Normograms in prenatal life of stomach and urinary bladder in the second and third trimester of pregnancy

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Abstract

This research analyzes the measurement of fetal stomach and urinary bladder in healthy fetuses in the second and third trimester of gestation based on the database of the tertiary center from 2016 to 2019. The fetuses were selected for the study group in case they presented normal biometry and normal cardiac structure and function, no extracardiac malformation and no extracardiac anomalies and their gestational age was between 14^{th} week up to the 40^{th} week of gestation. The normograms from the analysis are presented. The size of the fetal stomach and urinary bladder (S/UB index) increases with gestational age on a 1:1 basis.

Conclusions: The average size of the stomach in healthy fetuses between the 14 – 40 th week of gestation was 18 mm (8 – 40 mm) , the average urinary bladder measurement was 17 mm (15 mm – 42 mm) and the fetal stomach to urinary bladder index (S/UB index) was constant: 1.26 (0.09 – 3.93). These are simple measurements that be implemented in daily practice for fetal ultrasound assessment

Abstract content goes here

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Key words: fetal stomach, fetal bladder, stomach, urinary bladder, S/UB ratio, stomach to urinary bladder index, ultrasound examination, stomach size, urinary bladder size

SUMMARY

This research analyzes the measurement of fetal stomach and urinary bladder in healthy fetuses in the second and third trimester of gestation based on the database of the tertiary center from 2016 to 2019. The fetuses were selected for the study group in case they presented normal biometry and normal cardiac structure and function, no extracardiac malformation and no extracardiac anomalies and their gestational age was between 14^{th} week up to the 40^{th} week of gestation. The normograms from the analysis are presented. The size of the fetal stomach and urinary bladder (S/UB index) increases with gestational age on a 1:1 basis.

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AIM

The aim of this research was to analyze the measurement (in mm) of fetal stomach and urinary bladder in healthy fetuses and to evaluate the stomach to urinary bladder index (S/UB index).

MATERIALS AND METHODS

This research was done based on data withdrawn from the database of our tertiary and fetal ultrasound exams performed in years 2016 – 2019. The study group, 867 fetuses demonstrated normal biometry and normal heart structure (NHA), normal heart function (NHS) no extracardiac malformations (ECM) and no extracardiac anomalies (ECA) and had stomach measurements (in mm) and urinary bladder measurements (in mm). Reference curves for these values were determined based on gestational age.

In addition, the stomach to urinary bladder index was analyzed in the study group.

The examinations were performed with the use of the following ultrasound machines: Voluson E10, Philips and Voluson Expert, with convex transabdominal transducers.

The measurement of the size of the fetal stomach was evaluated in the abdominal cross-section. In the same section the measurement of fetal abdominal circumference (AC) was taken, for biometry calculation (Fig. 1) .

The measurement of the size of the fetal urinary bladder was evaluated based on longitudinal abdominal scans, taking into account the maximum internal dimension length (Fig. 2).

Interobserver variability and intraobserver variability were analyzed off line in a group of 10 fetuses, providing compliance at the level of 100%.

Linear regression analysis based on Microsoft Excel was used for statistical analysis.

RESULTS

Measurement of the fetal stomach in mm from 14th week of gestation to 38.4 week of gestation in the study group is presented in Figure 1 and Figure 3.

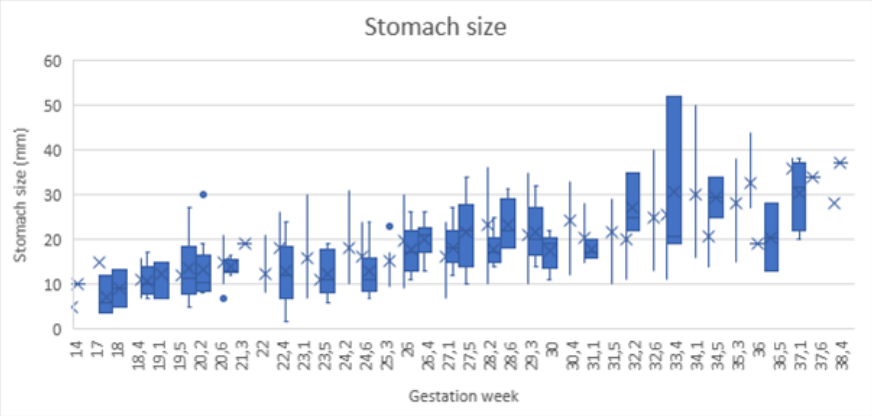

Figure 1: Caption

Figure 1: Measurement of fetal stomach length in relation to gestational age in a group of 867 healthy fetuses (Normal Heart Anatomy, no Extracardiac malformations, no Extracardiac anomalies). Data from of the Department of Prenatal Cardiology of the Polish Mother's Memorial Hospital in Lodz of 2016-2019

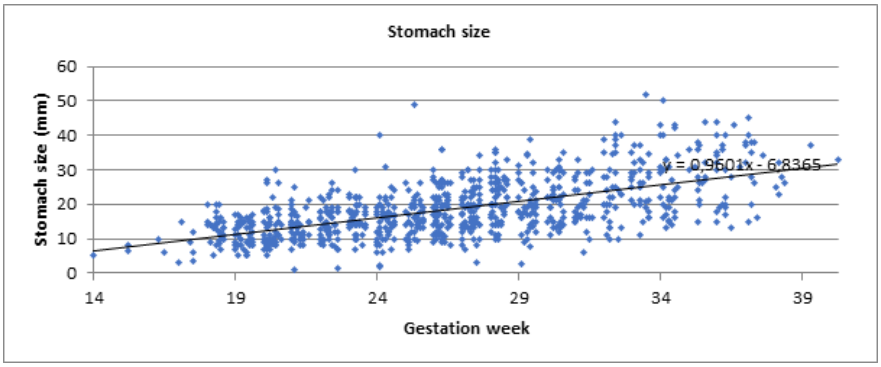

Figure 2: This is a caption

Figure 2: Measurement of fetal stomach length in relation to gestational age in a group of 867 healthy fetuses with a trend line. Figure according to the formula y=0,9601x-6,8365. Data from of the Department of Prenatal Cardiology of the Polish Mother's Memorial Hospital in Lodz of 2016-2019

The examination results presented in Figure 1 and 2 demonstrate an upward trend in fetal stomach size with the gestational age (in terms of weeks of gestation). The size of the stomach in "healthy" fetuses (with normal biometry, cardiac structure and function, without extracardiac malformation and extracardiac anomalies observed) during pregnancy from the 14^{th} week of gestation to the 40^{th} week of gestation was on average 18 mm, with the minimum value of 8mm, maximum value of 40mm and median value of 17mm.

The urinary bladder size measurements in the study group in fetuses without anomalies from the 14^{th} week of gestation to the 38.4 week of gestation are presented in Figure 5 and 6. The analysis of the data shows that the average urinary bladder measurement was 17 mm, with a minimum value of 15 mm, maximum value of 42 mm and median value of 15 mm.

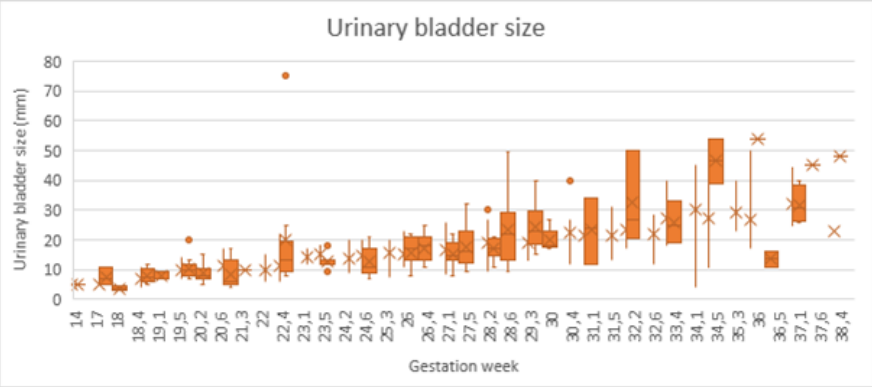

Figure 3: This is a caption

Figure 3: Measurement of fetal urinary bladder size in relation to gestational age in a group of 867 healthy fetuses. Data from of the Department of Prenatal Cardiology of the Polish Mother's Memorial Hospital in Lodz of 2016-2019

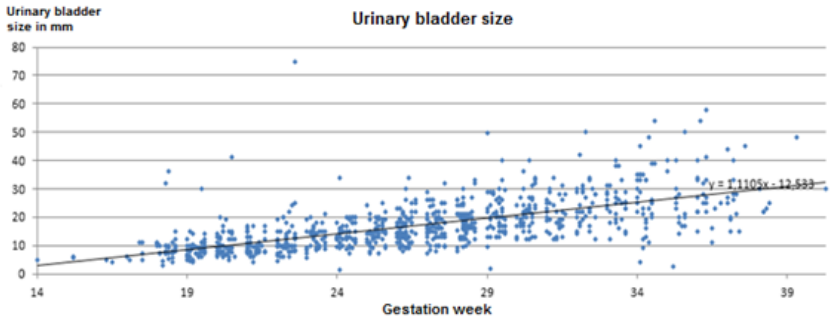

Figure 4: This is a caption

Figure 4: Measurement of fetal urinary bladder size in relation to gestational age in a group of 867 healthy fetuses with a trend line. Figure according to the formula y=1,1105x-12,533. Data from of the Department of Prenatal Cardiology of the Polish Mother's Memorial Hospital in Lodz of 2016-2019

Next, the fetal stomach to urinary bladder index was analyzed in the study group (Figure 5 and Figure 6) .

Correlation between the size of the fetal stomach and the urinary bladder

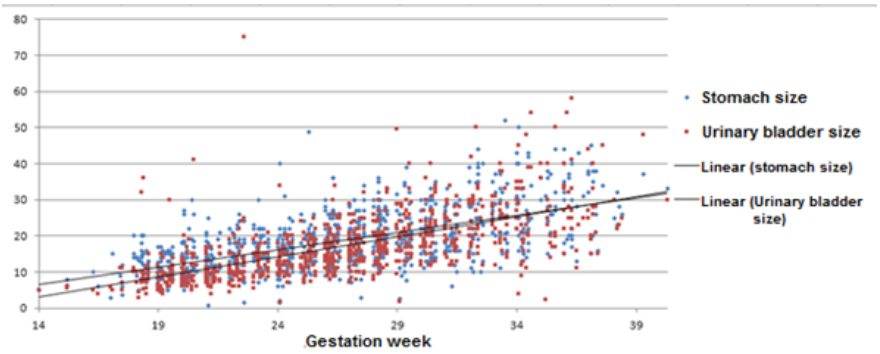

Figure 5: This is a caption

Figure 5: Comparison of the size of the fetal stomach and urinary bladder in fetuses without anomalies in relation to gestational age in a group of 867 healthy fetuses with trend lines. Data from of the Department of Prenatal Cardiology of the Polish Mother's Memorial Hospital in Lodz of 2016-2019

Figure 5 shows that the size of the fetal stomach and urinary bladder increases with gestational age parallelly on a 1:1 basis.

Fetal stomach to urinary bladder index

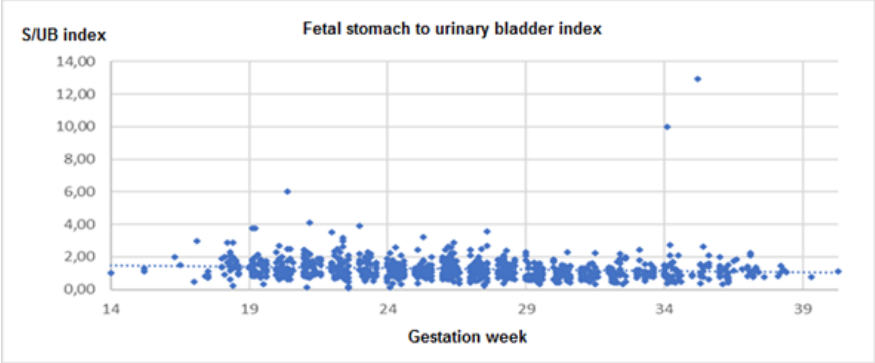

Figure 6: This is a caption

Figure 6: Ratio of the size of the fetal stomach and urinary bladder in relation to gestational age in a group of 867 healthy fetuses with a trend line. Data from of the Department of Prenatal Cardiology of the Polish Mother's Memorial Hospital in Lodz of 2016-2019.

The analysis shows that the fetal stomach to urinary bladder index during prenatal development is virtually constant and shows a slight tendency to decrease in the 3rd trimester of pregnancy. Assessment of the stomach to urinary bladder index (S/UB index) in the study group of fetuses without anomalies in the second and third trimester of pregnancy shows that the average value of the S/UB index is 1.26, with a minimum value of 0.09, a maximum value of 3.93 and a median value of 1.14.

DISCUSSION

In this study, the selection of patients (fetuses) included mainly fetuses older than 18th week of gestation due to the fact that this is a time when it is easy to visualize the size of the structures examined, and the lack of their visibility may have significant clinical consequences.

Under normal conditions, the fetal stomach is located on the left side of the descending aorta, as is the tip of the heart, which is also correctly located on the left side, this is on the same side as the stomach [1, 2]. The stomach is observed in the ultrasound image as a hypoechogenic structure and maybe be seen since 9th week of gestation [3]. Lack of stomach or too small stomach may be a result of esophageal atresia or esophageal atresia with an esophageal-tracheal fistula [4]. Too big stomach can be caused by duodenal atresia or small intestine atresia. The fetal stomach size can also be affected by gestational diabetes [5]. Too small or large stomach can be an ultrasound marker or fetal development anomaly [6].

The fetal stomach can be visualized in the first trimester of pregnancy and can be a good marker of fetal lateralization. Analysis of stomach location makes it easier to detect dextrocardia or situs inversus [7]. Ultrasound observation of the position of the stomach may be useful in diagnosing diaphragmatic hernia in the fetus [8, 9, 10].

Digestive system defects usually occur in combination with polyhydramnios, which is usually observed as of 28^{th} week of pregnancy or later, and then an enlarged or too small stomach can be an important marker for the detection and diagnosis of gastrointestinal anomalies.

Despite the good quality of modern ultrasound machines, the visibility and assessment of the esophagus even by an experienced ultrasound specialist is not easy. Assessment in 3D ultrasound imaging may be helpful here [11]. Nevertheless, ultrasound alone does not give a precise answer on the level of obstruction. That is why, we are increasingly using other examination methods, such as magnetic resonance imaging and amniotic fluid flow analysis, which may be helpful in the case of diagnostic problems [12].

It is worth quoting one of the works of Millener P. B. et. *al.* [13], which included a study group of 7200 fetuses. Among the study group, there were 31 fetuses with the fetal stomach not observed during ultrasound examination after 14 weeks of gestation. This means that sometimes fetal stomach may not be seen during ultrasound scan. "Not all fetuses with a nonvisualized stomach after 19 weeks' gestation have a poor outcome. Not all fetuses with a transiently nonvisualized stomach have a normal outcome". [13]

We compared our normogram with the Goldstein's normogram [5], which shows measurements of the stomach in 152 fetuses between 9th week of gestation to 40th week of gestation. Measurements were made in three dimensions: anteroposterior, longitudinal and transverse. A linear increase in stomach size was observed in parallel with the week of gestation. Analyzing the chart of Goldstein I. et *al.* [5], we see that in normal pregnancies from 13th week of pregnancy to 39^{th} week of pregnancy, the size of the fetal stomach ranges on average from 0.4 cm to 2 cm in the anteroposterior dimension, 0.6 cm to 2.4 cm in the transverse dimension and 0.9 cm to 4.1 cm in longitudinal dimension. On average, throughout the entire gestation period, the fetal stomach size ranges from 4 mm to 41 mm.

The measurements obtained in our center are similar to the Goldstein's data, but for the simplification and shortening of the examination protocol and, above all, to draw attention to the importance of stomach visualization, it seems that just one measurement proposed by us for analysis is also a good method.

In the literature there are also other normograms for fetal stomach assessment, but we did not find one that compared the size of the stomach with size of the fetal bladder.

The ultrasound measurement of the fetal urinary bladder is another important marker that can be used to diagnose fetal malformations [14]. The urinary bladder was located above the transverse plane in most of the cases and in the median sagittal plane in every case. It was determined that the angle of bladder did not change and the mean value of the angle was 151 degrees during the fetal period. The urinary bladder

was categorized into four different shapes, and the most common shape found during the fetal period was cuboid [15, 16].

With normal fetal development, the size of the urinary bladder should show an upward trend in parallel with subsequent weeks of pregnancy in the second and third trimester. The average urinary bladder size in the second and third trimester of pregnancy should be between the minimum value of 15 mm and an average value of about 50 mm. When comparing the data on the stomach and urinary bladder, it can be stated that the size of the fetal stomach and urinary bladder increases with gestational age on a 1: 1 basis. Any discrepancies in this regard may indicate fetal developmental abnormalities requiring further diagnosis. Ultrasound assessment of the urinary bladder allows the diagnosis of bladder anomalies such as bladder agenesis, bladder extrophy, or ureteral cyst [17].

Ultrasound bladder may be visible from the first trimester of pregnancy. This examination is important because the size of the bladder exceeding 4 cm may be a diagnosis of the so-called enlarged bladder, otherwise known as a giant bladder. Visualization of such a large bladder may suggest posterior urethral valves (57%), followed by urethral atresia/stenosis (7%), prune belly syndrome (4%), megacystis - microcolon -intestinal-hypoperistalsis syndrome (MMIHS) (1%), and cloacal anomalies (0.7%). Karyotype anomalies are found in 15%, and include trisomy 18, trisomy 13 and trisomy 21 [9, 18, 19].

Another important aspect is the assessment of the urinary bladder volume. In a study conducted by Fontanella F. et. *al.* [14] the urinary bladder volume was assessed in the 2nd and 3rd trimester of pregnancy. The study showed the urinary bladder volume in healthy fetuses increases slightly in the 2nd trimester in parallel with gestational age and increases more intensively from 25 week of gestation. At present, fetal urine production can only be measured indirectly by repeated ultrasound assessments of the successively increasing fetal bladder volume and it is not possible to validate the estimated urine production [20, 21].

Furthermore, the histological analysis of the smooth muscle, collagen, nerves and connective tissue of the developing bladders revealed that there were no gender differences during weeks 13 - 23 of gestation [22].

When fetal bladder enlargement is diagnosed, structures such as ureters, kidneys and genitals must be carefully evaluated. The fetus must then be assessed more frequently and examined in terms of AFI, as changes in the amount of amniotic fluid in fetuses with too large or small fetal urinary bladder can be life threatening [15].

When the bladder is repetitively not visible at all, the amount of amniotic fluid can help in making the differential diagnosis. In association with oligo- or anhydramnios, bilateral renal pathology should be suspected (e.g. bilateral multicystic kidney disease, severe bilateral ureteropelvic junction obstruction, bilateral renal agenesis or autosomal recessive polycystic kidney disease). If the amniotic fluid volume is normal, a bladder anomaly should be considered [23].

In turn, the assessment of the stomach to urinary bladder size index (S/UB index) in fetuses in the second and third trimester of pregnancy showed averaged values of 1.26 (with a minimum value of 0.09 and a maximum value of 12.92) with a tendency to a slight decrease in the S/UB index during the third trimester of pregnancy. Too low or too high values may suggest abnormalities requiring further evaluation to look for structural or functional anomalies.

It is also very important to remember about the correct position of a fetal stomach and fetal heart. Fetal stomach and fetal heart are normally located on one left side, thus providing situs solitus. In some cases situs inversus can be observed. Therefore, the position of the fetal spine must be correctly assess to provide proper interpretation of the position of fetal heart and stomach [24]. A deviation from the above normal situation can be dextrocardia, which has different incidence in fetuses. One study by Lidia Mikołajczyk, et. al. shows that situs inversus can be a common type of abnormality [25]

The normograms regarding the size of the stomach and urinary bladder and the stomach to urinary bladder index prepared based on our study group can contribute to the improvement of the accuracy of examination and thus to improving the detection of anomalies. Due to the fact that fetal structures are one of the most

challenging structures to be visualized and assessed by an ultrasound specialist, in our center we adopted the principle of measuring the size of the stomach and urinary bladder in mm in each fetal examination.

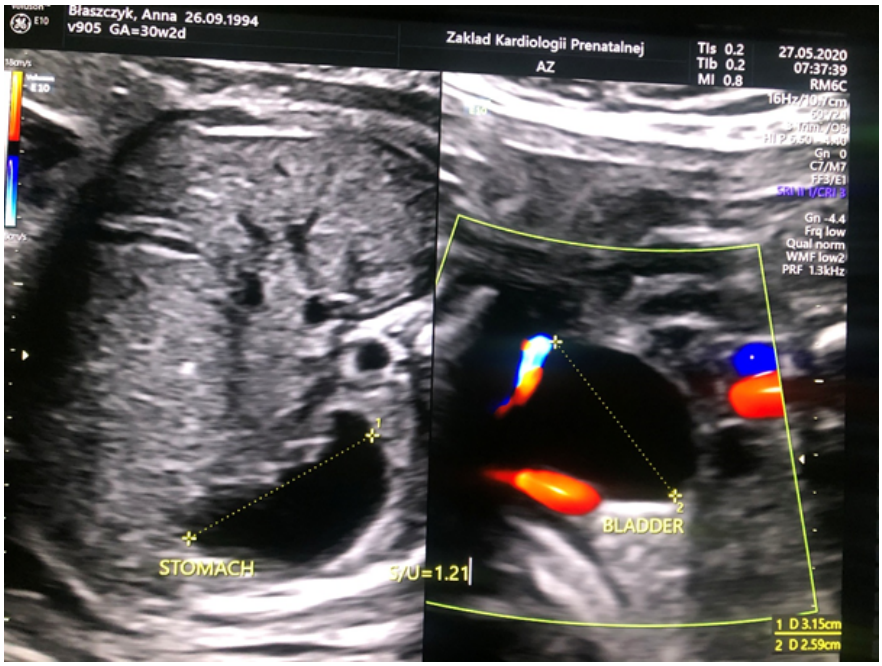

Figure 7: This is a caption

Figure 7: Ultrasound measurement of fetal stomach and bladder. Ultrasound image from of the Department of Prenatal Cardiology of the Polish Mother's Memorial Hospital in Lodz.

CONCLUSIONS:

The average size of the stomach in healthy fetuses between the 14 – 40 th week of gestation was 18 mm (8 – 40 mm) , the average urinary bladder measurement was 17 mm (15 mm – 42 mm) and the fetal stomach to urinary bladder index (S/UB index) was constant: 1.26 (0.09 – 3.93). These are simple measurements that be implemented in daily practice for fetal ultrasound assessment.

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