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Relationship between gestational age and transabdominal ultrasonographic measurements of fetus and uterus during the 2nd and 3rd trimester of gestation in cows

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ABSTRACT

Objective: The study was designed to estimate the relationship between gestational age and transabdominal ultrasonographic measurements of fetus and uterus during the 2nd and 3rd trimester of gestation in cows.
Methods: Seventeen cows with confirmed conception dates were used. The cows were examined transabdominally in standing position using the 3.5 MHz convex sector transducer of real-time ultrasonography. Measurements of length and height of placentomes, distance between uterine walls, width of trunk and heart, intercostal distance and width of umbilical cord were obtained from the ultrasonographic images by using the screen caliper software.
Results: Measurements at <90 and >250 d of gestation were for placentomes length (17.87 ± 2.26) and (75.92 ± 7.76) mm, height of placentomes (13.37 ± 1.12) and (36.50 ± 3.92) mm, distance between uterine walls (71.45 ± 10.68) and (144.63 ± 7.29) mm, and width of umbilical cord (7.80 ± 0.42) and (16.41 ± 0.41) mm, width of trunk (35.67 ± 7.11) and (146.50 ± 5.34) mm, width of heart (15.10 ± 5.50) and (74.57 ± 4.20) mm, and intercostal distance (3.85 ± 0.49) and (21.79 ± 0.48) mm, respectively. All the measurements were highly significantly correlated with gestational age $(P < 0.01)$. The measurements showing the highest correlation with gestational age were the width of heart $(r = 0.977)$, width of trunk $(r = 0.965)$, and intercostal distance $(r = 0.952)$, while the remaining measurements shown the least correlation with gestational age; distance between uterine walls $(r = 0.887)$, width of umbilical cord $(r = 0.882)$, placentomes length $(r = 0.880)$, and placentomes height $(r = 0.788)$.
Conclusion: Transabdominal ultrasonography is a practical and reliable method for obtaining the fetal and uterine measurements during the 2nd and 3rd trimesters of gestation. The correlation coefficients between gestational age and fetal measurements (width of trunk and heart and intercostal distance) were higher than those of uterine measurements, and the highest correlation was between heart width and gestational age in cows.

1. Introduction

Prediction of calving date is important for assessing reproductive efficiency. When the information about the estrus and breeding is available, the date of calving can be predicated from the mean and standard deviation of the gestation length in cows [1]. Estimation of the gestational age in cows that bred individually or bred together with bulls is difficult because these types of breeding have inadequate reproductive

information especially estrus and insemination dates, therefore a reliable method is requested to estimate the gestational age.

Post mortem studies reported that gestational age is positively correlated with some of uterine and fetal measurements [2–5]. On this basis, many of studies were carried out to found a practical method for determination of gestational age in cows.

Real time ultrasonography is an essential diagnostic tool for reproductive system and pregnancy diagnosis [6], and it has been used for estimation of gestational age in cows [7–14]. Ultrasonography was applied transrectally for predicating of gestational age in cows by measurement of crown rump length [7,8,14], head length [7], diameters of the trunk [7], uterine diameter [7,14], placentomes length and size [10,13,14], intercostal space [6]. Other measurements such as heart diameters were established for determination of gestational age in ewes and goats [15,16].

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In comparison with rectal palpation and transrectal ultrasonography, transabdominal ultrasonography was found an accurate and rapid method for determination of pregnancy and fetal viability especially for cows in mid and late gestation [17]. Only one study was published by Hunnam *et al.* who determined the gestational age in cows by transabdominal ultrasonography measurement of thoracic diameter, abdominal diameter, umbilical diameter, placentome length and placentome height [11].

In all studies that published also that used transabdominal ultrasonography, the gestational age in cows was determined only for the period between 60 and 190 d of gestation [7,9,11,12]. This study was designed to estimate the relationship between gestational age and transabdominal ultrasonographic measurements of fetus and uterus during the 2nd and 3rd trimester of gestation in cows.

2. Materials and methods

2.1. Animals

Seventeen cows aged 2–2.5 years with confirmed conception dates were used. At first sonographic scanning the gestational age of cows was between 60 and 85 d (seven cows) and 91–101 d (ten cows).

2.2. Ultrasonography

Ultrasonographic examination was performed according to the method was published by Aziz [17]. The cows were examined transabdominally in standing position using the 3.5 MHz convex sector transducer of real-time ultrasonography (Mindray, DP-6900Vet, China). The cows were examined nine times with an interval of 17–25 d during the period between June 2015 and January 2016. The ultrasonographic images of fetus and uterus were recorded for late analysis.

2.3. Fetal and uterine measurements

The ultrasonographic images of fetus and uterus were processed using the software Screen Calipers (Version 4.0, ©2006, Iconico, Inc., http://www.iconico.com/caliper/). An image of ultrasonic device with known distances in millimeter was used for calibration of the software to read the fetal and uterine measurements in millimeter.

Seven measurements were used in this study; placentomes length and height, distance between uterine walls, trunk and heart width, intercostal distance and umbilical cord width.

Ultrasonographic images showed the largest longitudinal sections of placentomes were used for obtaining the placentomes length and width. Placentomes length was obtained by measuring the distance between the farthest points of the horizontal axis of placentomes. Width of placentomes was obtained by measuring the vertical distance of placentomes between the highest point of placentomes that confronted the uterine cavity and the level of an extension of endometrium.

The images that showing the lower and upper uterine walls clearly were used for obtaining the distance between the uterine walls, this parameter was obtained by measuring the distance between the farthest points of the cross section of the uterus.

Measurements of trunk and heart width were obtained from the images that showing the longitudinal section of fetus on the thorax region. Trunk width was obtained by measuring the farthest distance of fetal body at the level of last ribs. The heart width was taken by measuring the distance between the farthest points of the short axis of the heart that is perpendicular on the heart median septum.

The intercostal distance measurements were taken from the ultrasonographic images that showing a longitudinal section of the chest and appearing a series of white circles that represent a cross-section of ribs, this parameter was obtained by measurement of the distance between two of these white circles.

The width of the umbilical cord were obtained from the images which were showing a straight longitudinal section of the umbilical cord, this parameter was taken by measuring the distance between the outer sides of the umbilical cord.

2.4. Statistical analysis

The correlation coefficient and equations of regression line for the relationship between gestational age and each of the seven measurements were established using Sigma Stat (Sigmastat, Jandel Scientific Software V3.1). $P < 0.05$ was considered as statistically significant.

3. Results

Measurements of placentomes length and height, distance between uterine walls and umbilical cord width are summarized in Figure 1. These measurements at <90 and >250 d of gestation were for placentomes length (17.87 ± 2.26) and (75.92 ± 7.76) mm, height of placentomes (13.37 ± 1.12) and (36.50 ± 3.92) mm, distance between uterine walls (71.45 ± 10.68) and (144.63 ± 7.29) mm, and width of umbilical cord (7.80 ± 0.42) and (16.41 ± 0.41) mm, respectively.

Measurements of trunk and heart width and intercostal distance are summarized in Figure 2. These measurements at <90 and >250 d of gestation were for width of trunk (35.67 ± 7.11) and (146.50 ± 5.34) mm, width of heart (15.10 ± 5.50) and (74.57 ± 4.20) mm, and intercostal distance (3.85 ± 0.49) and (21.79 ± 0.48) mm, respectively.

Results of the study showed that all the measurements were highly significantly correlated with gestational age ($P < 0.01$). The measurements showing the highest correlation with gestational age were the width of heart ($r = 0.977$), width of trunk ($r = 0.965$), and intercostal distance ($r = 0.952$), while the remaining measurements shown the least correlation with gestational age; distance between uterine walls ($r = 0.887$), width of umbilical cord ($r = 0.882$), placentomes length ($r = 0.880$), and placentomes height ($r = 0.788$). The regression line equations, squares of correlation coefficient of the relationship between the gestational age and measurements are shown in Figure 3.

4. Discussion

According to our knowledge and literature review, this is the first study to include the 3rd trimester of gestation in cows to observe the relationship between ultrasonographic measurements and gestational age; also it is the first ultrasonographic study that evaluates the relationship between heart width and gestational age in cow, and it is the second study after publication of Hunnam *et al.* [11] that used
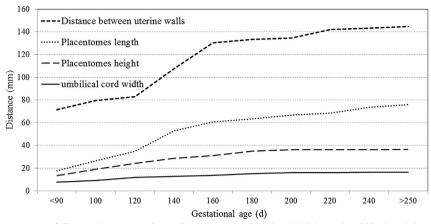
Figure 1. Measurement means (mm) of distance between uterine walls, placentomes length and height, and umbilical cord that obtained by transabdominal ultrasonography during the 2nd and 3rd trimester of gestation in cows.

transabdominal ultrasonography for estimation of gestational age in cows.

Placentomes length and height were increased clearly in our study during the gestation age between <90 and 180 d, after that length and width of placentomes were slightly increased, and there was a significant correlation between the placentome measurements and gestational age. Similar observation was reported earlier in an anatomical study that found a significant correlation between placentome length and size and age of gestation in cows and significant increase in the length of the placentomes from day 70 until day 190 and no significant difference between 190 and 280 d of gestation [5]. Our results agree with transrectal ultrasonographic studies that showed a significant relationship between placentome length and gestational age between 60 and 180 d of gestation [10,13,14], but our results disagree with those of Hunnam *et al.* [11] who reported that gestational length between 73 and 190 d of gestation was not significantly associated with placentome height or length which were measured by transabdominal ultrasonography.

Results of this study showed that distance between the uterine walls was significantly increased until 170th day of gestation and there was a significant relationship between this measurement and gestational age in cows, this distance not recorded previously in the ultrasonographic publications, but the

same observations were shown between transrectal ultrasonographic measurements of uterine diameter and bovine gestational age [7,11].

The obtained results of trunk and heart width and intercostal distance that recorded in this study were significantly and linearly increased throughout 2nd and 3rd trimesters of gestation in cows. Our results are in agreement with anatomical information for the relation between fetal measurements and age of pregnancy [18], and also agree with results that were obtained by transrectal ultrasonography of fetus during the gestation period between 60 and 150 d [7,8,19]. Trunk width that recorded in this study was positively correlated with gestational age, and similar high correlation was reported in other ultrasonographic studies that used transrectal [6] and transabdominal [11] transducer. Also the measurements of intercostal distance were highly correlated with gestational age in this study, except the information that published by Kähn [6] who shown a positive correlation between gestational age and intercostal space, no previous study was compared this parameter with gestational age in cows. The highest correlation was recorded in this study was between heart width and cows gestational age, no ultrasonographic information was published previously for the relationship between heart measurement and bovine gestational age. This parameter was measured in other studies that found a highly
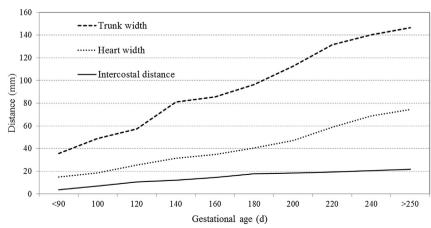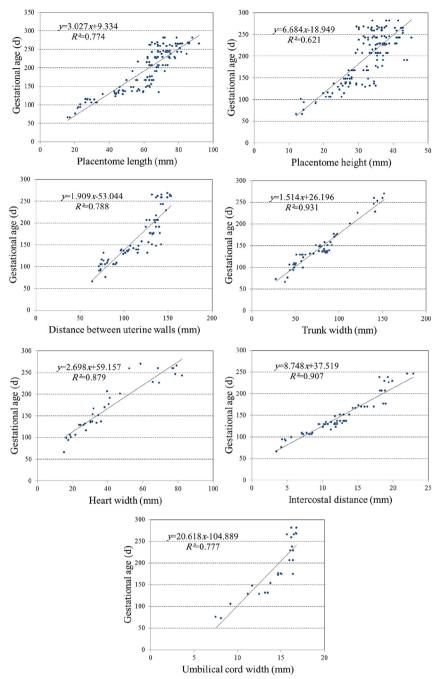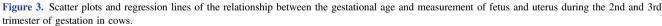

Figure 2. Measurement means (mm) of trunk width, heart width and intercostal distance that obtained by transabdominal ultrasonography during the 2nd and 3rd trimester of gestation in cows.

Figure 3. Scatter plots and regression lines of the relationship between the gestational age and measurement of fetus and uterus during the 2nd and 3rd trimester of gestation in cows.

y = gestational age, x = measurement obtained by transabdominal ultrasonography, R^2 = squares of correlation coefficient.

positive correlation between heart measurements and age of gestation in sheep [16] and goats [15].

Current research shows that umbilical cord width was correlated significantly with gestational age in cows, and this measurement was increased significantly until 210 d of gestation. This finding agreed with results that published by Hunnam et al. [11] who found a significant associated between gestational age and umbilical diameter that measured via transcutaneous ultrasound during the gestation age between 73 and 190 d.

In conclusion, transabdominal ultrasonography is a practical method for bovine pregnancy diagnosis and monitoring of embryo, and it is a reliable method for obtaining the fetal and uterine measurements during the 2nd and 3rd trimesters of gestation. The correlation coefficients between gestational age and fetal measurements (width of trunk and heart and intercostal distance) were higher than those of uterine measurements, and the highest correlation was between heart width and gestational age in cows.

Conflict of interest statement

We declare that we have no conflict of interest statement.

Acknowledgments

References

[1] Ginther OJ. *Ultrasonic imaging and animal reproduction: cattle.* Wisconsin: Equiservices Publishing; 1998, p. 187-195.

[2] Thomsen JL. *Body length, head circumference, and weight of bovine fetuses: prediction of gestational age.* Department of Anthropology, University of Copenhagen; 1974.

[3] Harris RM, Snyder BG, Meyer R. The relationship of bovine crown-rump measurement to fetal age. *Agric Pract* 1983; **4**: 16-22.

[4] Richardson C, Jones P, Barnard V, Hebert C, Terlecki S, Wijeratne W. Estimation of the developmental age of the bovine fetus and newborn calf. *Vet Rec* 1990; **126**: 279-284.

[5] Laven RA, Peters AR. Gross morphometry of the bovine placentome during gestation. *Reprod Domest Anim* 2001; **36**: 289-296.

[6] Kähn W. *Veterinary reproductive ultrasonography.* Germany: Schlutersche Verlagsgesellschaft mbH and Co; 2004, p. 143-168.

[7] White IR, Russel AJ, Wright IA, Whyte TK. Real-time ultrasonic scanning in the diagnosis of pregnancy and the estimation of gestational age in cattle. *Vet Rec* 1985; **117**: 5-8.

[8] Kähn W. Sonographic fetometry in the bovine. *Theriogenology* 1989; **31**: 1105-1121.

[9] Bergamaschi MACM, Vicente WRR, Barbosa RT, Machado R, Marques JA, Freitas AR. Ultrasound assessment of fetal development in Nelore cows. *Arch Zootec* 2004; **53**: 371-374.

[10] Kohan-Ghadr HR, Lefebvre RC, Fecteau G, Smith LC, Murphy BD, Suzuki J, et al. Ultrasonographic and histological characterization of the placenta of somatic nuclear transfer-derived pregnancies in dairy cattle. *Theriogenology* 2008; **69**: 218-230.

[11] Hunnam J, Parkinson T, Lopez Villalobos N, McDougall S. Association between gestational age and bovine fetal characteristics measured by transcutaneous ultrasound over the right flank of the dairy cow. *Aust Vet J* 2009; **87**: 379-383.

[12] Blankenvoorde G. *Determination of gestational age in dairy cattle using transrectal ultrasound measurements of placentome size.* New Zealand: Massey University; 2010.

[13] Adeyinka FD, Laven RA, Lawrence KE, van Den Bosch M, Blankenvoorde G, Parkinson TJ. Association between placentome size, measured using transrectal ultrasonography, and gestational age in cattle. *N Z Vet J* 2014; **62**: 51-56.

[14] Lawrence KE, Adeyinka FD, Laven RA, Jones G. Assessment of the accuracy of estimation of gestational age in cattle from placentome size using inverse regression. *N Z Vet J* 2016; **9**: 1-5.

[15] Lee Y, Lee O, Cho J, Shin H, Cho Y, Shim Y, et al. Ultrasonic measurements of fetal parameters for estimation of gestational age in Korean Black Goats. *J Vet Med Sci* 2005; **67**: 497-502.

[16] Oral H, Pancarci SM, Gungor O, Kacar C. Determination of gestational age by measuring fetal heart diameter with transrectal ultrasonograph in sheep. *Med Wet* 2007; **63**: 1558-1560.

[17] Aziz DM. Clinical application of a rapid and practical procedure of transabdominal ultrasonography for determination of pregnancy and fetal viability in cows. *Asian Pac J Reprod* 2013; **2**: 326-329.

[18] Noakes DE, Parkinson TJ, England GC. *Arthur's veterinary reproduction and obstetrics.* 8th ed. USA: Saunders; 2001, p. 54-202.

[19] Hughes EA, Davies DAR. Practical uses of ultrasound in early pregnancy in cattle. *Vet Rec* 1989; **124**: 456-458.