J. Dairy Sci. 100:1–14
https://doi.org/10.3168/jds.2016-11940


# Udder firmness as a possible indicator for clinical mastitis

**A. Rees, C. Fischer-Tenhagen, and W. Heuwieser[1,2]**
Clinic for Animal Reproduction, Faculty of Veterinary Medicine, Freie Universität Berlin, Koenigsweg 65, 14163 Berlin, Germany

## ABSTRACT

Swelling of the mammary gland is an important sign to detect clinical mastitis (CM) in dairy cows. The overall objective of this study was to evaluate if udder firmness can be used as a cow-side indicator for mastitis and to evaluate how CM affects firmness within 14 d after diagnosis. A dynamometer was used to objectively determine udder firmness before and after milking in 45 cows with CM and 95 healthy cows. Udder firmness of both hind quarters was measured daily on 3 locations (upper, middle, lower measuring point) from the day of mastitis diagnosis until d 7 and again on d 14. Firmness of the middle measuring point was highest before and after milking in all cows. Udder firmness before milking was similar in quarters without and with CM. Subsequently, we concentrated on firmness measured on the middle point after milking. After milking, quarters with CM were firmer than healthy quarters. An increase of firmness of a quarter with mastitis did not affect firmness of the healthy neighboring quarter, nor did firmness of all healthy quarters differ. One firmness value per cow [i.e., Δ firmness (difference in udder firmness between both hind quarters)] was used for all further calculations. After fitting a generalized mixed model, CM affected Δ firmness in all cases. In multiparous cows, Δ firmness was also affected by continuous milk yield per day and DIM. Firmness thresholds for detection of CM were calculated using receiver operation characteristic curves. The threshold for detection of CM using Δ firmness was 0.282 kg (area under the curve: 0.722, sensitivity: 64.3%, specificity: 89.7%) and 0.425 kg (area under the curve: 0.817, sensitivity: 62.5%, specificity: 96.7%) in primiparous cows and multiparous cows, respectively. Linear mixed-model ANOVA were used to evaluate how CM affects udder firmness within 14 d after diagnosis. Cows with CM had a higher Δ firmness compared with cows without CM throughout the 14 d after the mastitis diagnoses. Parity had an effect on Δ firmness. Depending on systemic signs of sickness, mastitic cows were divided into cows having mild to moderate (n = 21) or severe mastitis (n = 24). Cows with severe mastitis suffered from a firmer udder on all measuring days. Bacteriological cure was defined based on 2 milk samples taken at 7 and 14 d after enrollment. An effect of parity and bacteriological cure on Δ firmness of cows with CM did not exist within the 14 d. Cows not clinically cured showed an increased Δ firmness of 0.560 kg compared with cured cows. In conclusion, udder firmness can be a useful indicator for CM. Further research is warranted to evaluate if udder firmness can be used as a predictor for the prognosis of a CM or the cure of inflammation.
**Key words:** udder firmness, dynamometer, clinical mastitis, diagnosis

## INTRODUCTION

Mastitis is a highly relevant disease (Hertl et al., 2011, 2014) and the most common indication for the use of antimicrobial agents in dairy cows (Thomson et al., 2008). Approximately 50% of all parenterally administered antibiotics are used for the therapy of clinical mastitis (**CM**; Pol and Ruegg, 2007). A prudent use of antibiotics, however, has been emphasized and advocated as the issue is a top priority public health challenge (Oliver et al., 2011; Machado et al., 2014).

Detection of the infected quarter, however, precedes an antibiotic therapy of CM (Oliver et al., 2011). Clinical symptoms to detect CM include changes in milk characteristics and redness, swelling, and warming of the infected quarter. Besides checking the milk for abnormalities, determination of udder firmness is a plausible and practical method to diagnose this disease as an increased firmness is a manifestation of the swelling (i.e., increase of udder tissue consistency). Veterinarians and farmers frequently base treatment decisions on clinical symptoms of the udder (Swinkels et al., 2015). Udder firmness, however, seems to be a difficult variable to determine correctly (Fossing et al., 2006). Also, no data are available to quantitatively define a healthy udder using specific thresholds for udder firmness. Be-

Received August 30, 2016.
Accepted November 22, 2016.
[1]Current address: Department of Population Medicine and Diagnostic Sciences, College of Veterinary Medicine, Cornell University, Ithaca, NY 14853.
[2]Corresponding author: w.heuwieser@fu-berlin.de

sides a description in a textbook (Rosenberger et al., 1990), data are not available to objectively differentiate healthy from affected udders. Furthermore, farmers' insecurity in mastitis therapy and frequent occurrence of extended treatment of CM has been described (Swinkels et al., 2015). Therefore, more research is warranted on the evolution of clinical criteria (Swinkels et al., 2015) and specific guidelines are needed to provide differentiation between cows without and with CM. The timely detection of signs of CM would also allow shorter and more effective drug treatments (Trevisi et al., 2014).

It was demonstrated (Bertulat et al., 2012; Rees et al., 2014) that udder firmness in healthy cows could be determined with a good repeatability by trained observers by using an electronic handheld device (i.e., a dynamometer). Furthermore, a preliminary comparison between cows with and without CM indicated that the milking induced decrease of udder firmness was lower in mastitic quarters (Rees et al., 2013). In this study, however, cows with CM were included on different days relative to the onset of infection (0 to 72 d). Thus, different stages of CM were included confounding the results.

Therefore, the overall objective of this study was to evaluate if udder firmness can be used as a cow-side indicator for mastitis. Specifically, we set out to (1) establish firmness thresholds for the differentiation between cows without and with CM and (2) to evaluate how CM affects udder firmness within 14 d after diagnosis.

## MATERIALS AND METHODS

### Housing and Animals

The study was conducted from April 2014 to August 2014 on a commercial dairy farm milking 1,200 Holstein-Friesian dairy cows in Sachsen-Anhalt, Germany. Cows were housed in a free-stall barn with slatted floors and cubicles equipped with rubber mats. They were grouped regarding parity (primiparous and multiparous) throughout the whole lactation. Cows were fed a TMR consisting of 38.5% corn silage, 35.9% concentrate mineral mix, 22.5% grass silage, and 3.1% barley straw. Feed was delivered via a conveyer belt system 10 times per day. All cows had ad libitum access to water. Cows were milked 3 times a day during 3 milking shifts from 0700 to 1400 h and 1500 to 2200 h and 2300 to 0600 h in a 52-stall external rotary milking parlor (Lemmer-Fullwood GmbH, Lohmar, Germany). Each stall was equipped with a digital display that reported milk yield per cow and current milking. The average 305-d milk yield was 10,147 kg (4.04% fat and 3.35% protein). During the study period, average SCC was 250,000 per mL of bulk tank milk and incidence of CM was 24 cases per 100 cow-years.

### Mastitis Management

The milking personnel checked all cows before each milking for signs of CM by visually examining foremilk on a dark surface as the standard procedure. An udder quarter was diagnosed as having CM when clots or flakes in foremilk samples were observed. Based on a severity classification system described previously (Oliveira et al., 2013), such a case was defined as a mild to moderate case of CM. Because *Streptococcus uberis* was known to be the dominant pathogen causing CM on this farm, the infected quarter was treated with an intramammary infusion of 3,000,000 IU of procaine benzyl penicillin (Procain-Penicillin-G Injektor aniMedica, 300 mg/mL, Selactavet, Weyarn-Holzolling, Germany) every 24 h for 3 consecutive days. When signs of generalized sickness such as reduced feed intake, dullness, or a rectal temperature above 39.5°C were present, the case was considered severe (Oliveira et al., 2013) and intramammary treatment was complemented by parenterally administered antibiotic and nonsteroidal anti-inflammatory drugs. Specifically, 10,000 IU of penethamate hydriodide (Mamyzin, Boehringer Ingelheim GmbH, Ingelheim, Germany) and 2.0 mg of marbofloxacin (Odimar 100 mg/mL, Animalcare Limited, Dunnington, United Kingdom) and 0.5 mg of meloxicam (Melovem 20 mg/mL, Dopharma Research B.V., Raamsdonksveer, the Netherlands) or 2.2 mg of flunixin meglumine (Finadyne, MSD Animal Health GmbH, Luzern, Switzerland) per kilogram of BW were administered intramuscularly or intravenously in the latter case. Additional intramammary treatment was administered (and if necessary changed) according to the culture results and susceptibility testing. An intramammary infusion of 200 mg of cefalexin and 100,000 IU of kanamycin (Ubrolexin, Boehringer Ingelheim Vetmedica GmbH, Ingelheim/Rhein, Germany) or 100 mg of cefoperazon (Peracef, Zoetis Österreich GmbH, Wien, Austria) twice in a period of 24 h completed treatment of mastitis caused by pathogens not susceptible to procaine benzyl penicillin. All treatments were documented in the on-farm computer program (Herde, Agrosoft, Paretz, Germany).

Cows with signs of CM diagnosed by the milking personnel were moved to the mastitis pen. They were reintroduced into the production groups when the withdrawal period for milk had expired and the appearance of the milk had returned to normal. Cubicles in the mastitis pen were equipped with rubber mats and covered by a 10-cm layer of recycled manure solids from the on-site biogas plant. All cubicles were cleaned