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Place of first trimester ultrasound at the university teaching hospital of Bogodogo (UTH-B) in Burkina Faso

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Abstract
Objective: To describe the experience of the UTH-Bogodogo obstetrics and gynecology department in ultrasound determination of fetal sex in the first trimester of pregnancy.
Patients and Methods: This was a prospective descriptive study conducted over a 30-month period from February 1, 2021 to June 30, 2022 in the gynecological and obstetric ultrasound unit of the UTH-Bogodogo in Ouagadougou. The study sample consisted of 311 fetuses. The sample included all pregnant women who came for an obstetrical ultrasound scan in a non-emergency situation, whose gestational age was between the 11^{th} and 14^{th} week of amenorrhea, and who expressed a wish to know the fetal sex. The methods described by Mazza and Efrat were used to determine fetal sex. Patients were followed until delivery, after clinical verification of the sex of their newborns. Data were collected using an individual data collection form. Participation in the study was conditional on patients signing an informed consent form.
Results: Fetal sex determination was possible in 280 of 311 fetuses, for a feasibility rate of 89.7%. In the remaining 31 cases, it was not possible to determine the fetal sex, as the position of the fetus did not allow a clear view of the genital bud. In terms of reliability, of the 238 fetuses monitored, fetal sex determination was correct in 204 fetuses, for a success rate of 85.7%. Accuracy was better when sex determination was performed after 12 weeks of amenorrhea. There was no significant difference in measurements between single and multiple fetuses.
Conclusion: Ultrasound determination of fetal sex at first birth could be an effective, simple, available and inexpensive option in developing countries.

Keywords: Ouagadougou, fetal sex, first-trimester ultrasound, ultrasound scanning

1. Introduction

Ultrasound scanning of the first trimester of pregnancy has evolved considerably since the 1980s. The last 10 years have seen an increase in the quality of screening due to the widespread use of high frequencies, improved probes and a wide range of signal processing software. Analysis is more accurate and structures that were previously difficult to access are now routinely explored. This is the case for the early determination of fetal sex in the first trimester of pregnancy during first trimester ultrasound (T1) [9].

Stocker and Evens in 1977 [26] were the first authors to determine fetal sex on ultrasound. They showed that at 30 weeks' amenorrhea (WA), determination of fetal sex was possible in 124 patients out of 229 with a single fetal pregnancy, i.e. a feasibility rate of 54%. Fetal sex was determined on ultrasound by visualizing the external genitalia of male fetuses, and when these could not be visualized, the fetuses were female.

The development of ultrasound and the increased skills of operators now allow early and reliable determination of fetal sex during T1 ultrasound. This means that unnecessary invasive procedures such as chorionic villus sampling can be avoided, especially in patients at high risk of X-linked diseases such as haemophilia or Duchenne muscular dystrophy. In most of these cases, female fetuses are healthy, whereas male fetuses have a 50% risk of inheriting the anomaly. In 2006, Effrat *et al*. [9] found a 93% feasibility rate for determining fetal sex on T1 ultrasound. In Burkina Faso, many couples express their desire to know the sex of their future baby at the first obstetric ultrasound scan. At the obstetrics and gynecology department of University teaching hospital of Bogodogo in Ouagadougou (UTH-Bogodogo), such requests are admissible during the first-trimester ultrasound by those in charge of the obstetrics and gynecology ultrasound unit.

The aim of this study is to analyze the feasibility and reliability of determining fetal sex during first-trimester ultrasound in an African context. The aim is to report the results of Burkina Faso's first experience of ultrasound determination of fetal sex in the first trimester of pregnancy.

2. Methodology

2.1 Type of study, sample and study materials

This was a prospective descriptive study based on an exhaustive sample over a period of 30 months, from 1 February 2021 to 30 June 2022. The study was conducted in the gynecological and obstetric ultrasound unit of the Bogodogo University Hospital (UTH-B) in Burkina Faso, West Africa. This unit is the largest national reference structure for gynecology and obstetrics. The department is divided into several units: Inpatient unit, delivery room unit, outpatient unit, family planning unit, gynecological and obstetric ultrasound unit, operating theatre unit and an administrative secretariat.

Our study sample consisted of 299 patients who came for a first-trimester ultrasound scan. These included 287 patients with singleton pregnancies and 12 patients with twin pregnancies. A total of 311 fetuses underwent first-trimester ultrasound. Our sample included all pregnant women who came to the department for an obstetric ultrasound scan in a non-emergency situation, whose gestational age was between the 11th and 14th week of amenorrhea and who had expressed a wish to know the fetal sex. Patients who expressed no wish to know the fetal sex, those whose gestational age was less than 11 WA or more than 14 WA, those with arrested pregnancies, those with molar pregnancies, those with extra uterine pregnancies, those who came for an emergency ultrasound scan, those with an ultrasound scan not performed in our ultrasound department and those who had not signed an informed consent were excluded from our sample.

Determination of fetal sex was carried out by the same operators: A doctor with a diploma in obstetric ultrasound assisted by an intern from the department and ourselves as a trainee with a diploma in ultrasound. The images were then used to determine the fetal sex. We also followed the women to carry out a second ultrasound (T2 ultrasound), and then checked the sex at birth to confirm or invalidate the fetal sex determined in the first and second trimesters.

- Patients not seen at delivery were considered lost to follow-up.
- We used a SIEMENS ultrasound machine that had been in use since 2010. Ultrasound was performed transabdominally and, if necessary, endovaginally.
- We used two methods to measure fetal sex, which have been reported during the first trimester of pregnancy.
- The first method takes into account the ultrasound criteria used to determine fetal sex. These are those reported by Emerson *et al.* [2] in Israel or Mazza *et al.* [10] in Italy as described in figure 1 and image 1 below. The sagittal sign is obtained by scanning the fetus in the medio-sagittal plane. Following the circumference of the slice in this plane, from dorsal to ventral, a focal bulge reflecting the penis or clitoris is obtained in the ventral plane. A caudal acute angle or caudal << notch >> between the axis of the fetal ventral surface and the long axis of the bulge (clitoris) indicates the female genitalia, while a cranial acute angle or cranial << notch >> between the axis of the fetal ventral surface and the long axis of the bulge (penis) indicates the male genitalia.

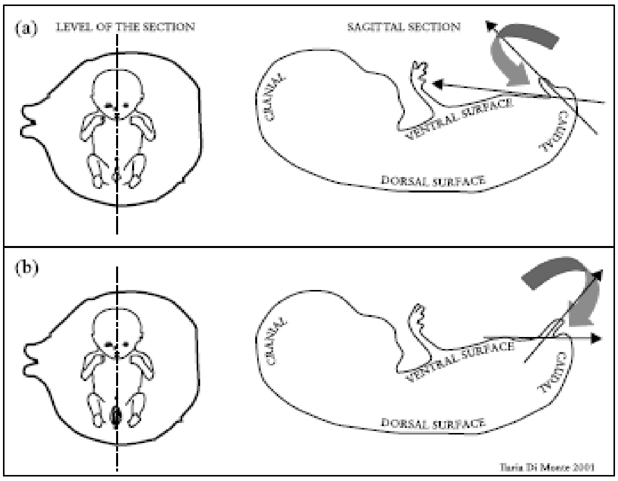

Diagram 1: Technique for measuring fetal sex in the 1st trimester using the method of Emerson *et al.* or Mazza *et al.*

a) Male fetus: Note the acute cranial angle or cranial notch (curved arrow) between the ventral surface of the fetus and the long axis of the bulge (penis) (straight arrows).
b) Female fetus: The acute caudal angle or caudal notch (curved arrow) between the ventral surface of the fetus and the long axis of the bulge (clitoris) (right arrows) indicates a female fetus.
Ultrasound images showing the Emerson *et al.* or Mazza *et al.* measurement technique.

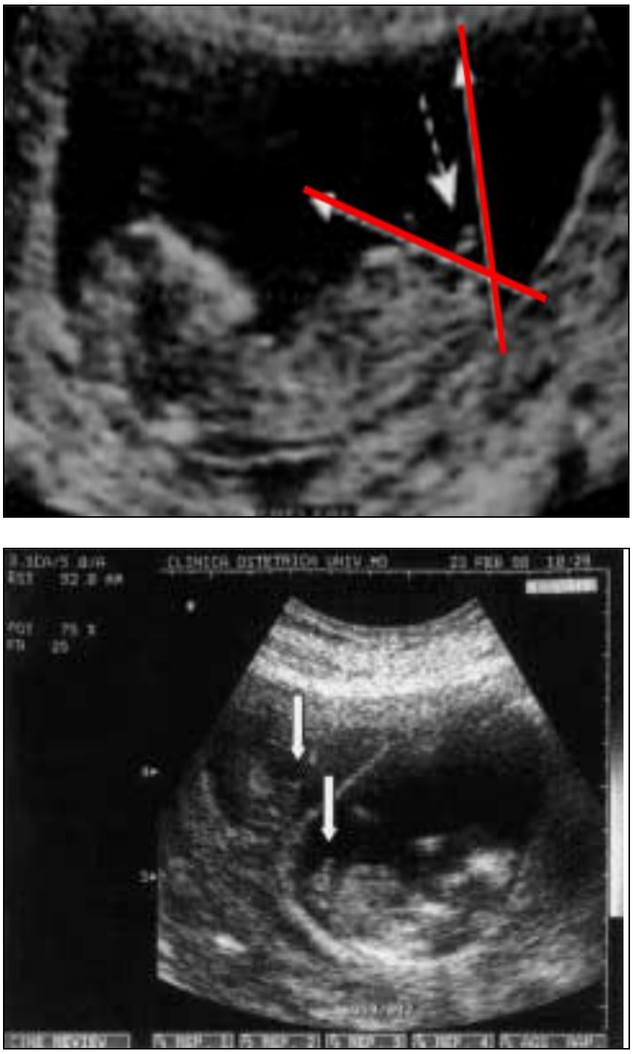

Image No 1 and 2: Male fetus

Acute cranial angle or cranial "notch" between the axis of the ventral surface of the fetus and the long axis of the bulge (penis) in a twin pregnancy at 74 days from fertilization and 70 days from embryo transfer.

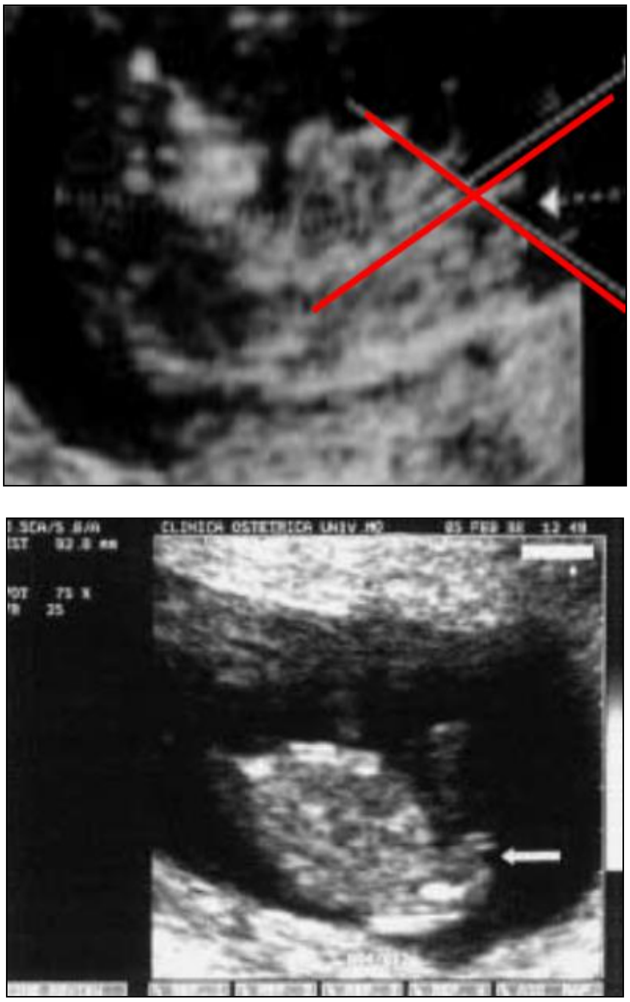

Image No 3 and 4: Female fetus

Acute caudal angle or caudal "Notch" between the axis of the ventral surface of the fetus and the long axis of the bulge (clitoris).

The second method takes into account the ultrasound criteria used to determine fetal sex, recently reported by Efrat *et al*. in 2006 [1]. The genital region was examined in a sagittal median plane with the fetus in the normal position, i.e. neither in hyperflexion nor in hyperextension. This involved measuring the angle of the genital tubercle formed with a horizontal line passing through the lumbosacral surface of the fetal skin (Image N°1). The fetus was male if the angle was greater than 30° and female if the genital tubercle was parallel or convergent (i.e. an angle of less than 10°) to the horizontal line. Cases where the angle was intermediate (10°-30°) were considered indeterminate. Method of Efrat Z. Strict sagittal section 12-14 WA.

Fetus horizontal on the screen
Angle axis tubercle + cutaneous-lumbosacral plane

In our study, we adopted the method of Efrat [1] based on the measurement of the angle formed by the genital tubercle and a horizontal line passing through the lumbosacral surface of the skin. The two different methods seem to lead to the same conclusions [14]. We adopted the second method in almost all cases because of its greater objectivity (angle measurement), making it an easily reproducible procedure.

Image No 5: Male fetus, Angle greater than 30°

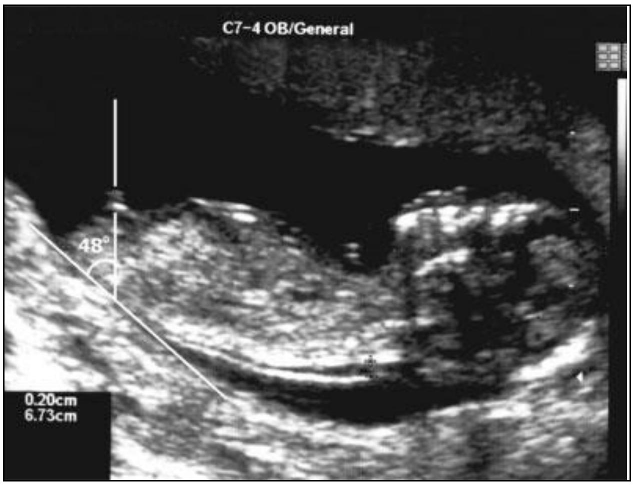

Image No 6: Male fetus, Angle greater than 30°

Image No 7: Female fetus, Angle less than 30°

Image No 8: Female foetus

Image No 9: Male fetus, Angle greater than 30°

Image No 10: Male fetus. Angle > 30°

2.2 Data collection instruments and data collection
Data was collected using an individual data collection form. Data were collected on the basis of well-defined variables contained in the data collection form.
The data collected concerned the identity of the patients, their socio-demographic characteristics, nuchal translucency, craniocaudal length (CCL), the sex of the fetus, and the particularities presented by certain patients such as twinhood or fetal malformation**.**

2.3 Ethical considerations
Authorisation to conduct the study was obtained from the head of the pole. Participation in the study was conditional on patients signing an informed consent form, which clearly indicated that the request had come from the couple. All patients consulting during the study period had an outpatient interview early in the first trimester to explain the principles of fetal sex determination and their follow-up and the risks of error attributable to the method.

2.4 Data processing
The data were analysed using SPSS version 16.0. Calculations were made using the chi-square test or the Fisher test at the 0.05 significance level. A p value <0.05 was considered significant. Word processing was carried out using Microsoft Office 2007.

3. Results
3.1 Feasibility
The mean gestational age at the time of ultrasound was 13 weeks' amenorrhea. The mean craniocaudal length was 68.28 mm, with extremes of 45.8 and 91 mm. It was possible to determine fetal sex in 280 of the 311 fetuses, giving a feasibility rate of 89.7%.
In the remaining 31 cases, it was not possible to determine the fetal sex, as the position of the fetus did not allow the genital bud to be clearly seen. In these cases, the angle was intermediate (10°-30°) and they were considered indeterminate.
In addition, 42 of the 280 patients (15%) were lost to follow-up and confirmation with phenotypic sex at birth was therefore impossible.

3.2 Reliability
In terms of reliability, of the 238 fetuses monitored, fetal sex determination was correct in 204 foetuses, giving a success rate of 85.7%. The reliability and feasibility of the determination are presented in Table I.

Table 1: Comparative feasibility and reliability of fetal sex determination

	Female	Male	Both Genders	P
Feasibility	91.93%	89.20%	89.7%	0.47
Reliability	83.3%	87.9%	85.7%	0.36

Accuracy or reliability was slightly better in male fetuses than in female fetuses (87.9% versus 83.3% with a statistically non-significant difference p = 0.36).

3.3 Reliability according to gestational age
Reliability according to gestational age is presented in Table II.

Table 2: Reliability of fetal sex determination according to gestational age

Gestational age	Female gender	Male Gender	Both Gender	P
11WA-11WA+6d	75%	68.4%	63.6%	0.0036
12WA-12WA+6d	89.5%	90.8%	91.7%	0.056
13WA-14WA	80.6%	83.9%	88.2%	0.049

Accuracy was better when sex was determined after 12 weeks of amenorrhea.

3.4 Reliability according to type of pregnancy
Twelve (12) cases of twin pregnancies were included in the study. Out of 24 fetuses examined between 11 WA-14 WA, the determination of the fetal sex was indeterminate in only one fetus, with a feasibility rate of 96%. One patient was lost to follow-up and confirmation of phenotypic sex at birth was possible in 23 fetuses giving an accuracy rate of 86.4% (92.3% in male fetuses compared with 77.8% in female fetuses with a statistically non-significant difference).
The comparative study of sex determination according to the type of pregnancy is presented in Tables III and IV.

Table 3: Comparative table of the reliability of determining the fetal sex of multiple pregnancies and single fetal pregnancies

	Multiple pregnancies			Singletons
	Male	Female	Bouth	
Reliability	92.3%	77.8%	86.4%	85.6%

P-Value=0.085

As shown in Table III, we compared the feasibility and reliability of determining fetal sex. Between the gemellar pregnancy (GP) and the single fetal pregnancies (SFP)

Table 4: Reliability of twin pregnancies compared with single fetal pregnancies

	Correctly determined by 1st trimester ultrasound (%)									Not determined (%)		
	Male &Female			Female foetus			Male foetus					
	GP vs SFP		P	GP vs SFP		P	GP vs SFP		P	GP vs SFP		P
11-14WA+3D	86.4%	85.6%	NS	77.8%	83.8%	NS	92.3%	87.4%	NS	4%	10.8%	NS
11-11WA+6D	66.7%	70.6%	NS	0%	77.8%	NS	66.7%	62.5%	NS	0%	13.6%	NS
12-12WA+6D	92.3%	89.6%	NS	83.3%	89.7%	NS	100%	89.5%	NS	0%	8.8%	NS
13-14WA+3D	83.3%	84.8%	NS	66.7%	81.8%	NS	100%	88.6%	NS	11.1%	11.9%	NS

WA: Weeks of Amenorhea, D: Days

4. Discussion

There are numerous publications on the determination of fetal sex during first trimester ultrasound [1-14, 17-24]. Unfortunately, most studies have been conducted on very small samples. The aim of this paper is to report the results of the first experiment in Burkina Faso on ultrasound determination of fetal sex in the first trimester of pregnancy. We found that the accuracy of fetal sex determination between 11-14 weeks of amenorrhea was 85.7%. Our rate is slightly lower than those recently reported by Hsiao [23] and Efrat [1]. These results show the variability in the accuracy of fetal sex determination at first trimester ultrasound. The better accuracy obtained by Efrat could be explained by his long experience as a sonographer and the quality of the ultrasound machine used [1, 9]. In our series, determination of fetal sex was possible in the majority of cases (89.7%). Similarly, Hsiao [23] reported a feasibility rate of 88.91% and Efrat [1] a rate of 93%.

Table 5: Compares our results with those of these two previous authors

Authors	Year	Sample	WA	Feasibility	Reliability		
					Both Gender	Male Gender	Female Gender
Efrat [1]	2006	656	12-14	93%	97.2%	99.6%	97.4%
Hsiao [23]	2008	496	11-14	88.91%	91.8%	92.5%	91.2%
Our range	2013	311	11-14	89.7%	85.7%	87.9%	83.3%

The value of three-dimensional (3D) ultrasound in determining fetal sex has also been discussed [7, 11, 17]. Michailidis [17] reported on 200 3D ultrasounds performed and showed a feasibility rate of 81.5% and an accuracy rate of 85.3% for determining fetal sex, which is comparable to those obtained with two-dimensional (2D) ultrasound. The main value of 3D ultrasound is that it is easier to identify the mid-sagittal plane by using multiple multi-sector slices [7, 11]. Moreover, when congenital malformations of the external genitalia are suspected, 3D ultrasound can help to better determine congenital malformations of the external genitalia [24].

What is interesting is that measuring multiple pregnancies did not significantly increase the difficulty of determining fetal sex on first-trimester ultrasound compared with singleton pregnancies.

Over and above parental satisfaction, early detection of fetal sex on first-trimester ultrasound has significant clinical value for fetuses at high risk of X-linked genetic diseases such as haemophilia or Duchenne muscular dystrophy. In most of these cases, female fetuses are healthy, while male fetuses have a 50% risk of inheriting the anomaly. Thanks to its high accuracy rate (85.7%), early detection of fetal sex by ultrasound can help avoid unnecessary invasive procedures such as chorionic villus sampling and their relative complications in ultrasound determination of fetal sex.

Several publications [8, 9, 23] have focused on determining the optimal gestational age at which it would be reasonably safe to make the decision regarding the need for invasive testing procedures on the basis of fetal sex gender determined on ultrasound. Our results show that there is a significant increase in accuracy for male fetuses examined between 12WA-12WA + 6days. However, no significant difference was found for female fetuses. Determining the male sex therefore seems more difficult than determining the female sex during the period between 11WA-11 WA + 6days.

Efrat [9] reports that he was unable to correctly determine the fetal sex in 56% of male fetuses at 11 WA, whereas at 12 WA only 3% could not be correctly determined. However, by 13 weeks' gestation, all male fetuses were correctly identified on ultrasound. This reinforces the fact that a final decision on invasive testing for sex-linked cases should only be made after 12 WA [9].

In our study, we observed that the angle of the genital tubercle increased significantly with increasing craniocaudal length and in female fetuses the angle did not change significantly with increasing gestational age.

These results are well explained by the embryological development of the external genitalia [15]. The structural precursors of the external genitalia are present but are not sufficiently differentiated to make a clear distinction on examination of the genitalia up to about 10 weeks' gestation. However, from 12 weeks of amenorrhoea, there are distinct changes in the structure of the urogenital sinus. A process of sex-specific changes takes place. In male fetuses, the urogenital sinus is replaced by the scrotum and the urethral raphe. The closure of the urogenital sinus takes place in the manner of a fashionable zip from the caudal end of the embryo. This process, combined with the elongation of the genital tubercle, gradually moves the phallus in a rostral direction.

In female fetuses, the urogenital sinus remains open and eventually becomes the vestibule of the vagina [15]. The difference in growth rate between the penis and the clitoris becomes significantly evident in the second trimester of pregnancy. The majority of prenatal penile growth occurs after 14 weeks of amenorrhoea at an almost linear rate [16].

Despite its high accuracy, first-trimester ultrasound did not clearly identify the fetal sex in an average of 1 to 23% of cases according to our study. This rate varies with an average of 3 to

14% according to the authors. Therefore, parents wishing to know the sex of their fetus during the first trimester ultrasound should be aware of the failure and error rates. The possibility of sexual ambiguity, discovery of feminising testis and hypospadias should also always be kept in mind. Fortunately, in our study sample, we did not observe any cases of sex ambiguity.
In our experience, a second ultrasound was scheduled at 15-17 weeks' amenorrhoea for all female fetuses diagnosed at the first-trimester ultrasound and those of undetermined sex. For male fetuses who were misdiagnosed but had the lowest risk of sex-linked genetic disease, we proposed amniocentesis. This sequential strategy should make it possible to reduce unnecessary invasive sampling and its relative risks. It is also cost-effective, particularly in developing countries.
From 2D to 3D ultrasound, another non-invasive approach to determining fetal sex has now been proposed [14, 25]. It is based on the molecular analysis of free fetal DNA extracted from maternal plasma. According to a recent study [25], this procedure achieved a sensitivity of 99% and a specificity of 94% for determining fetal sex in the first trimester of pregnancy. Although this new technique seems to be a promising alternative, ultrasound remains the most accessible, simple, valid and economical method for determining the sex of fetuses at high risk of X-linked diseases, particularly in developing countries such as Tunisia.

5. Conclusion
Technological advances in ultrasound equipment have recently made it possible to determine fetal sex as early as the first trimester of pregnancy. This non-invasive approach to fetal sex determination has been shown to be quite feasible and accurate. These results suggest that in cases of high risk of sex-linked genetic disorders, early ultrasound determination of fetal sex may help prevent unnecessary invasive procedures in healthy female fetuses. The best ultrasound accuracy rates have been achieved at 12 weeks' amenorrhoea. Despite the promise of testing for free fetal DNA in maternal serum, ultrasound determination of fetal sex should be an effective, simple, available and inexpensive option in some countries, particularly in the developing world.

Conflict of Interest
Not available

Financial Support
Not available

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