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Pelvimetry in the Teramana goat breed: a comparison between radiography and ultrasound

Ippolito De Amicis[1], Ladislav Stehlik[2], Francesca Del Signore[1], Salvatore Parrillo[1], Domenico Robbe[1], Roberto Tamburro[1], Massimo Vignoli[1]*

[1]*Faculty of Veterinary Medicine, University of Teramo, Piano D'Accio, Teramo, Italy*
[2]*Small Animal Clinic, Faculty of Veterinary Medicine, University of Veterinary and Pharmaceutical Sciences Brno, Brno, Czech Republic*

**Corresponding author: lstehlik@vfu.cz*

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Abstract: Radiography is routinely used for pelvimetry, but it is not easily accessible for farm animals, while ultrasonographic pelvimetry could be used due to the better accessibility and lack of radiation hazard. Radiographic and ultrasonographic pelvimetry in goats were compared, and three diameters of the pelvis were measured; the narrowest transverse pelvic diameter at the level of the acetabula, from the pecten pubis to the sacral promontorium and from the dorsal edge of the pubis to the coccygeal vertebra. The measurement was performed three times by one observer on both modalities. Intraclass correlation coefficient (ICC) and Bland-Altman analyses were performed. The intraobserver agreement was excellent for all the measurements and modalities in the study. Excellent agreement (ICC 0.96) was achieved for the transverse pelvic diameter. The agreement for the other two diameters was poor. We can conclude that the ultrasonographic pelvimetry of a goat is reliable only in the transverse pelvic diameter just cranial to the pecten pubis.

Keywords: farm animals; radiographic measurement; ultrasonographic measurement

Pelvimetry has been used to evaluate the size of the pelvic canal and to compare it with the size of the foetus in several species. Radiography (X-ray) is the most common modality (Farrow 1978; Eneroth et al. 1999; Monteiro et al. 2013). Also computed tomography (CT) has been described recently in dogs (Ocal et al. 2003; Pentea and Ganta 2007; Dobak et al. 2018). In humans, three-dimensional CT in non-pregnant multiparous women who delivered vaginally has been described (Salk et al. 2016).

In humans, every effort should be made to avoid unnecessary irradiation to any woman who might be pregnant. Radiation damage in the first two weeks of pregnancy, should be "all or nothing", resulting in either a miscarriage or a normal child. There are no data about the clinical effect of irradiation on the foetus of livestock, however it should be stated that due to the X-ray hazard, radiography should be avoided in animals also, especially in the first period of pregnancy. Ultrasound (US) has replaced ionising radiation in most examinations of the foetus and placenta. Pelvimetry should be performed only when the decision to do a caesarean section hinges on the precise knowledge of the measurements of the bony pelvis (Houston 1977).

We therefore aimed to study the pelvimetry of goats, comparing the radiographic and ultrasonographic measurements. To our knowledge, there are no studies on the pelvimetry of goats using ultrasound.

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MATERIAL AND METHODS

This was a prospective study that is part of a project aimed at the recovery of the Teramo breed goat, in danger of extinction with the favourable opinion of the Ethics Committee (Protocol No. 62126 del 23/04/2018).

Eleven female goats were included in the study. The mean age was 5.5 years (a range of 4–7 years), and the mean body weight was 32.5 kg (a range of 24–42 kg). The X-ray and US measurements were obtained and analysed for 10 goats. One goat died after the US study and was, therefore, excluded. All the goats considered in the study were not pregnant. The animals underwent an US of the pelvis with a 5 MHz convex probe (GE S8, SCIL Italy, Milan, Italy) for the measurement of the narrowest transverse diameter of the pelvis just cranial to the pubis and at the level of the medial part of the acetabula, between the pecten pubis and the promontorium of the sacrum, and from the dorsal edge of the pubis to the first coccygeal vertebra. This procedure was followed within 14 days by an X-ray of the pelvis, performed in two orthogonal projections, the right lateral and ventrodorsal (VD), and the same measurements were acquired as in the US. For the radio-

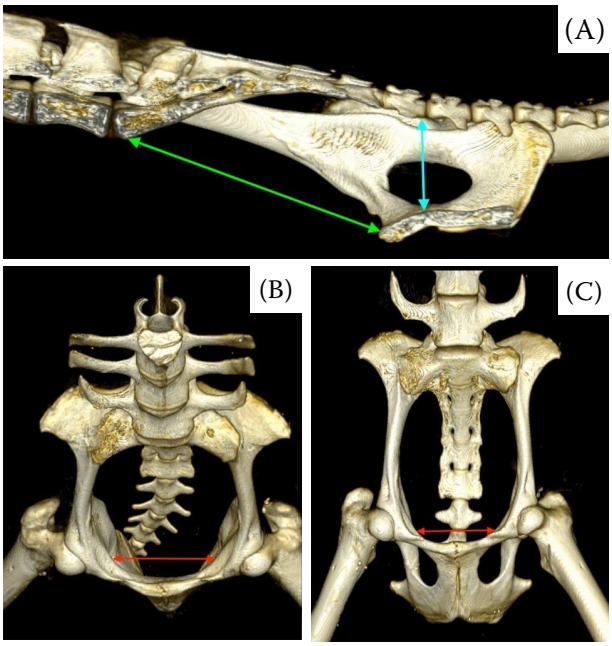

Figure 1. The volume rendered CT images in the sagittal (**A**), craniocaudal (**B**) and ventrodorsal (**C**) view. The red line represents the narrowest transverse diameter of the pelvis, the green line represents the diameter from the pecten pubis to the promontorium and the blue line shows the diameter from the dorsal surface of the pubis to the ventral edge of the first coccygeal vertebra

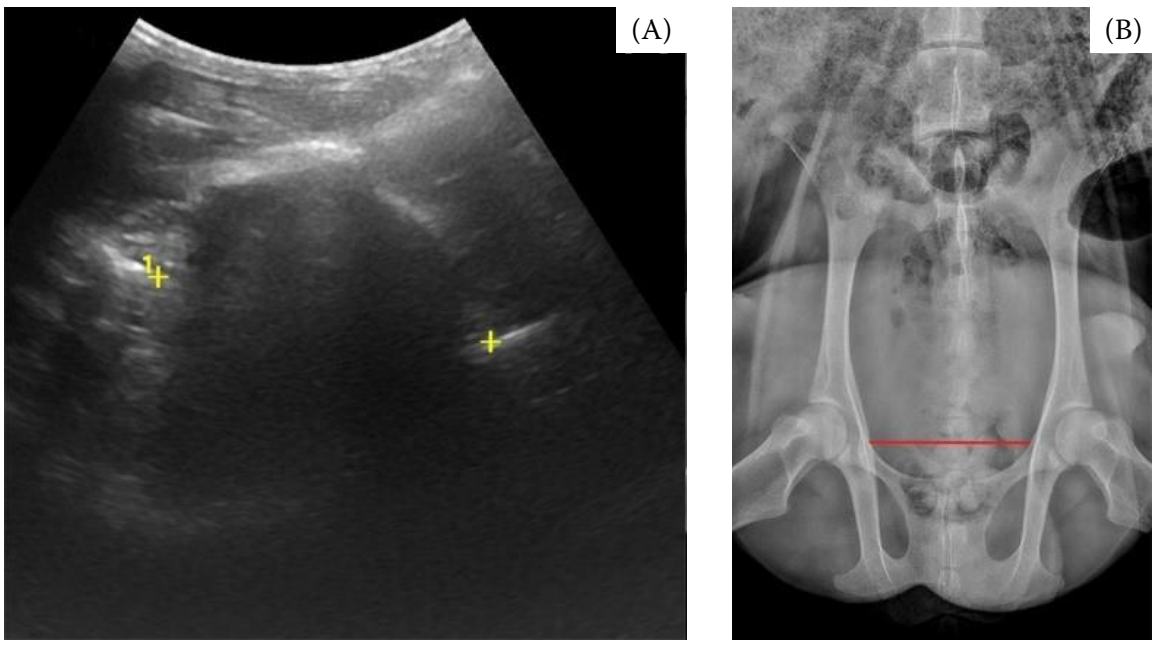

Figure 2. (**A**) The US image of the pelvis performed with the probe in the transverse position just cranial to the pubis. The electronic callipers show the transverse diameter of the pelvis at the narrowest point. The borders of the bones are well defined. (**B**) The ventrodorsal X-ray of the pelvis of the same animal as in A. The red line shows the transverse diameter of the pelvis at the narrowest point

US = ultrasonography; X-ray = radiography

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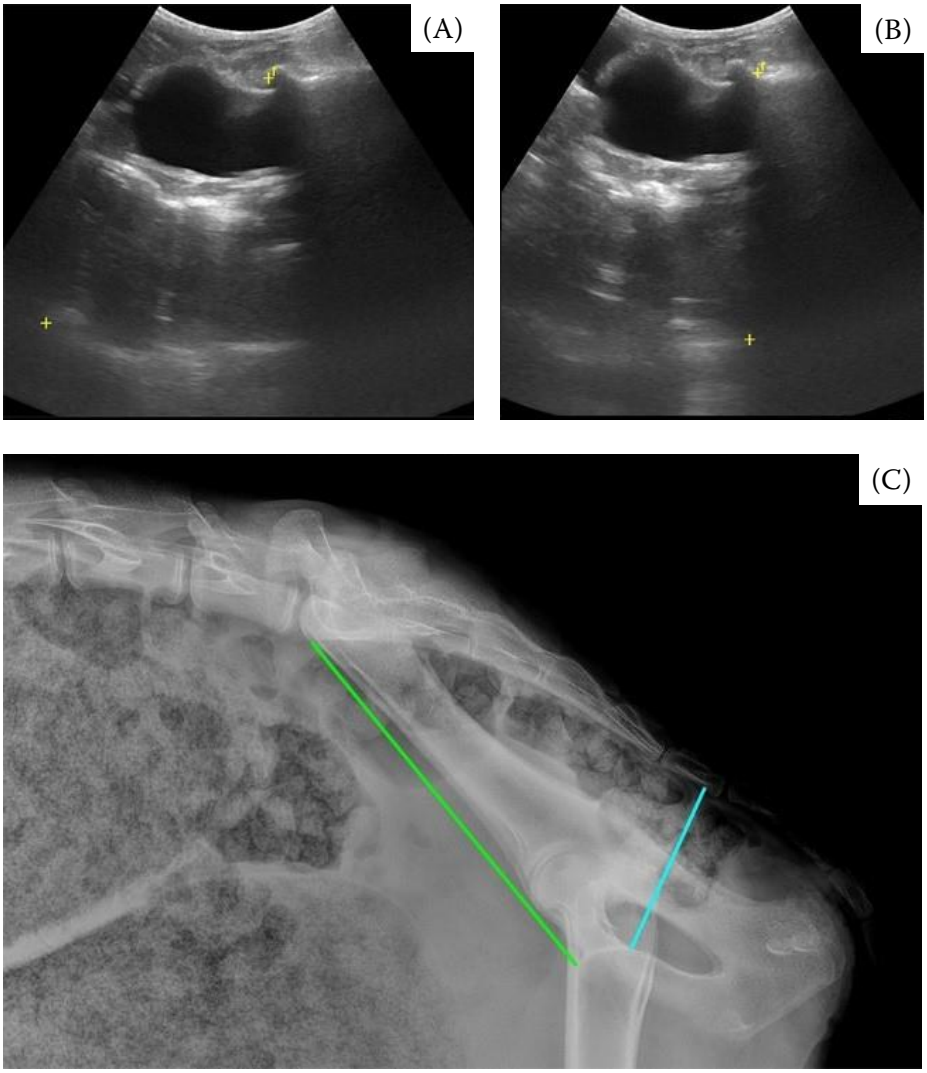

Figure 3. The US images with the measurements between the pecten pubis and the sacral promontorium (**A**) and between the pubis and coccygeal vertebra (**B**) are limited by the large depth (**A**) or the reverberation artefact (**B**) compared to lateral view of the pelvis (**C**). The green and blue lines on the radiograph show the pubis to the promontorium, and the pubis to the first coccygeal vertebra diameters, respectively

US = ultrasonography

graphs, a radiological unit (a high-frequency beta tube generator, table delta 90, Cat Medical Systems, Monterotondo, Rome, Italy) was used with a direct acquisition system provided with software for the necessary measurements (Aria, Foschi, Rome, Italy). The measurements were taken three times for each radiographic and ultrasonographic study. One goat died a few days after the US study, and the animal's skeleton was subjected to a CT study (Optima 540, GE, Milan, Italy). The volume-rendered images of the pelvis were created and are used here to show where the measurements were taken (Figure 1). All the measurements were taken by a board-certified radiologist (MV) and are also displayed on the X-ray and US images (Figures 2 and 3). For anonymisation and objectiveness, the goats were assigned different numbers for the ultrasound and radiography, so it was not possible for the observer to identify the animal during the measurements. All the measurements and their mean values were recorded in Microsoft Excel (version 16.26; Microsoft Corporation, Redmond, WA).

The data analysis was generated using the Real Statistics Resource Pack software (Release 6.3) in Microsoft Excel (version 16.26). The Saphiro-Wilk normality test provided the assumption of the data distribution. To compare the radiographic and ultrasonographic measurements, a Bland-Altman analysis was performed using the mean values. The Bland-Altman analysis is used to assess the agreement between the two measuring methods, but only provides a graphical representation of the data (Bland and Altman 1986). For a more accurate interpretation of the agreement between the two methods and also for the intraobserver agreement, the Intraclass Correlation Coefficient (ICC) was used. We used model ICC (2,k) and ICC (3,1) for the agreement between the X-ray

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and US measurements and for the intraobserver agreement, respectively (Shrout and Fleiss 1979; Koo and Li 2016). The statistical significance level was set to 0.05. The results were interpreted as follows: < 0.5 poor reliability; 0.5 to 0.75 moderate reliability; 0.75 to 0.9 good reliability; > 0.9 excellent reliability.

RESULTS

The mean values from the pelvimetric measurements for each animal are shown in Table 1. The intraobserver agreement w

-ray and US measurements was excellent for the transverse pelvic diameter (ICC 0.96; 95% CI 0.8359–0.9891) and poor for the pubis to the promontorium and the pubis to the first coccygeal vertebra measurements with ICC 0.43 (95% CI –0.1202–0.8316) and ICC 0.44 (95% CI –0.1199–0.8214), respectively. The differences between the X-ray and US measurements are shown in Figures 4, 5 and 6. Problems were found in the US measurements between the pecten pubis and the promontorium in eight goats, due to the considerable depth between the bones and the loss of the bone visualisation, in five goats for the measurements between the pubic bone and the coccygeal vertebra for the same reason or reverberation artefacts, and in two cases for the measurements between the acetabula due to reverberation artefacts.

DISCUSSION

Pelvimetry is a method useful to compare the size of the pelvic canal and foetus and can be undertaken by radiology (Farrow 1978; Eneroth et al. 1999; Monteiro et al. 2013) or CT (Ocal et al. 2003; Pentea and Ganta 2007; Dobak et al. 2018). Both radiology and CT modalities pose a radiation hazard, especially for pregnant females. The use of US could be preferred because of no ionising radiation. Moreover, for farm animals, it is not easy to perform a radiographic examination directly on the farm, while it is easier to transport the US machine and perform the US examination directly on the farm.

Table 1. The mean values of the X-ray and US pelvimetric measurements in all three diameters. The measurements are in cm

Animal	Pelvis transversal		Pubis-promontorium		Pubis-vertebra	
	X-ray	US	X-ray	US	X-ray	US
1	4.69	4.30	10.02	9.07	4.98	5.21
2	6.03	6.12	10.60	9.52	5.98	6.55
3	5.66	5.88	13.80	11.40	6.81	7.20
4	6.41	6.74	15.09	11.15	7.33	8.52
5	7.70	7.63	15.08	13.79	6.76	8.47
6	6.81	6.85	13.00	12.57	6.53	8.41
7	6.51	6.63	14.75	12.51	6.15	8.30
8	6.60	6.28	14.05	12.63	6.29	6.69
9	6.97	6.95	14.20	10.65	7.91	7.65
10	6.19	6.59	14.30	11.49	6.49	7.49

US = ultrasonography; X-ray = radiography

Table 2. The ICC values for the intraobserver agreement for each diameter and modality

Modality	Pelvis transversal		Pubis-promontorium		Pubis-vertebra	
	ICC	95% CI	ICC	95% CI	ICC	95% CI
X-ray	0.99	0.9964–0.9997	0.96	0.8867–0.9888	0.99	0.9994–0.9999
US	0.99	0.9983–0.9998	0.99	0.9989–0.9999	0.99	0.9986–0.9999

CI = the confidence interval; ICC = intraclass correlation coefficient; US = ultrasonography; X-ray = radiography

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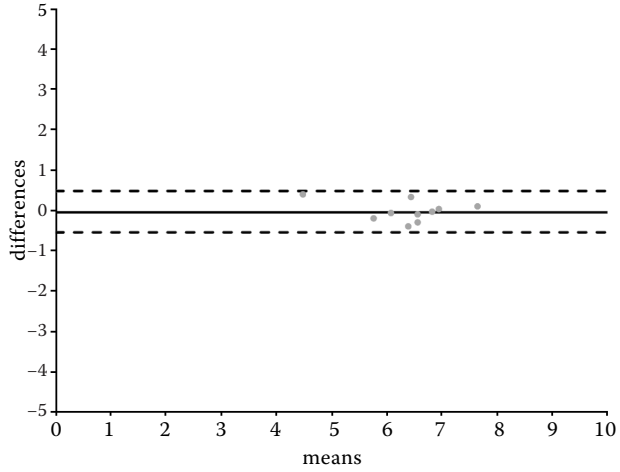

Figure 4. The Bland-Altman plot for the differences between the X-ray and US measurements in the transverse pelvic diameter. The ICC was 0.96

ICC = intraclass correlation coefficient; US = ultrasonography; X-ray = radiography

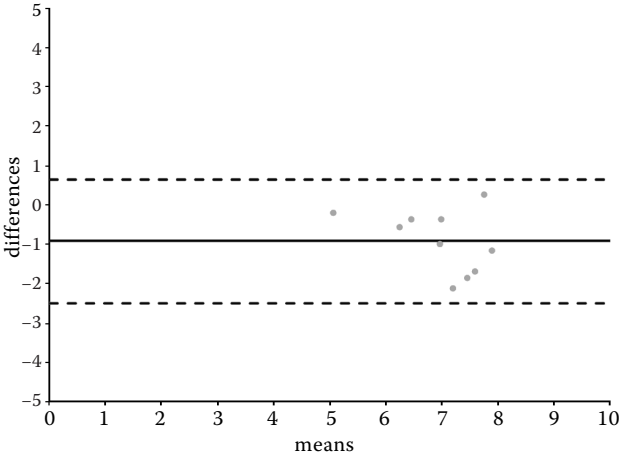

Figure 6. The Bland-Altman plot for the differences between the X-ray and US measurements in the pubis to the first coccygeal vertebra diameter. The ICC was 0.44

ICC = intraclass correlation coefficient; US = ultrasonography; X-ray = radiography

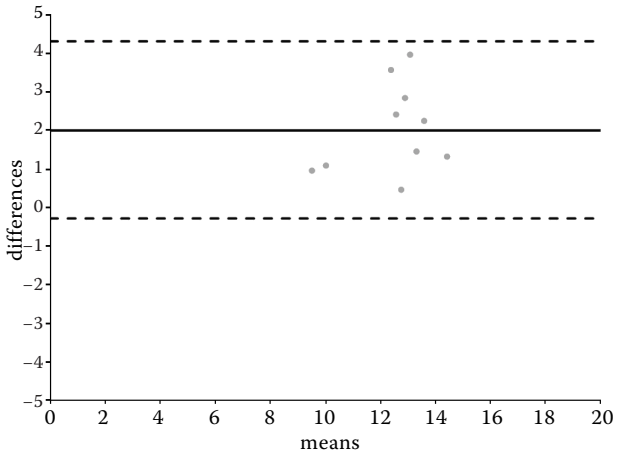

Figure 5. The Bland-Altman plot for the differences between the X-ray and US measurements in the pubis to the promontorium diameter. The ICC was 0.43

ICC = intraclass correlation coefficient; US = ultrasonography; X-ray = radiography

Many different measurements in animals were published to define the size of the pelvic canal (Haughey and Gray 1982; Kene 1991; Eneroth et al. 1999; Nahkur et al. 2011; Dobak et al. 2018). In our study, we tried to simplify the measurements for the better applicability in clinical practice.

We encountered some difficulties regarding the measurements between the pecten pubis and the promontorium, due to the considerable distance, over 10–12 cm, particularly in the larger-sized goats. Furthermore, there were difficulties in some measurements between the pubic bone and coccygeal vertebra and, to a lesser extent, the transverse diameter of the pelvis. In these latter cases, the problem was related to the presence of artefacts from the bones. These difficulties need to be taken into account when performing US pelvimetry, especially in larger goats and are the only disadvantage when compared to the radiographic measurements.

The highest agreement (ICC 0.96) between the X-ray and US measurements was achieved for the transverse pelvic diameter. The Bland-Altman analysis provides us with an interval called the limits of agreement where 95% of the differences will lie (Bland and Altman 1986). This interval is very narrow for the measurements of the transverse pelvic diameter, with the agreement limits of –0.55 cm and 0.46 cm. So, the US measurements may be 0.55 cm below or 0.46 cm above the X-ray measurements. For the other two diameters, the intervals were much bigger. The limits of agreement were –0.28 cm to 4.31 cm for the pubis to the promontorium diameter and were –2.48 cm to 0.63 cm for the pubis to the first coccygeal vertebra diameter. The limits of agreement for the transverse diameter are acceptable in clinical practice, while they are not for the latter two because they could mislead the clinicians in their decision making regarding the parturition.

Based on the results of this preliminary study, we can conclude that ultrasonographic pelvimetry

https://doi.org/10.17221/96/2019-VETMED

of the goat is reliable only in the transverse pelvic diameter just cranial to the pecten pubis. More studies should be taken to review this and the other diameters, to fully validate the ultrasound measurement technique. The main limitation of this study was the large distance between the bones and in some cases the artefacts.

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