

**ORIGINAL ARTICLE****ULTRASOUND ACCURACY IN DETERMINING FETAL SEX AND WEIGHT PERFORMED BY EXPERIENCED RADIOLOGISTS VERSUS RECENT MEDICAL GRADUATES**Tesfaye Kebebe, MD<sup>1</sup>, Fetiya oumer, MD<sup>2</sup>, Yasmin Hashim, MD<sup>3</sup>**ABSTRACT**

**Background:** *Ultrasound is one of the non-invasive methods for fetal sex determination which has made visualization of fetal genitalia possible. Although mainly fetal sex determination is done for parental curiosity it has also some clinical implications. Accurate prenatal estimated fetal weight in late pregnancy and labor is extremely useful in management of labor.*

**Objective:** *the purpose of the study was to compare the accuracy of ultrasound when performed by more experienced versus less experienced physicians in determining fetal sex during the second and third trimesters and fetal weight in pregnancies of 38 weeks or more.*

**Methods:** *Obstetric ultrasound of the perineal region of the fetus was carried out on 600 pregnant women to detect fetal sex from a gestational age of 16 weeks to term. Complete data and information was available in only 550 of the study participants. There were 20 twins in the study making the overall number of fetuses in the study 570. For the fetal weight accuracy study 235 mothers with gestational age of greater than 38 weeks were included. Ultrasound results were registered on prepared forms. The sex and weight was confirmed at time of delivery through phone calls and for some, by rechecking their medical cards.*

**Results:** *Out of 570 fetuses, the sex was determined by ultrasound for 527 (92.5%). Females and males were 287 and 240 respectively. The overall accuracy was 84.9%. Accuracy for females was 91.6% and for males it was 92.1%. The accuracy of ultrasound fetal weight estimation which was within 10% of actual birth weight for those with gestational age of 38 weeks or more, was 85.5%.*

**Conclusion:** *Ultrasound is an accurate method to determine the fetal sex and weight even when it is performed by medical professionals with less experience. The overestimation of low birth weight and underestimation of macrosomia found in ultrasound weight estimation should be given due attention.*

**Keywords:** *Ultrasound, fetal sex, estimated fetal weight, accuracy.*

**INTRODUCTION**

For centuries guessing the sex of the unborn child has been a popular activity amongst expectant parents and their families. With the introduction of ultrasound, visualization of the fetal genitalia has become possible (1).

Although determining the fetus gender using ultrasound is still mainly attempted for reasons of parental curiosity, it can sometimes form part of a protocol, as it can be clinically important. For example accurately assessing fetal sex assists in assigning zygosity in twin pregnancies. In women at risk of X-linked genetic diseases such as hemophilia, or of ambiguous development of external genitalia, early gender assignment may give parents the option to avoid invasive tests. (1)

Fetal sex can be determined by different means, invasive and non-invasive. Among the invasive methods, chorionic villous sampling (CVS) and amniocentesis are the common ones. These procedures are associated with a risk of miscarriage (2).

From the non-invasive methods, analysis of fetal DNA in maternal blood and colorimetric assay of pregnant women's urine as well as ultrasound are used for fetal sex determination.

First trimester sonographic prenatal sex determination can be done from 11 weeks of gestation onwards using the direction of genital tubercle and the 'sagittal sign'. Prenatal determination of fetal gender by ultrasound of the fetal perineum during second and third trimester of pregnancy is based on the demonstration of the penis and/or scrotum in males and labial folds or the three echogenic lines in females. Absence of a scrotum or penis was previously considered to be an indication of female gender (3) but more recent evidence suggests that their absence may not be construed as definitive proof of being female. Unfortunately ultrasound sex determination during the first trimester has a substantial probability of mistaking the sex of the fetus.

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The ability to assign fetal gender correctly increases with increasing gestational age (1). Correct visualization of fetal parts depends on many factors including fetal position, amount of amniotic fluid, maternal abdominal wall thickness and technical skill of the operator. (1)

Accurate prenatal estimation of fetal weight (EFW) in late pregnancy and labor is extremely useful in the management of labor and delivery, permitting obstetricians to make decisions about instrumental vaginal delivery, trial of labor after caesarean delivery and elective caesarean section for patients suspected of having a macrosomic fetus (4).

EFW can be done by mothers (if they are parous), by clinicians using Leopold's maneuvers or by ultrasound. In the 1970s the use of ultrasound to estimate fetal weight gained popularity because of the perceived ability to standardize and reproduce measurements (4).

The accuracy of ultrasound depends on the technician's skill, the position of the baby at the time of examination, the amount of fluid, and thickness of the maternal abdomen.

In the Ethiopian context, so far, a single study has been conducted on the role of ultrasound in determining fetal sex but to the authors' knowledge, no study was ever conducted in Ethiopia which evaluated the accuracy of ultrasound in estimating fetal weight.

The purpose of this study was to assess the accuracy of ultrasound in fetal sex and weight determination and also to identify factors that affect its ability to accurately determine fetal gender and weight when it was being performed by those experienced in radiology versus recent medical graduates who were comparatively less experienced in performing the technique.

## METHODS

A prospective cross-sectional hospital-based study was conducted from January 1, 2013 to June 30, 2015. The following hospitals in Addis Abeba were included in the sample as potential sources of information: Black Lion Hospital (BLH), Ethio-Tebib Mothers' and Children's Hospital (ETH) and Police Hospital (PH).

Study samples were assigned from those mothers visiting the above mentioned hospitals for routine obstetric ultrasound evaluation.

Obstetric ultrasound and ultrasound of the perineal area were done by Sonoscape and Samsung ultrasound machines transabdominally using a 3.5MHz curvilinear transducer on clients to assign the sex of the fetus with gestational age of 16weeks and above. Fetal biometry including biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC) and femur length (FL) were done to estimate the fetal weight in those with gestational age of 38 weeks and above which was calculated by the ultrasound machine using the Hadlock method.

A proportional sampling technique was used to estimate the sample size of clients to be enrolled. Sample size for fetal sex determination was calculated assuming an average accuracy of ultrasound of 93%, a desired precision of 4%, 95% confidence interval and 10% allowance for non-respondents. The minimum sample size required for the study was 172 pregnant women. For fetal weight determination assuming an ultrasound accuracy of 80%, a desired precision of 5% with a 95% confidence interval, the calculated sample size was 245. A self-prepared data collection sheet / questionnaire / was developed.

The data from Police and EthioTebib hospitals was collected by a radiologist working in the hospitals who had recently completed her residency program while the data from Black Lion hospital was collected by residents who worked in the hospital. Ethical clearance to conduct the research was obtained from the research and ethics committee of the Radiology department. Before starting data collection verbal consent was obtained from the participating clients. Phone calls were made to the mothers at the time of the expected date of delivery for those examined in Black Lion Hospital and hospital cards were reviewed for those mothers from Police Hospital and Ethio Tebib hospital, to confirm the actual gender and weight of the babies at delivery.

Diagnosis for sex determination was made based on the following criteria:

1. Visualization of three white lines or labia, fetus was classified as female (Figure 1A);
2. Visualization of scrotum and/or penis, fetus was classified as male (Figure 1B);
3. If perineum was tight (not well visualized), or the operator failed to visualize the genitalia, it was entered as "Not sure".

Evaluation of estimated fetal weight was carried out by using the different fetal biometrics and subsequently calculated using the Hadlock method.

The accuracy was determined as the proportion of estimates which were within 10% of actual birth weight (ABW).

Data was entered and cleaned using Excel and analyzed using statistics, graphics and data management software (STATA). Multivariate logistic regression model was employed to control for confounders.

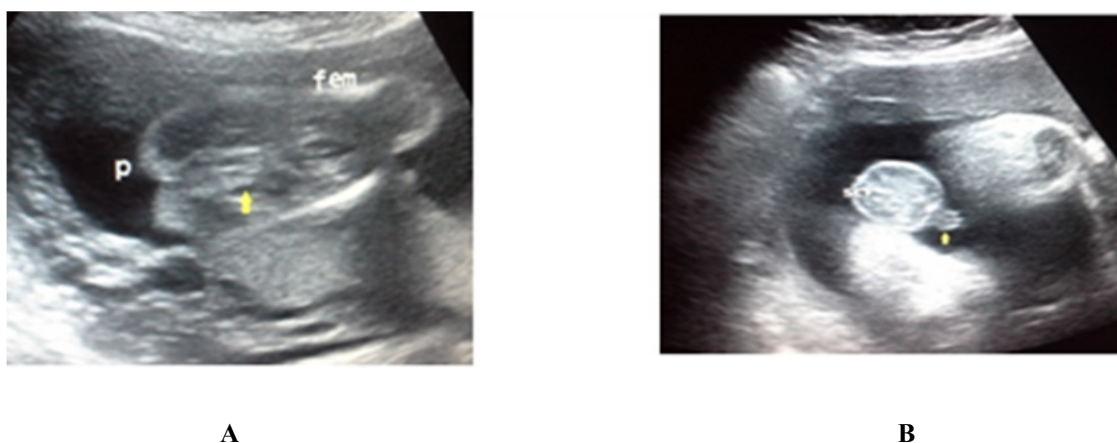
## RESULTS

### a) Fetal Sex Determination

The relevant ultrasound and other examinations were performed for a total of 600 mothers; however, 50 of them were excluded from the sample observation due to incomplete information. A total of 550 mothers with 570 fetuses (20 twins) were included in the analysis for ultrasound sex determination. Most of the samples (61.5%) were from public hospitals in Addis Abeba, namely Black Lion and Police Hospitals and the remaining 38.5% were from the privately owned hospital Ethio Tebib Hospital also in Addis Abeba. Moreover, all the sample observations were in the category of second and third trimesters, starting from 16 weeks up to 41 weeks of gestation and among these more than two-thirds of the observations were in the third trimester.

The mean ( $\pm$ SD) age of the mothers was 27.08 ( $\pm$ 4.49) years with a range of 16 to 40 years. Mean gravidity was 1.95 with a range of 1-6. Mean gestational age was 35 weeks and 5 days with a range of 16 -41 weeks.

Fetal lie was evaluated for 549 fetuses; in 389 (70.9%) it was cephalic, in 15.3% it was breech while the remaining constituted 13.8%. Amniotic fluid was evaluated for 550 mothers; out of these 534 (97.1%) had adequate amniotic fluid volume, 8(1.5%) had polyhydramnios and a further 8(1.5%) had oligohydramnios. Placental position was also assessed. It was observed that anterior fundal and / or anterior was the most frequent observation, in 287(52.2%) of the cases and posterior and posterior fundal in 36% of the cases. Isolated fundal or a lateral position was observed in 5% and 7% of cases respectively. Accuracy of ultrasound for determination of fetal sex was carried out by comparing the sex determined by ultrasound with the sex of the baby after delivery. The results are presented in **Figure 1** and **Table 1**.



**Figure 1:** Ultrasound of the perineum (A) indicating female sex, showing three white lines and (B) indicating male sex, showing the scrotum and penis, P=Perineum; Fem=Femur; Arrow in A = 3 white lines; Arrow in B = Penis,

**Table 1:** Accuracy of fetal sex determination by ultrasound in Black Lion Hospital, Addis Abeba, Ethiopia, 2013-2015.

Status	Frequency	Percent (%)
Accurate	484	84.9
Not accurate	43	7.5
Not sure	43	7.5
Total	570	100

However, considering only the actual determined result (i.e. excluding all results designated as “not sure”), the accuracy rate was 91.8% which indicates a high level of accuracy of ultrasound in determining fetal sex.

It was also of interest to investigate whether the accuracy of ultrasound in determining fetal sex was dependent upon the gender of the fetus and number of weeks of gestation. The data obtained suggested that ultrasound accuracy in determining fetal sex was roughly the same for both genders. (**Table 2**)

**Table 2:** Accuracy of ultrasound for determination of fetal sex in male and female fetuses, Black Lion Hospital, Addis Abeba, Ethiopia, 2013-2015.

No. of observations	Sex			
	Female (287)		Male (240)	
Accurate	263	91.6%	221	92.1%
Not accurate	24	8.4%	19	7.9%

However, accuracy of ultrasound seems to have been influenced by the gestational age of the fetus. In the case of twins, for 29 out of the 35 cases (82.9%), it was possible to accurately determine fetal sex using ultrasound, a level of accuracy that was lower than when only one fetus was involved. This implies that determination of fetal sex by ultrasound is likely to be more challenging in those instances where more than one fetus is present (twins and more).

Accuracy of ultrasound sex determination in the second and third trimesters was 86.0% and 85.7% respectively, indicating that there was no significant difference between the two trimesters.

The presence of adequate amniotic fluid more likely aids in knowing the fetal sex accurately than in the presence of oligohydramnios. In other words having adequate amniotic fluid has a positive contribution for the accuracy of ultrasound in determination of fetal sex (coefficient of adequate amniotic fluid is positive, having p-value of 0.10). Regarding the fetal lie, the values are not significant enough to affect the sex determination outcomes.

Finally, placental locations of anterior and posterior positions were found to be among the significant variables to influence the accuracy of ultrasound fetal sex determination positively, at 1% level of significance. The result showed that both variables had positive coefficients with p-values of 0.004 and 0.002, respectively. Hence, it can be inferred that the fetal sex of the child could easily be identified using ultrasound if its placental location was either anterior or posterior.

#### *b) Fetal weight determination*

From the total sample size in the study herein described, 235 cases were eligible to be incorporated in the analysis to examine the accuracy of ultrasound in fetal weight determination after the relevant ultrasound assessment was done.

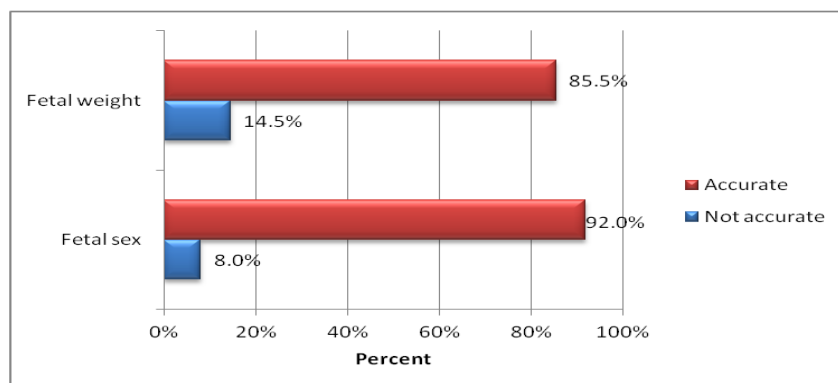
Accuracy of birth-weight was determined by calculating the ratio by percentage of ultrasound estimate within 10% of actual birth-weight. Out of a total sample of 235 pregnant women, fetal weight was able to be determined accurately in 85.5% of the cases. Those with inaccurate results comprised 14.5% of the total. (**Figure 2**)

Accuracy of fetal weight estimation by ultrasound was also evaluated across the different gestational ages. The accuracy of weight estimation using ultrasound at 38 weeks gestational age was 87.9% but declined significantly to just 50% at 41 weeks (**Table 3**).

From those evaluated at 38 weeks, 22 were inaccurate; ultrasound overestimated weight in 6 of them and underestimated weight in 16 cases. At 39 weeks, 8 were inaccurate, all of them having underestimated weight and at 40 weeks, 2 were inaccurate, both having underestimated weight.

Of the 235 mothers examined in determining the accuracy of ultrasound in estimation of fetal weight, the weight difference between expected fetal weight and weight at delivery was analyzed. The average difference between the expected and actual fetal weight was 226.7grams. The standard deviation was

**Figure 2:** Accuracy of ultrasound to determine fetal sex and weight at Black Lion Hospital, Addis Abeba, Ethiopia, 2013-2015.

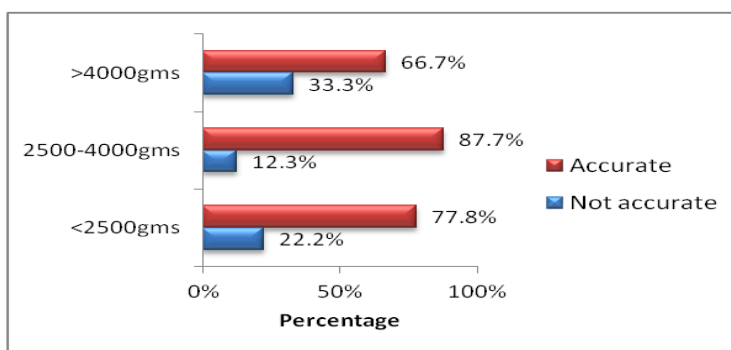


**Table 3:** Accuracy of ultrasound fetal weight estimation among the different gestational ages, at Black Lion Hospital, Addis Abebe Ethiopia, 2013-2015.

Accuracy status	Gestational age							
	38 weeks		39 weeks		40 weeks		41 weeks	
Number of observations	<b>181</b>		<b>46</b>		<b>6</b>		<b>2</b>	
No. Accurate	159	87.8%	38	82.6%	4	66.7%	1	50%
No. not accurate	22	12.2%	8	17.4%	2	33.3%	1	50%

This implies that on average 226.7 grams were either overestimated or underestimated using ultrasound examination. The most accurate estimation had a 0.02% variation and the worst estimation had a 45.7% variation from the actual weight.

The accuracy of ultrasound fetal weight estimation was highest (87.7%) when fetal weight was in the range of 2500- 4000grams and lowest when the fetal weight exceeded 4000 grams (66.7%). (**Figure 3**).



**Figure 3:** Accuracy of fetal weight determination by ultrasound at three different weight categories in Black Lion Hospital, Addis Abeba, Ethiopia, 2013-2015.

The variables considered in this regression analysis were found to have no significant association with the outcomes considered in the study (fetal sex and weight) ( $p=0.10$ ). This implies that the major determinant factors for accurately determining fetal sex and weight using ultrasound could be factors not considered in the present study.

Furthermore, the results showed that fetal lies (cephalic and transverse) affected the correct estimation of fetal weight negatively at 10% level of significance, with  $p$ -values of 0.09 and 0.10 respectively. Placental location, anterior fundal and posterior fundal, also influenced the probability of making an accurate determination negatively, having a negative coefficient at 10% level of significance ( $p$ -values of 0.08 and 0.03 respectively).

## DISCUSSION

From the 570 evaluated fetuses, ultrasound was able to correctly determine the fetal sex in 527 of the cases with an overall accuracy of 92%. This result is comparable with the studies done by Plattner *et al* which showed an accuracy of 93% (4). By contrast the result was lower than what was reported by other investigators (3,5). Possible reasons for the difference could have been the wide range in technical skill/ experience of the operators, which ranged from more experienced radiologists to less experienced junior resident doctors.

In this study gender of the fetus was not a significant factor in the accuracy of ultrasound to determine sex; accuracy was 91.6% for females and 92.1% for males, which is similar to the findings of a study by Stocker and Evens as well as Dunne and Cunat (2,14) but different from the findings reported in a study by Plattner *et al* (4) which showed a higher accuracy of ultrasound in determining sex for the male fetus. No significant difference was noted in the accuracy of ultrasound to determine fetal sex between the second and third trimesters. Accuracy was 86.0% and 85.7% for the second and third trimesters respectively. A similar result was observed in a study by Stocker and Evens (2). However the results differed from a study by Plattner *et al* (4). The results also differed from a study reported by Gelaw and Bisrat (5) which showed an increase in accuracy as the gestational age increased.

Ultrasound fetal sex determination was not possible in 43 (7.5%) of the cases. From those in whom ultrasound sex determination was not possible, after delivery it was possible to see that 17 and 19 were females and males respectively.

The majority of the women in whom ultrasound could not definitively determine sex, were examined in the third trimester. Possible reasons for failure of ultrasound to determine fetal sex could be the crowding of fetal parts and the decrease in the amount of amniotic fluid as the gestational age increased, making it difficult to visualize the perineal region clearly. The other possible reason could be the lack of experience of the operators resulting in a large number of cases in which sex of the fetus could not be determined.

The accuracy of fetal sex determination by ultrasound decreased to 82.9% when the pregnancy involved twins instead of a single fetus. Plausible reasons for this finding could be the crowding of fetal parts making visualization harder and also by mistaking the perineum of one fetus for the other due to limited experience.

The presence of adequate amniotic fluid was found to facilitate the accurate determination of fetal sex. While the result showed that the presence of oligohydramnios and polyhydramnios were not significant enough to affect fetal sex determination outcomes, the sample size was too small (8 cases from 550 in both cases) to reach a definitive conclusion. The results are also similar with the findings by Stocker and Evens, indicating that the presence of adequate amniotic fluid facilitates the correct fetal sex determination (2). For the placental position, anterior and posterior locations were found to have a significant relation with correct fetal sex determination with an accuracy of 84.7% and 87.9% respectively.

In the present study, fetal lie was not found to be significant in affecting the accuracy of ultrasound to determine fetal sex, similar to findings of Gelaw and Bisrat (5) but different from the findings of a study by Scholly *et al* where breech presentation was found to be a limiting factor in correct determination of fetal sex (3). However it would be difficult to conclusively assert that fetal lie has no significant effect on fetal sex determination since the number of breech and other presentations were too few in the present study.

Overall in this study ultrasound was found to have a sensitivity of 90.2% and a specificity of 93.2% with a positive predictive value of 92.1% in determining fetal sex in utero, which is a very good result, given the limited experience of some of the operators.

Fetal weight estimation by ultrasound using Hadlock's method in those with gestational age of 38 weeks and above was found to be accurate in this study. From a total of 235 mothers who were included in the analysis, fetal weight determination was found to be within 10% of the actual birth weight in 85.5% of the cases. The level of accuracy for fetal weight determination in this study was higher than what has been reported from other studies, 68% in a study by Shittu *et al* (10), 72% in a study by Njoku *et al* (12) and 75% in a study by Colman *et al*(13).

One of the main limitations of this study was that it included births that occurred over a wide range of days after the last ultrasound examination was performed. In cases where the fetal weight estimation was either greater or lower than 10% of the actual birth weight, ultrasound tended to underestimate the fetal weight, similar to findings of a study by Njoku *et al* (12) but different from findings reported in other studies (8,11) which showed overestimation. The reason for the weight underestimation in this study could partly be due to the fact that most of the weight estimations may have been done at an earlier stage of the pregnancy and not close to the time of delivery, giving ample time for the fetus to gain weight in the remaining period.

When comparing the estimated weight outcomes based on different gestational ages, the accuracy, defined to be within 10% of actual birth weight, dropped as gestational age increased (87.7% at 38 weeks, 82.2% at 39 weeks, 66.7% at 40 weeks and 50% at 41 weeks). One reason for the observed result could have been the relatively greater sample size in the category of 38 weeks. The sample size of those in the range of 39-41 weeks may have been too small, making it more difficult to find evidence of an effect. The other possible reason could be the engagement of the head as the gestational age increased, making the correct measurement of fetal biometry, especially the biparietal dimension and head circumference), more challenging.

The accuracy of ultrasound estimation of fetal weight obtained in this study was highest in the birth-weight range of 2500-4000 grams and lowest for the high birth-weight group (greater than 4000 grams). The observation in this study showed that ultrasound tended to overestimate low birth-weight and underestimate high birth-weight as has been previously reported by other investigators (8,9,10,13).

Under and over-estimation of fetal weight was defined as a weight difference less than or greater than 10% of the actual weight at birth.

The sensitivity, specificity and positive predictive value of ultrasound to accurately estimate fetal weight was found to be 63.6%, 66.7% and 77.8% in those under 2500grams.

For those in the range of 2500 to 4000 grams, sensitivity, specificity and positive predictive value was 97.4%,40.9% and 87.7% respectively. For those over 4000 grams, it was 26.3%, 97.5% and 66.7%.

## Conclusion

Ultrasound was found to be an accurate method to determine the fetal sex in the second and third trimesters with an accuracy of 92%, sensitivity of 90% and specificity of 93.2%, even when it was performed by medical professionals who have fewer years of professional experience.

The accuracy rate for ultrasound fetal sex determination was lower in twin pregnancies compared to pregnancies with only one fetus. As a result, careful examination is recommended when performing ultrasound fetal sex determination where twins (or triplets or more) are present. The accuracy of ultrasound in estimation of fetal weight performed in term pregnancies was found to be higher in our study than that reported in other studies. It is therefore recommended to use ultrasound in estimating the fetal birth weight whenever accessible, even when it is done by those with less experience. However the general overestimation in cases of low birth weight and underestimation of macrosomia in ultrasound weight estimation should be given due attention so as not to under diagnose these conditions.

This study failed to identify factors that may affect the accuracy of ultrasound in fetal weight estimation. As a result further studies are recommended to assess other possible determinant factors which might be involved in accurately predicting fetal weight using ultrasound.

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