure 3. Visualization of the fetal head was particular difficult because of the maternal BMI and fetal position within the gemellarity context. We found abnormal posterior brain complex with intracranial translucency not measurable, with normal aspects of cranium shape, choroid plexus and cerebral peduncles; the fetus developed severe cardiac defect; the other gemelar showed normal genetic and sonographic features. In the second trimester in the affected fetus was visualized also open defect of the spine along the abnormal shape and the CNS anomaly was confirmed at birth.

Discussion

The direct visualization of the spine during the first trimester is often difficult even with the help of hi-

Figure 2. Cranial planes in fetus with associated SB. (case 1). A: sagittal view of the face with measurement of nuchal translucency and facial angle and present nasal bone (arrow), non measurable intracranial translucency; B: axial plane at the level of choroid plexus; retraction of frontal bones is suggested; C: axial plane at the level of cerebral peduncles: parallel peduncles is also suggested

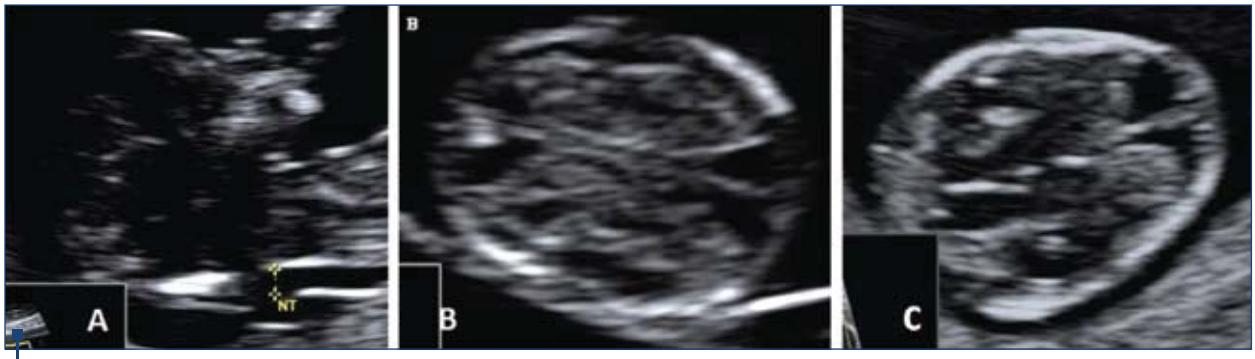


Figure 3. Sectional planes of cranium in SB affected fetus (case 2). A: non identifiable/measurable intracranial translucency on sagittal view of fetal face. B: normal cranium and choroid plexus shape. C: normal aspect and angulations of cerebral peduncles

gh-resolution ultrasound machines; local conditions related to the thickness of the maternal abdomen, the anterior position of placenta, the small size of the fetus, unfriendly position or the poor echogenity of the spine and suprajacent teguments provide the reasons for non-visualization of the entire cervico-sacral aspects of spine. Our retrospective study of the CRL stored sections found in only 22.1% satisfactory images of the spine. Therefore, indirect markers for open spina bifida are needed for early suspicion of such anomalies, and their abnormal aspects should be followed by careful evaluation of spine.

Indirect signs as the retraction of frontal bones, parallel cerebral peduncles and parameters of the posterior brain were successfully monitored in routine ultrasound examination at 11(+0)–13(+6) weeks' scan, on the standard planes of the fetal head. However, in our knowledge comparative analysis regarding the feasibility of the first trimester OSB markers have never been published.

The findings of the retrospective study demonstrate that at 11 + 0 to 13 + 6 weeks of gestation intracranial translucency is an accessible marker on the stored sagittal sections of the fetal face, extensively used in genetic screening, for nuchal translucency, nasal bone and facial angle evaluations. In our research, the parameter has mean values that correlates and increases with fetal CRL from 1,39 mm to 2,59 mm during 11 - 13+6 weeks. Evaluation of IT provided an objective sonographic method in early defining open spina bifida, because abnormal aspects were found in the SB cases, probably because of the associated caudal displacement of the brain, characterized by compression of the fourth ventricle. However, the small number of affected cases represents a limitation of the study.

Another study published by our group found that the measurement of the IT is reproducible at least in normal neurological fetuses, with differences between two consecutive measurements <5% in 93.75% of cases measured by the same sonographer and in 91.07% of the cases measured by two sonographers on 3D stored data[16].

Effective first-trimester screening for open spina bifida is provided by the classical markers in the second trimester[2]. Preliminary results suggest that the abnormal IT aspect/measurement may offer the possibility of first trimester diagnosis of open spina bifida[6]. Consequently, this measurement is likely to improve the performance of first-trimester morphological sonographic screening, and no time-consuming, because the examination of the sagittal plane is necessary not only for measurement of the IT but also for accurate assessment of the nasal bone and measurement of the fetal NT.

Accurate assessment of the IT necessitates extensive experience in scanning and, in our study as demonstrated in other papers[10], it may not be possible to obtain the exact midsagittal plane of the fetal face within a period of 15 min in up to 20% of the cases. However, in the centers that already perform first-trimester screening with measurement of nuchal translucency and assessment of the nasal bone, the subjective evaluation "at a glance" of intracranial translucency is not time-consuming, having in mind that nor further time for scanning is involved. It is unlikely that the measurement of IT will be part of the routine sonographic screening in all cases, but an alternative approach is to reserve this examination for the subgroup of pregnancies at increased risk for neural tube defects which constitutes about 5-10‰ of the total population.

Conclusions

The originality of our study consisted in the comparative analysis of the feasibility of first trimester markers for OSB. Preliminary results suggest that posterior brain measurements may offer the possibility of first trimester diagnosis of OSB, and may comport a greater value than the other suggested parameters. In normal neurological fetuses the measurements correlates with gestational age and are reproducible. ■

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