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

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Keywords
ureter; ultrasonography; urinary tract

Abstract

Aim: The aim of this study was to prepare normograms for the fetal stomach, urinary bladder, and stomach to urinary bladder index in healthy fetuses. **Material and methods:** The study was conducted based on the data extracted from the database of our tertiary center in the years 2016–2019. The study group, comprising 867 fetuses, demonstrated normal biometry and normal heart structure, normal heart function, no extracardiac malformations, and no extracardiac anomalies. 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. Linear regression analysis based on Microsoft Excel was used for statistical analysis. **Results:** The average size of the stomach in healthy fetuses between the 14–40th week of gestation was 18 mm (8–40 mm), the average urinary bladder measurement was 17 mm (15–42 mm), and the fetal stomach to urinary bladder index was constant: 1.26 (0.09–3.93). **Conclusions:** The normograms for the stomach, urinary bladder and the stomach to urinary bladder index prepared based on our study group can contribute to an improvement in the accuracy of examination and provide an unified organization of the description of fetuses. These normograms constitute an additional marker for the assessment of fetal condition. A clear disproportion in the size of the urinary bladder and stomach can be helpful in terms of paying more attention to fetuses with untypical features in screening centers.

Introduction

The development of pregnancy affects many organs, including fetal stomach and urinary bladder. Both structures can be easily measured in routine fetal screening. Ultrasound detection of macrosomia is still a challenge, and the commonly used markers often fail to contribute to an accurate assessment of fetal macrosoma. Therefore, a new ultrasound marker is needed to increase the chance of detection of fetal macrosomia prenatally. The normograms regarding the average size of the stomach and urinary bladder, and the stomach to urinary bladder index, which were prepared based on our study group, can contribute to an improvement of the accuracy of examination and provide a unified organization of the description of fetuses.

Aim

The aims of this study were 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). Normograms for fetal stomach and urinary bladder as well as S/UB index were prepared to provide reference tables for everyday screening in order to present a unified medical report of fetuses in reference centers for fetal assessment.

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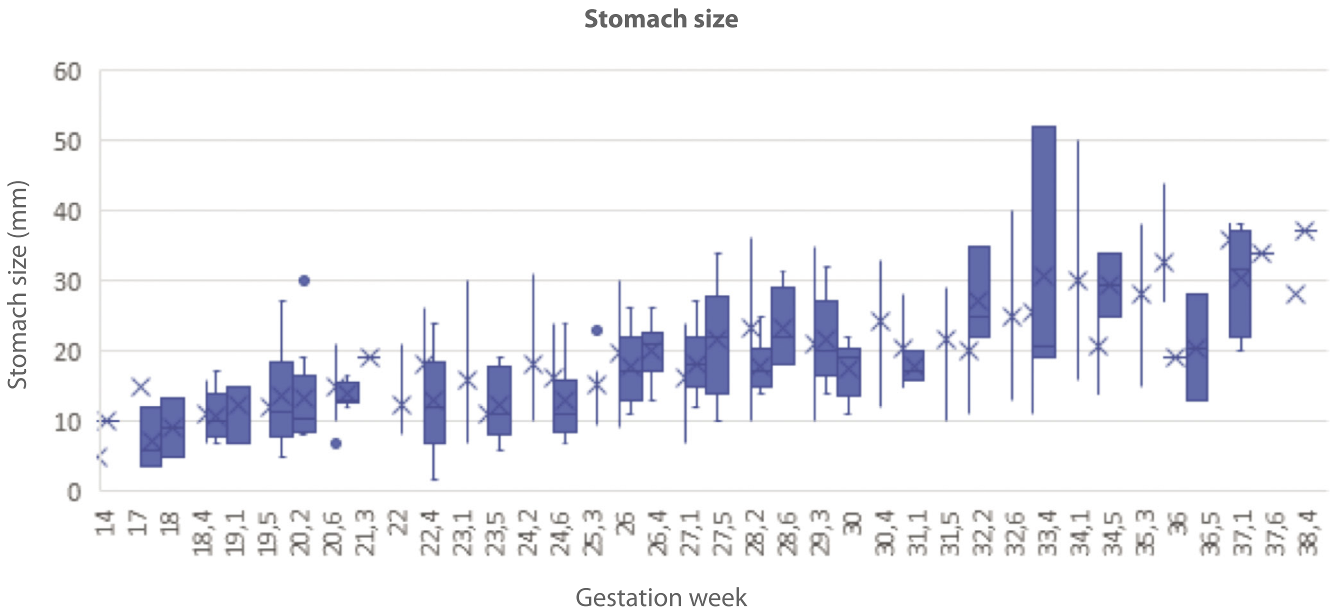

Fig. 1. *Measurement of fetal stomach length in relation to gestational age in a group of 867 healthy fetuses (normal heart anatomy, no extracardiac malformations, no extracardiac anomalies). Data obtained from the Department of Prenatal Cardiology of the Polish Mother's Memorial Hospital in Lodz, 2016–2019*

Materials and methods

The study was conducted based on the data extracted from the database of our tertiary center, which included fetal ultrasound exams performed in the years 2016–2019. The study group, comprising 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). The 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 longitudinal plane, with its longest diameter measured. The same section was applied in the measurement of fetal abdominal circumference (AC) for the purposes of biometry calculation (Fig. 1).

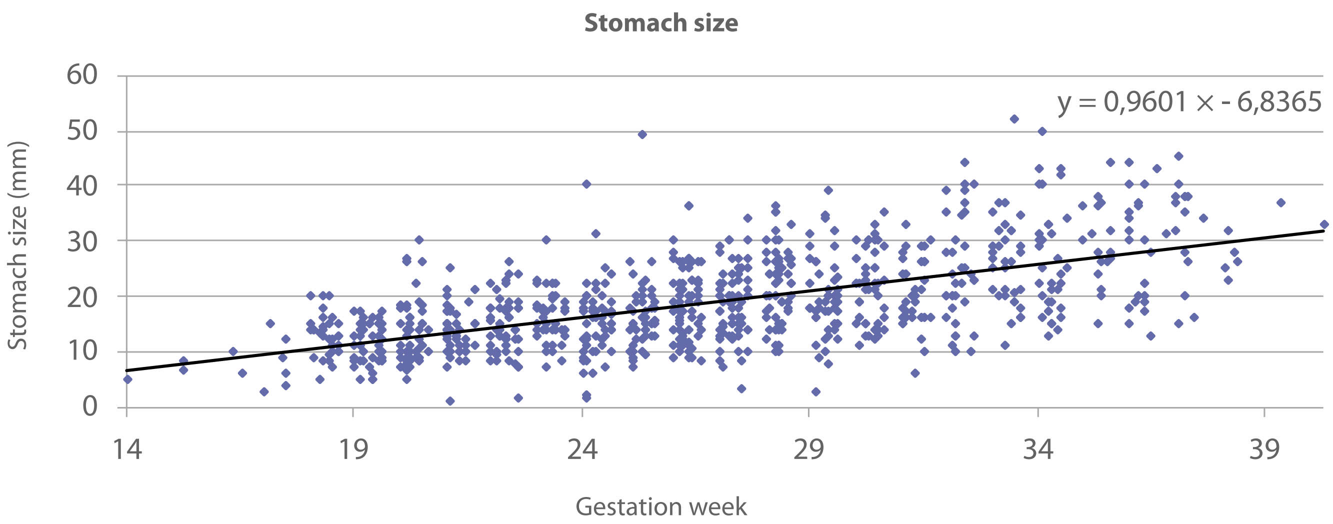

Fig. 2. *Measurement of fetal stomach length in relation to gestational age in a group of 867 healthy fetuses with a trend line. Figure according to the formula: y = 0.9601 × -6.8365. Data obtained from the Department of Prenatal Cardiology of the Polish Mother's Memorial Hospital in Lodz, 2016–2019*

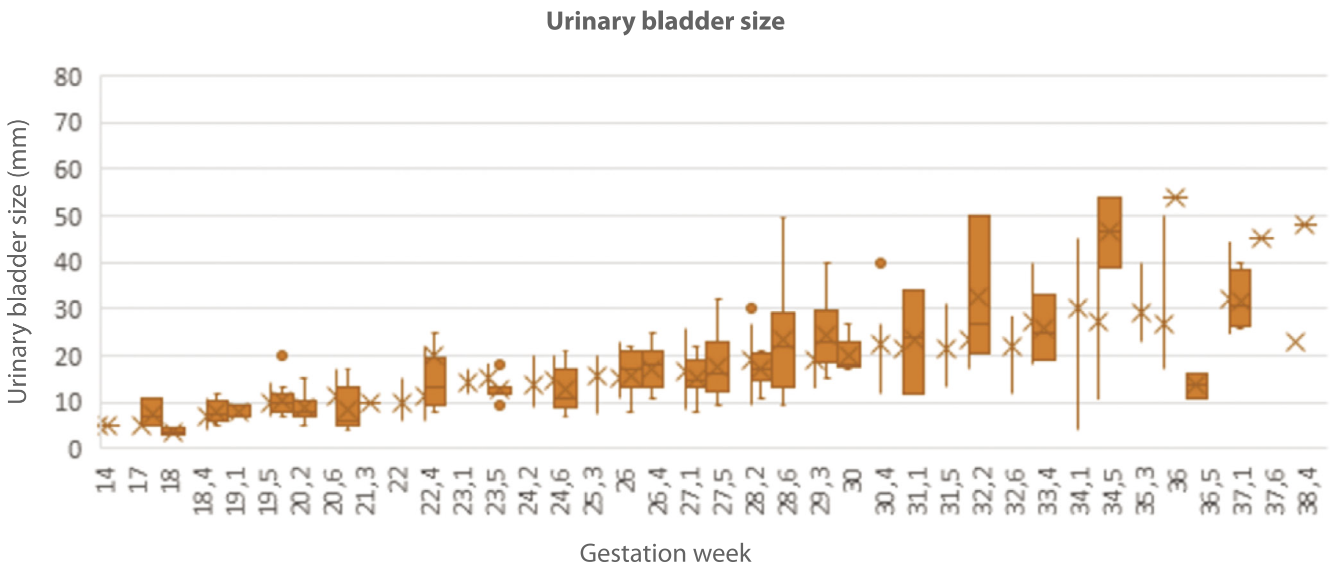

Fig. 3. *Measurement of fetal urinary bladder size in relation to gestational age in a group of 867 healthy fetuses. Data obtained from the Department of Prenatal Cardiology of the Polish Mother's Memorial Hospital in Lodz, 2016–2019*

The measurement of the size of the fetal urinary bladder was performed based on transverse abdominal scans, taking into account the maximum internal dimension length.

The observation of the fetal stomach and urinary bladder took place at the second and third trimesters, during routine ultrasound screening of fetuses. This is the period of pregnancy when both structures are clearly visible and well-developed and, as a result, can be evaluated quite easily.

Interobserver variability and intraobserver variability were analyzed off line on a group of 10 fetuses, yielding compliance at the level of 100%. Linear regression analysis based on Microsoft Excel was used for statistical analysis.

Results

Measurements of the fetal stomach in mm from 14 to 38.4 weeks into gestation in the study group are presented in Fig. 1 and Fig. 2.

The examination results presented in Fig. 1 and Fig. 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 any extracardiac malformation and extracardiac anomalies observed) during pregnancy from the 14th week of gestation to the 40th week of gestation was on average 18 mm, with the minimum value of 8 mm, maximum value of 40 mm, and median value of 17 mm.

The urinary bladder size measurements in the study group of fetuses without anomalies from 14 to 38.4 weeks into gestation are presented in Fig. 3 and Fig. 4. 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.

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

Correlation between the size of fetal stomach and urinary bladder

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

Fetal stomach to urinary bladder index

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 S/UB index in the study group of fetuses without anomalies in the second and third trimesters of pregnancy shows that the average value of the S/UB index is 1.26, with a minimum value of 0.09, maximum value of 3.93, and median value of 1.14.

All the values presented should be clinically referred to the average values due to the fact that they have the best predictive power for a general assessment of the population of fetuses.

Discussion

In this study, the selection of subjects (fetuses) included mainly fetuses with a gestational age exceeding 18 weeks due to the fact that this is a time when it is easy to visualize

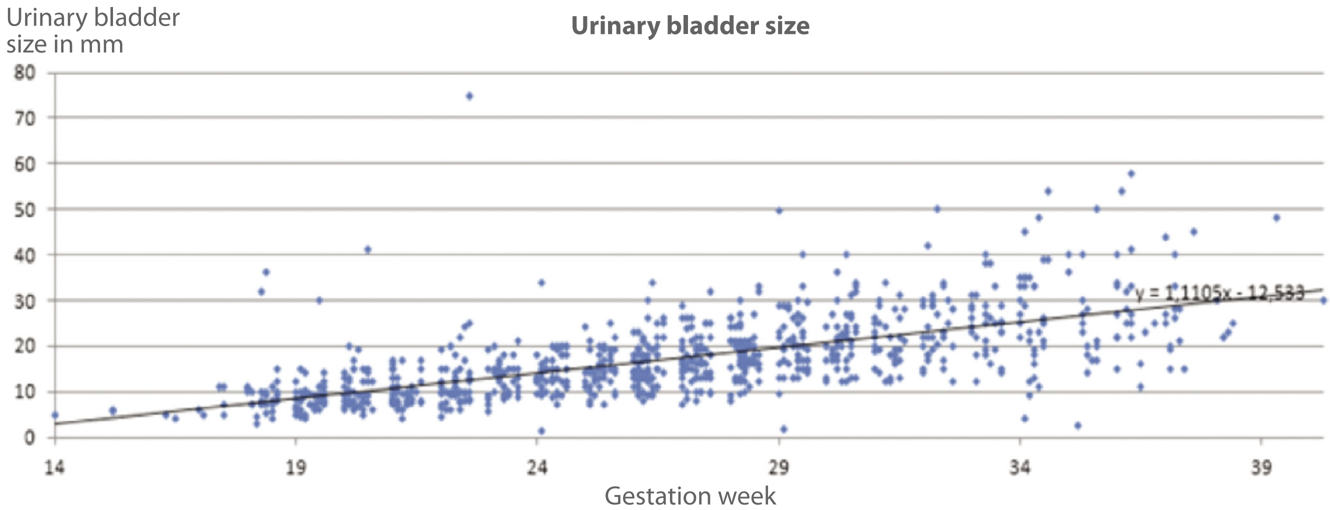

Fig. 4. *Measurement of fetal urinary bladder size in relation to gestational age in a group of 867 healthy fetuses with a trend line. Figure according to the formula: y = 1.1105 × -12.533. Data obtained from the Department of Prenatal Cardiology of the Polish Mother's Memorial Hospital in Lodz, 2016–2019*

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 typically located on the left, that is on the same side as the stomach[1,2]. The stomach is observed in the ultrasound image as a hypoechogenic structure and may be seen from the 9th week of gestation[3]. The lack of stomach or undersized stomach may be a result of esophageal atresia or esophageal atresia with an esophageal-tracheal fistula[4]. Oversized stomach can be caused by duodenal atresia or small intestinal atresia. Fetal stomach size can also be affected by gestational diabetes[5]. Abnormally 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[8–10].

Digestive system defects usually occur in combination with polyhydramnios, which is usually observed at 28 weeks of pregnancy or later, and then an enlarged or abnormally 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 by 3D

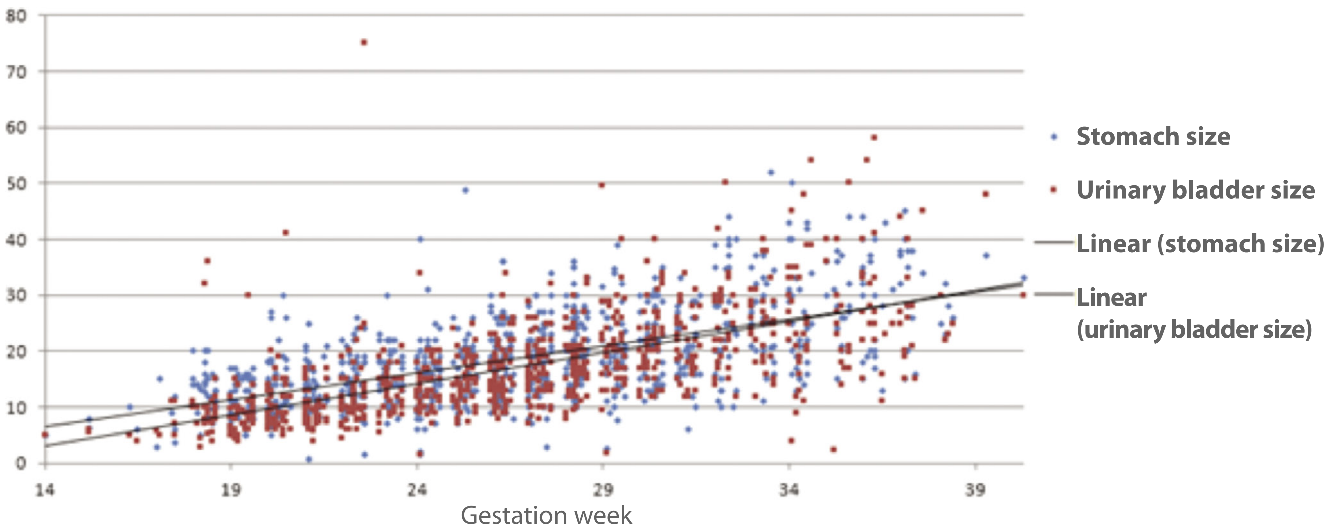

Fig. 5. *Comparison of the size of the fetal stomach and urinary bladder in fetuses without anomalies in relation to gestational age in a group of 867 healthy fetuses with trend lines. Data obtained from the Department of Prenatal Cardiology of the Polish Mother's Memorial Hospital in Lodz, 2016–2019*

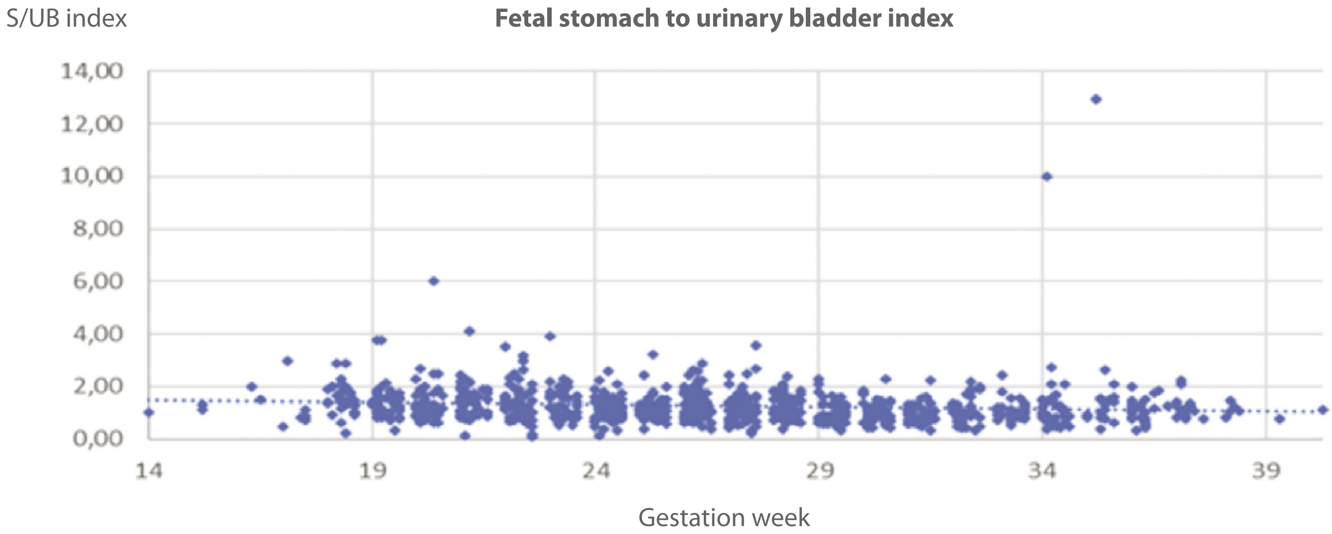

Fig. 6. *Ratio of the size of the fetal stomach and urinary bladder in relation to gestational age in a group of 867 healthy fetuses with a trend line. Data obtained from the Department of Prenatal Cardiology of the Polish Mother's Memorial Hospital in Lodz, 2016–2019*

ultrasound imaging may be helpful here[11]. Nevertheless, ultrasound alone does not give a precise answer on the level of obstruction. That is why other examination methods are increasingly used, such as magnetic resonance imaging and amniotic fluid flow analysis, which may be helpful in resolving diagnostic problems[12].

It is worth quoting one of the studies by Millener *et al.* [13], which included a study group of 7,200 fetuses. In the study group, there were 31 fetuses with an absent stomach during ultrasound examination after 14 weeks of gestation. This means that sometimes fetal stomach may not be seen on 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 Goldstein's normogram[5], which shows measurements of the stomach in 152 fetuses from the 9th week of gestation to the 40th week of gestation. Measurements were performed 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 presented by Goldstein *et al*.[5], one sees that in normal pregnancies from the 13th week of pregnancy to the 39th 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 the 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 Goldstein's data, but for the purpose of simplification and streamlining of the examination protocol and, above all, with a view to highlighting 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 the 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 cases and in the median sagittal plane in every case. It was determined that the angle of the bladder did not change, and the mean value of the angle was 151 degrees during the fetal period[15]. The urinary bladder was categorized into four different shapes, and the most common shape found during the fetal period was cuboid[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 trimesters. Based on our data, the average urinary bladder size in the second and third trimesters of pregnancy is between the minimum value of 15 mm and the average value of about 50 mm, and should not exceed 3–4 cm in the third trimester of pregnancy[7]. When comparing the data on the stomach and urinary bladder, it can be concluded 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 diagnostic work-up. Ultrasound assessment of the urinary bladder allows the diagnosis of bladder anomalies including bladder agenesis, bladder exstrophy, 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 point towards a diagnosis of the so-called enlarged bladder, otherwise known as 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% of cases, and include trisomy 18, trisomy 13, and trisomy 21[9,18,19].

Another important aspect is the assessment of urinary bladder volume. In a study conducted by Fontanella *et al*. [14], urinary bladder volume was assessed in the second and third trimesters of pregnancy. The study showed the volume of the urinary bladder in healthy fetuses to increase slightly in the second trimester in parallel with gestational age, and more intensively from 25 weeks 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 including the ureters, kidneys and genitals must be carefully examined. The fetus must then be assessed more frequently and evaluated for AFI, as changes in the amount of amniotic fluid in fetuses with abnormally 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 S/UB index in fetuses in the second and third trimesters of pregnancy showed the averaged value 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. Atypically low or 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 the fetal stomach and fetal heart. Fetal stomach and fetal heart are normally located on the left side, thus providing *situs solitus*. In some cases, though, situs inversus can be observed. Therefore, the position of the fetal spine must be correctly assessed to provide proper interpretation of the position of the fetal heart and stomach[24]. A deviation from the above normal situation can be dextrocardia, which has a varying incidence in fetuses. A study by Lidia Mikołajczyk, *et al*. shows that situs inversus can be a common type of abnormality[25].

This paper, including 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 improving the accuracy of examination and thus enhancing the detection of anomalies. Due to the fact that fetal structures are among 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.

Conclusions

The development of pregnancy affects the size of many organs, including fetal stomach and urinary bladder. Both structures can be easily measured in everyday fetal screening. The normograms for the average size of the stomach and urinary bladder, as well as the stomach to urinary bladder index, prepared based on our study group can contribute to an improvement in the accuracy of examination and provide an unified organization of the description of fetuses. These normograms can be applied in daily practice as an additional marker for the assessment of fetal condition and identification of fetuses whose urinary bladder and/or stomach can or cannot be observed in ultrasound examination. A clear disproportion in the size of the urinary bladder and stomach can be helpful in paying more attention to fetuses exhibiting atypical features in screening centers.

Conflict of interest

The authors do not report any financial or personal connections with other persons or organizations which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

Author contributions

Original concept of study: SW. Writing of manuscript: SW. Analysis and interpretation of data: SW. Final acceptation of manuscript: MR-L. Collection, recording and/or compilation of data: SW. Critical review of manuscript: MS, MR-L, AŻ.

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