Turkish Journal of Veterinary and Animal Sciences

http://journals.tubitak.gov.tr/veterinary/

Research Article

Turk J Vet Anim Sci
(2015) 39: 741-744
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doi:10.3906/vet-1505-106

# Correlation between the milk vein internal diameter surface and milk yield in Simmental cows

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**Received:** 31.05.2015 • **Accepted/Published Online:** 09.09.2015 • **Printed:** 31.12.2015

**Abstract:** It is known that milk production is directly correlated with the blood flow through the mammary gland, and milk veins drain approximately 90% of the total blood passing through this organ. The aim of the present study was to determine the relationship between milk vein internal diameter surface and milk production in Simmental cows. The milk vein internal diameter was measured by ultrasonography in heifers during the 2nd month of the first gravidity, and again on day 50 following the second calving. After the application of exclusion criteria, the internal vein diameter surface area was mathematically calculated ($mm^2$) for a total of 80 cows. No significant correlation between milk vein internal diameter surface in heifers and milk production for the same animal during the second lactation was recorded. However, greater milk vein internal diameter surface 50 days following the second calving was correlated with higher milk production during the second lactation ($P < 0.05$). These findings suggest that ultrasonography is a useful tool in calculating the milk vein internal diameter surface as an indicator of possible milk production in Simmental cows.

**Key words:** Cow, ultrasonography, milk vein, milk production

## 1. Introduction

Blood supply to the udder is critical in milk production, since it provides necessary constituents that are converted to milk as a final product. It is estimated that for production of 20 kg of milk/day during a 24-h period, approximately 9000 L of blood needs to be circulated through the udder of a dairy cow (1). The leading factors influencing milk production in cattle are management (2,3), nutrition, (4), age (2,5), breed (4,5), parity (2–4), year (3,5), and season in which lactation started (2–4). In addition, the persistent level of the highest milk production (6), environmental factors (3), climate (5), genetic background (7,8), diseases, and feeding regimen (9), along with lactation length and parity, have also been reported to affect milk production (6,9,10).

The milk vein (*vena epigastrica cranialis superficialis s. vena subcutanea abdominis*) exits the mammary gland at the anterior pole of the udder and passes along the abdominal wall, enters the body cavity at the level of xiphoid process, an area known as the "milk well" (*fons lactis*), and eventually empties into the *vena cava* (11). According to Huth (12), approximately 90% of blood is carried out of the mammary gland by milk veins, while the remaining 10% drains via the perineal vein. The mammary blood flow increases in proportion to the cardiac output (13) caused by the increase in the heart rate and the heart volume, and it represents the basic mechanism to meet the increased demand for blood supply during lactation (14). The amount of the blood supply is closely related to the level of milk production (15), with mammary blood flow in nonlactating cows being much lower in comparison to lactating cows, as well as in low-producing compared to high-producing cows (16–18).

Historically, the anatomic location and easy accessibility of the milk well and milk veins, and especially measurements of their diameter and shape, were useful tools for predicting the milk yield in lactating cows (19,20). Today, modern technologies could be applied: the milk vein in dairy cattle is suitable for ultrasonography due to its superficial position, size, recognizable shape, and easy access (17,18,21,22).

Given that the mammary gland blood supply is higher in cows with higher milk production, and that milk veins carry approximately 90% of blood output from the mammary gland, we hypothesized that higher milk production, and thus higher blood flow through the

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veins, would be correlated with greater milk vein internal surface. Due to the limited and insufficient data in the available literature, the aim of the present study was to use ultrasonography to determine the correlation between milk vein internal diameter surface (MVIDS) and milk yield in Simmental cows.

## 2. Materials and methods

### 2.1. Animals

A total of 138 Simmental heifers were included in the study. The study was conducted on a single commercial dairy farm over the course of 8 years in Sisak-Moslavina County, Croatia, in order to exclude possible influences of the farm, management, and breed on the results. Furthermore, all cows included in the study calved between February and May in order to exclude calving season as a factor in data analysis. The average milk yield was recorded during the 2nd lactation in order to exclude possible influence of age and parity on results, and it varied from 3909 to 8488 kg of milk per animal per year. Heifers, lactating cows, and dry cows were housed separately in free stalls in groups of 30 to 90 animals with the possibility of grazing during the day hours from February until November. During the cold period, animals also had the possibility of going out voluntarily. Animals were fed hay ad libitum. Concentrate consisting of barley, oat, corn, soybean, and straw mixed with corn silage and grass silage was provided twice a day according to the milk yield. Before inclusion in the study, heifers were scored for body condition according to Edmonson et al. (23) during the 2nd month of the first gravidity. Only animals with body condition score between 3.25 and 3.75 were included, while others were excluded due to the possible effect of obesity or poor body condition on the results. The same exclusion criteria were applied to animals examined 50 days after the 2nd calving. In addition, exclusion criteria included cows suffering from polyarthritis, recurrent mastitis (mastitis occurring more than once during the previous or second lactation), increased somatic cell count (>200,000 CFU/mL of milk) for more than 2 months during the first lactation, cows with one or more dry quarters, animals with extreme deformities of the hind limbs or laminitis, and cows suffering from dystocia at the 2nd calving.

### 2.2. Experimental protocol

Measurements of the internal milk vein diameter were done via ultrasonography using a 7.5 MHz rectal linear probe (Draminski PROFI L, Olsztyn, Poland). The measurements were taken in heifers during the 2nd month of the first gravidity, and again in the same animal on day 50 following the 2nd calving. The hair was shaved, skin was disinfected, and contact gel was applied to the probe and the skin. The animals were not sedated and stood during the evaluation process. The measurements were taken at an arbitrarily selected point 25 cm caudally from the milk well for the left and right milk veins, with minimal pressure applied in order to minimize compression of the milk vein during the procedure. The veins were examined in longitudinal and cross-sections, with the transducer surface positioned perpendicular to the vein. The internal vein diameters (intimal-to-intimal surface) were measured in cross-section after freezing the ultrasonographic image. Left and right milk vein diameters in each animal were summarized and divided by 2 in order to obtain the mean milk vein inner diameter value for further mathematical calculations. As a milk vein in cross-section has an oval shape, the mathematical formula $\pi ab$ was used ($a$ = the smaller milk vein radius, b = the larger milk vein radius, $\pi$ = constant) in order to calculate the MVIDS expressed in $mm^2$.

The data regarding the milk yield for individual cows during the 2nd lactation and the somatic cell count were provided by the Croatian Agriculture Agency (HPA).

### 2.3. Clinical examination

Body temperature was measured daily during the first 10 days following the second calving. Gynecological examination (vaginoscopy, transrectal examination, and ultrasonography) was performed twice weekly during the first 2 weeks postpartum. Physical examination included appetite evaluation, general condition, heart and respiratory rates, and ruminal motility assessment. Urine samples were analyzed by a strip test (Combur-Test, Roche, Basel). Clinical examination included inspection and palpation of the udder, gross examination of the milk from each quarter, and the Zagreb mastitis test. During the third and fourth week postpartum, cows were examined once weekly, and then at 2-week intervals during the second month. Animals diagnosed with fever of any origin, cows with any postpartum pathological uterine condition (including retained placenta and clinical endometritis), and animals with any abnormal physical exam findings were excluded from the study. After applying all exclusion criteria, a group of 80 animals was selected for further statistical analysis.

### 2.4. Statistical analysis

Milk vein internal surface in $mm^2$, distance of the vein from the skin surface in mm, and milk yield in kg were analyzed using categorical data modeling (StatSoft, Tulsa, OK, USA). Frequencies, means, and standard deviations were calculated, and differences were analyzed using analysis of variance (ANOVA) and an unpaired two-sided t-test for normally distributed variables. Pairwise analysis of factorial ANOVA was performed according to the Bonferroni–Dunn post hoc test in order to prevent inflated P-values. Results were found significant when $P < 0.05$.

### 3. Results

The results of the ultrasonographic measurements and mathematical calculations of the MVIDS are presented in the Table. In heifers, no significant correlation between MVIDS and milk yield following the second calving was recorded. On the other hand, in adult cows, differences regarding MVIDS, measured 50 days following the second calving, and milk production during the second lactation were found to be statistically significant. As presented, the greater the MVIDS, the higher was the milk production ($P < 0.05$).

The distance of the milk vein from the skin surface was greater for cows compared to heifers ($P < 0.05$), yet no significant relationship between the milk vein distance from the skin surface and milk production was recorded in heifers and cows.

### 4. Discussion

Our results showed that the MVIDS is in positive correlation with the milk yield in adult cows 50 days following the second calving: the greater the MVIDS, the higher the milk production. This is in concordance with the previous findings of Braun and Hoegger (17) and Huth (12), who measured the blood flow through the milk vein. As these measurements used color Doppler ultrasonography (17,18,24), to our knowledge this is the first report of the use of ultrasound to calculate the milk vein internal surface area as a prognostic criterion for predicting milk yield in cows. Our results are also supported by the previous reports of Davis and Collier (15), Kensinger et al. (16), Braun and Hoegger (17), and Braun and Forster (18) with higher blood flow in lactating compared to nonlactating cows, and in high-producing compared to low-producing cows. On the other hand, no positive correlation of the MVIDS measured in heifers (on day 50 of the first gravidity) and the milk yield in the same animal following the second calving was recorded. Hence, this measurement has no predictive value for future milk yield. These results were not surprising, since the somatic growth and development of the mammary gland continues during the first and second pregnancy in cows (25).

Dowling (26) reported that the skin of cattle is thin at birth and becomes thicker with age. Our study also found that the distance of the milk vein from the skin surface is greater in cows compared to heifers, but this showed no correlation with milk production.

Contrary to recent reports of Braun et al. (22), our study showed statistically significant correlation between the milk yield and MVIDS calculations 50 days following the 2nd calving. Differences between these two studies could be related to the small sample size (8 cows) and different breed (7 cows were Swiss Braunvieh) in the cited study. Our sample size of 80 cows of Simmental breed (a dual purpose breed: meat and milk production) included in the study could also have influenced the results due to the small sample and one breed of animals included.

Based on the reports that blood flow through the udder is higher in higher milk producing animals, and that milk veins drain 90% of the total blood volume from the mammary gland, the presented results are in agreement with our hypothesis. These results offer a simple measurement method in Simmental dairy cows by using ultrasonography for predicting the milk production level after the 2nd calving. However, these findings offer only

**Table.** Milk vein internal diameter surface and distance from the skin in heifers and cows compared to milk yield during the second lactation presented as mean, SD, min, and max.

| Group | Cows | | Heifers | |
|---|---|---|---|---|
| | MVIDS | Distance | MVIDS | Distance |
| 3800–4000 | $134.5 \pm 0.16^{a}$ (129–151) | $14 \pm 0.12^{1a}$ (11–16) | $66 \pm 0.06^{a}$ (63–69) | $8 \pm 0.12^{2a}$ (6–12) |
| 4001–4500 | $176.4 \pm 0.23^{b}$ (148–198) | $13 \pm 0.12^{1a}$ (9–15) | $63 \pm 0.11^{a}$ (57–69) | $9 \pm 0.14^{2a}$ (6–12) |
| 4501–5000 | $247.1 \pm 0.46^{c}$ (195–257) | $15 \pm 0.05^{1a}$ (14–16) | $69 \pm 0.12^{a}$ (65–71) | $7 \pm 0.12^{2a}$ (6–10) |
| 5001–6000 | $338.3 \pm 0.12^{d}$ (322–351) | $15 \pm 0.09^{1a}$ (12–16) | $69 \pm 0.22^{a}$ (62–73) | $10 \pm 0.21^{2a}$ (8–13) |
| 7000–8000 | $388.8 \pm 0.44^{e}$ (344–398) | $13 \pm 0.11^{1a}$ (10–15) | $74 \pm 0.21^{a}$ (66–79) | $9 \pm 0.32^{2a}$ (8–15) |
| 8001–8500 | $421.1 \pm 1.39^{f}$ (395–432) | $12 \pm 0.06^{1a}$ (11–14) | $73 \pm 0.09^{a}$ (70–76) | $9 \pm 0.12^{2a}$ (8–10) |

Group: Milk production (kg) during the 2nd lactation; Cows: cows following the 2nd calving; Distance: distance between the milk vein and skin surface expressed in mm; MVIDS: milk vein internal diameter surface expressed in $mm^2$.
[a,b,c,d,e,f]: Values marked with different letters within the same column differ significantly ($P < 0.05$).
[1,2]: Values marked with different numbers within the same row differ significantly ($P < 0.05$).

a predictive value for selection purposes under similar management practices, since many external and internal factors can influence milk production in lactating animals. Future larger-scale studies are warranted in order to confirm the possible correlation of the MVIDS following the first calving and future milk yield for dairy cows of different breeds. If confirmed, these results would improve predictive methodology and facilitate selection of cows on commercial dairy farms for increased milk production.

## References


1. Bickerstaffe R. Uptake and metabolism of fat in the lactating mammary gland. In: Falconer IR, editor. Lactation. London, UK: Butterworths; 1971. pp. 317–332.
2. Ray DE, Halbach TJ, Armstrong DV. Season and lactation number effects on milk production and reproduction of dairy cattle in Arizona. J Dairy Sci 1992; 75: 2976–2983.
3. Nebel RL, McGilliard ML. Interactions of high milk yield and reproductive performance in dairy cows. J Dairy Sci 1993; 76: 3257–3268.
4. Gullay MS, Haydn M, Bachman KC, Belloso T, Liboni M, Head HH. Milk production and feed intake of Holstein cows given short (30-d) or normal (60-d) dry periods. J Diary Sci 2003; 86: 2030–2038.
5. Çilek S, Tekin ME. The environmental factors effecting milk yield and fertility traits of Simmental cattle raised at Kazova State Farm and phenotypic correlations between these traits. Turk J Vet Anim Sci 2005; 29: 987–993.
6. Tekerli M, Kucukkebabci M, Akalin NH, Kocak S. Effects of environmental factors on some milk production traits, persistency and calving interval of Anatolian buffaloes. Liv Prod Sci 2001; 68: 275–281.
7. Hansen PJ. Effects of coat colour on physiological responses to solar radiation in Holsteins. Vet Rec 1990; 13: 333–334.
8. Çilek S, Tekin ME. Calculation of adjustment factors for standardizing lactations to mature age and 305 days and estimation of heritability and repeatability of standardized milk yield of Simmental cattle reared on Kazova State Farm. Turk J Vet Anim Sci 2006; 30: 283–289.
9. Catillo G, Macciotta NPP, Carretta A, Cappio-Borlino A. Effects of age and calving season on lactation curves of milk production traits in Italian water buffaloes. J Dairy Sci 2002; 85: 1298–1306.
10. Özçelik M, Arpacık R. The effect of lactation number on milk production and reproduction in Holstein cows. Turk J Vet Anim Sci 2000; 24: 39–44.
11. Budras KD, Wünsche A. Arterien, Venen und Nerven der Beckenhöhle. In: Budras KD, Wünsche A, editors. Atlas der Anatomie des Rindes: Lehrbuch für Tierärzte und Studierende. 1st ed. Hannover, Germany: Schlütersche; 2002. pp. 84–87 (in German).
12. Huth FW. Die Laktation des Rindes: Analyse, Einfluß, Korrektur. Stuttgart, Germany: Eugen Ulmer GmbH & Co.; 1995 (in German).
13. Linzell JL. Mammary-gland blood flow and oxygen, glucose and volatile fatty acid uptake in the conscious goat. J Phys 1960; 153: 492–509.
14. Gravert HO. Die Milch: Erzeugung, Gewinnung, Qualität. Stuttgart, Germany: Eugen Ulmer GmbH & Co.; 1983 (in German).
15. Davis SR, Collier RJ. Mammary blood flow and regulation of substrate supply for milk synthesis. J Dairy Sci 1985; 68: 1041–1058.
16. Kensinger MH, Collier RJ, Wilcox CJ, Caton D. Variability of resting mammary blood flow in nonlactating Holstein cows. J Dairy Sci 1983, 66: 1742–1746.
17. Braun U, Hoegger R. B-mode and colour Doppler ultrasonography of the milk vein in 29 healthy Swiss Braunvieh cows. Vet Rec 2008;163: 47–49.
18. Braun U, Forster E. B-mode and colour Doppler sonographic examination of the milk vein and musculophrenic vein in dry cows and cows with a milk yield of 10 and 20 kg. Acta Vet Scan 2012; 54: 15.
19. King A. Do milk veins indicate dairy capacity? Hoard's Dairyman 1912; 44: 523–524.
20. Becker RB. Certain points of the physiological processes of the cow: flow of venous blood from the udder. J Dairy Sci 1937; 20: 409–410.
21. Kjaersgaard P. Mammary blood flow ante and post partum in cows. Acta Vet Scan 1968; 9: 180–181.
22. Braun U, Forster E, Bleul U, Hässig M, Schwarzwald C. B-mode and colour Doppler ultrasonography of the milk vein and musculophrenic vein in eight cows during lactation. Res Vet Sci 2013; 94: 138–143.
23. Edmonson AJ, Lean IJ, Weaver LD, Farver T, Webster G. A body condition scoring chart for Holstein dairy cows. J Dairy Sci 1989; 1: 68–78.
24. Braun U, Hoegger R, Haessig M. Colour-Doppler sonography of the musculophrenic vein in cows. Vet J 2009; 179: 451–454.
25. Ferrell CL, Garrett WN, Hinman N. Growth, development and composition of the udder and gravid uterus of beef heifers during pregnancy. J Anim Sci 1976; 42: 1477–1489.
26. Dowling DF. The significance of the thickness of cattle skin. J Agri Sci 1964; 3: 307–311.