Effects of xylazine hydrochloride on hormonal, metabolic, and cardiorespiratory stress responses to lateral recumbency and claw trimming in dairy cows

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Objective—To investigate the hormonal, metabolic, and cardiorespiratory effects of xylazine hydrochloride on dairy cows undergoing lateral recumbency and claw trimming.

Design—Prospective crossover study.

Animals—6 healthy Holstein-Friesian cows.

Procedures—Cows were treated with xylazine (0.05 mg/kg [0.023 mg/lb], IM) or an equal volume of saline (0.9% NaCl) solution 15 minutes before being placed in lateral recumbency for claw trimming. As a third treatment, cows also received xylazine (0.05 mg/kg, IM) but underwent no further manipulation. At preset time intervals, heart rate (HR), respiratory rate (RR), systolic arterial blood pressure, diastolic arterial blood pressure, mean arterial blood pressure (MAP), blood gas values, and plasma concentrations of cortisol, insulin, glucose, lactate, and nonesterified fatty acids (NEFA) were measured, and signs of sedation and ruminal bloat were recorded.

Results—Saline solution treatment resulted in a temporary significant increase in SAP, diastolic arterial blood pressure, MAP, RR, and cortisol, lactate, and NEFA concentrations and a significant decrease in arterial oxygen saturation (SaO2). Xylazine treatment induced significant decreases in HR, RR, MAP, insulin and NEFA concentrations, and SaO2 and induced significant increases in glucose concentration. Compared with saline solution treatment, HR, RR, MAP, SaO2, and cortisol, lactate, and NEFA concentrations were significantly decreased with xylazine treatment. Xylazine treatment resulted in mild signs of sedation as well as clinically negligible ruminal bloat.

Conclusions and Clinical Relevance—Xylazine administered in a low dose to cows preceding lateral recumbency for claw trimming decreased hormonal and metabolic stress responses, but augmented the respiratory depressive effect of lateral recumbency reflected by a decreased PaCO2 and increased Paco2. (J Am Vet Med Assoc 2012;240:1223–1230)

Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>BE</td>
<td>Base excess</td>
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<tr>
<td>DAP</td>
<td>Diastolic arterial blood pressure</td>
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<td>MAP</td>
<td>Mean arterial blood pressure</td>
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<td>NEFA</td>
<td>Nonesterified fatty acids</td>
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<tr>
<td>PLR</td>
<td>Placebo-lateral recumbency</td>
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<td>SaO2</td>
<td>Arterial oxygen saturation</td>
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<td>SAP</td>
<td>Systolic arterial pressure</td>
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<td>SID</td>
<td>Strong ion difference</td>
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<td>XLR</td>
<td>Xylazine-lateral recumbency</td>
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<td>XSt</td>
<td>Xylazine-standing</td>
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The growing concern about the welfare of farm animals has emphasized the need for analgesic protocols not only for painful surgical interventions, but also for routine procedures, which may be intensely stressful to the animal. A common method of restraining cows for claw trimming and minor claw treatment is placement in lateral recumbency on a surgical tipping table. This type of restraint, however, is perceived to cause considerable stress to the animal. Alpha-2-Adrenoceptor agonists such as xylazine have dose-dependent, strong sedative, moderate analgesic, and myorelaxing effects in cattle. Adverse effects of alpha-2-adrenoceptor agonists include cardiopulmonary depression such as bradycardia, bradypnea, hypotension, hypoxemia, and hypercapnia. As a result of the considerable weight of the cow's visceral organs and the increased pressure imposed onto the abdominal vessels, lateral recumbency is known to impede the venous blood return to the heart, resulting in cardiopulmonary depression. Concern exists that sedation of cows restrained in lateral recumbency may possibly enhance the cardiorespiratory depressive effect caused by lateral recumbency. Therefore, the purpose of the study reported here was to investigate the effect of sedation with xylazine on cardiopulmonary, endocrine, and metabolic stress response in dairy cows undergoing...
painless claw trimming while in lateral recumbency on a surgical tipping table.

**Materials and Methods**

The study was approved by the Ethical Animal Care and Use Committee of the Federal State of Lower Saxony, Germany.

Experimental animals, housing, and feeding—This study included 6 healthy nonpregnant nonlactating Holstein-Friesian cows (age, 4.37 ± 3.27 years; body weight, 610 ± 87.9 kg [1,342 ± 193 lb]). All cows were clinic owned and kept in open free stalls at the Clinic for Cattle of the University of Veterinary Medicine Hanover, Germany; were fed a diet consisting of hay and 1 kg of concentrate; and had free access to water.

Study design and treatments—The study was performed in a crossover design in which the 6 cows were paired, and each pair of cows received 3 treatments in a different sequence. Intervals between treatments were 3 weeks. Animals were randomly selected by lot for allocation to pairs and treatment sequences.

To allow differentiation between the effects of xylazine, lateral recumbency, and the combination of xylazine and lateral recumbency, the following treatment protocols were chosen: 15 minutes prior to claw trimming in left lateral recumbency (lateral recumbency duration, 30 minutes), cows received either xylazine (ie, XLR treatment, 0.05 mg/kg [0.02 mg/lb], IM) or an equal volume of saline (0.9% NaCl) solution (ie, PLR treatment). As a third treatment protocol, xylazine was administered at the same dosage and route as for XLR-treated cows, but cows remained standing without further manipulations (ie, XSt treatment). The right anococcygeus muscle was used for IM injections. All treatments were performed by a person unrelated to the study, ensuring the examiner remained blinded to treatments in XLR-treated and PLR-treated cows.

Hydraulic table—Feed was not withheld from cows before treatments. Cows had access to water and hay at all times, and the last concentrate feeding (1 kg) was approximately 2 hours before the procedure. All cows wore a head halter with a 1.5-m-long rope attached that was used to guide the cows to the hydraulic tipping table. The entire table was padded with a rubber mat, and an extra rubber cushion was placed under the left front limb to avoid muscular and nerve damage during lateral recumbency. The cow's head was fixed to the table with a neck belt, and the abdominal and thoracic belts were tightened thoroughly, while ensuring that thoracic movements were not substantially inhibited. Thereafter, the table's hydraulic system was used to place cows horizontally on their side, and the 2 hind legs were fixed tightly at the center of the metatarsus to leg pads. All cows in this study were familiar with human contact and handling and had previous experiences with claw trimming while in lateral recumbency on the surgical tipping table.

Instrumentation—in all cows, an indwelling catheter was placed into the right caudal auricular artery and the right jugular vein after surgical preparation of the skin and local anesthesia 2 hours before the experimental procedure started. The arterial catheter was inserted by use of the Seldinger technique, as described by Muller and Goetze, and immediately connected to a calibrated electromechanical transducer via a fluid filled extension set. The jugular vein catheter was sutured to the skin and additionally secured with adhesive tape. The auricular artery catheter was continually flushed with heparinized saline solution (3 mL/h), while the jugular vein catheter was flushed with heparinized saline solution after insertion and each blood sampling. Both catheters were equipped with 3-way stopcocks and were removed after the experiment was finished.

Monitoring SAP, DAP, and MAP—Measurements of SAP, DAP, and MAP were continuously recorded from the arterial catheter by means of a fluid-filled extension connected to an electromechanical transducer. The level of the shoulder joint was considered as the zero pressure point in standing cows, and the center of the thorax was used during lateral recumbency. A bipolar ECG was used to monitor heart rate (beats/min). Respiratory rate was measured by counting thoracic excursions for a period of 1 minute.

Blood gas variables were analyzed in arterial blood samples that were collected anaerobically into heparinized syringes, placed on ice immediately after collection, and analyzed within 15 minutes of sampling with an automated blood gas analyzer after prior adjustment for body temperature and hemoglobin concentration. Arterial measurements of Pao, and Paco, BE, SaO, and pH were analyzed.

Hormonal and metabolic variables—Heparinized venous blood samples were collected at short-term intervals and immediately centrifuged for 10 minutes at 1,500 X g. Plasma was stored at −20°C until analyzed for cortisol and insulin content. Plasma glucose, NEFA, and lactate concentrations were measured by use of an automated analyzer with commercial test kits. Sodium (Na), potassium (K), and chloride (Cl) were measured with ion-sensitive electrodes on an automated analyzer. As described by Constable, the SID was calculated by means of the following equation: SID = [Na + K] − [Cl].

Clinical signs—Five characteristically clinical indicators of sedation (change from initial attitude, head lowering, ptosis, ptysalism, and ability to stand) were scored (score 0 = no change, 1 = mild change, 2 = moderate change, and 3 = severe change) and added to obtain a total clinical sedation score (range, 0 to 15). An overall sedation score of 0 through 7 was assigned to each cow on the basis of total clinical sedation score as follows: an overall sedation score of 0 was derived from a total clinical sedation score of 0 or 1, score of 1 reflected a total clinical score of 2 or 3, score of 2 reflected a total clinical score of 4 or 5, score of 3 reflected a total clinical score of 6 or 7, score of 4 reflected a total clinical score of 8 or 9, score of 5 reflected a total clinical score of 10 or 11, score of 6 reflected a total clinical score of 12 or 13, and an overall sedation score of 7 reflected a total clinical sedation score of 14 or 15. Furthermore, the occurrence of ruminal bloat was scored according to the degree of bulge and elastic tension in the dorsal part of the left flank (score 0 = none, 1 = mild, 2 = moderate, 3 = severe, and 4 = life threatening).
Study protocol—The time of administration of drugs was set as time 0. Baseline values were determined 15 minutes before drug administration (~15). During each treatment protocol, the SAP, DAP, MAP, heart rate, and respiratory rate were recorded and blood samples were drawn for analysis of blood gas tensions and endocrine-metabolic variables at ~15, 15, 30 (first value while in lateral recumbency), 45, 60 (last value while in lateral recumbency), 75, 105, 135, 195 minutes. Clinical variables were recorded at ~15, 15, 75, 105, 135, and 195 minutes after drug administration.

Statistical analysis—Data were analyzed with a software program. Continuous data were analyzed by use of 2-factorial ANOVAs for repeated measurements (factor: treatment, time, and time * treatment) at each time point; multiple comparisons of treatment means were performed, provided the F test was significant (P < 0.05). Within different treatments, means at different time points were compared with baseline values via the paired t test. Clinical signs scores were analyzed with the Wilcoxon rank sum test for statistical differences. The level of significance was set at P < 0.05. Data are presented as mean ± SEM.

Results

Clinical signs—The mean sedation scores in XLR- and XSt-treated cows were significantly higher, compared with scores for cows in lateral recumbency without xylazine treatment (PLR-treated cows; Table 1). Ruminal bloat was mild overall (score 1) in both XLR- and XSt-treated cows. Independent of the treatment, the entire procedure of placing cows from lateral recumbency and back into standing position was always uncomplicated and never required more than gentle and patient verbal encouragement and moderate nudging at the hip area towards the table. After lateral recumbency, all cows moved calmly and patiently back to the stable.

Cardiorespiratory response—Mean heart rate was not affected by lateral recumbency alone (PLR-treated cows), while a decrease in heart rate was induced in both treatment protocols involving xylazine (XLR-treated and XSt-treated cows; Table 2).

Table 1—Mean ± SEM heart rate (HR), respiratory rate (RR), SAP, DAP, and MAP in cows that were placed in lateral recumbency (time, 30 to 60 minutes) following IM injection (time 0) of placebo (PLR treatment) or xylazine (XLR treatment) or that remained standing after xylazine administration (XSt treatment). A crossover study was performed in which 6 cows were paired, and each pair received 3 treatments in a different sequence; the interval between treatments was 3 weeks.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Treatment</th>
<th>Time after treatment (min)</th>
<th>-15</th>
<th>15</th>
<th>30</th>
<th>45</th>
<th>60</th>
<th>75</th>
<th>105</th>
<th>135</th>
<th>195</th>
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<tbody>
<tr>
<td>HR (beats/min)</td>
<td>PLR</td>
<td>73 ± 3.5</td>
<td>72 ± 3.5</td>
<td>76 ± 6.1</td>
<td>72 ± 4.0</td>
<td>72 ± 3.4</td>
<td>77 ± 4.9</td>
<td>70 ± 2.9</td>
<td>67 ± 1.7</td>
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<tr>
<td></td>
<td>XLR</td>
<td>69 ± 5.2</td>
<td>61 ± 4.1</td>
<td>53 ± 2.9</td>
<td>50 ± 2.4</td>
<td>51 ± 4.0</td>
<td>48 ± 1.9</td>
<td>50 ± 2.1</td>
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<td>50 ± 3.2</td>
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</tr>
<tr>
<td></td>
<td>XSt</td>
<td>62 ± 6.1</td>
<td>43 ± 2.9</td>
<td>44 ± 2.3</td>
<td>42 ± 3.0</td>
<td>46 ± 1.9</td>
<td>47 ± 2.0</td>
<td>48 ± 1.9</td>
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<td>50 ± 3.0</td>
<td>TxG &lt; 0.001</td>
</tr>
<tr>
<td>RR (breaths/min)</td>
<td>PLR</td>
<td>26 ± 3.9</td>
<td>16 ± 1.1</td>
<td>15 ± 2.2</td>
<td>16 ± 3.3</td>
<td>16 ± 3.8</td>
<td>15 ± 2.1</td>
<td>14 ± 1.5</td>
<td>15 ± 1.7</td>
<td>16 ± 2.0</td>
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</tr>
<tr>
<td></td>
<td>XLR</td>
<td>28 ± 5.1</td>
<td>14 ± 1.8</td>
<td>12 ± 0.4</td>
<td>12 ± 0.7</td>
<td>13 ± 1.2</td>
<td>15 ± 2.0</td>
<td>16 ± 2.3</td>
<td>16 ± 2.0</td>
<td>22 ± 3.2</td>
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<tr>
<td></td>
<td>XSt</td>
<td>136 ± 5</td>
<td>137 ± 6</td>
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<td>166 ± 7</td>
<td>143 ± 7</td>
<td>138 ± 5</td>
<td>127 ± 5</td>
<td>135 ± 6</td>
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<td>SAP (mm Hg)</td>
<td>PLR</td>
<td>92.6 ± 5</td>
<td>70.5 ± 3</td>
<td>81.3 ± 4</td>
<td>89.0 ± 5</td>
<td>89.0 ± 3</td>
<td>102 ± 5</td>
<td>105 ± 5</td>
<td>103 ± 5</td>
<td>106 ± 5</td>
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<tr>
<td></td>
<td>XLR</td>
<td>92.6 ± 5</td>
<td>70.5 ± 3</td>
<td>81.3 ± 4</td>
<td>89.0 ± 5</td>
<td>89.0 ± 3</td>
<td>102 ± 5</td>
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<td>106 ± 5</td>
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</tr>
<tr>
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<td>80.0 ± 3</td>
<td>81.3 ± 4</td>
<td>90.0 ± 3</td>
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<td>90.0 ± 3</td>
<td>90.0 ± 3</td>
<td>90.0 ± 3</td>
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<td>DAP (mm Hg)</td>
<td>PLR</td>
<td>107 ± 4</td>
<td>106 ± 3</td>
<td>134 ± 6</td>
<td>132 ± 6</td>
<td>135 ± 7</td>
<td>113 ± 8</td>
<td>114 ± 4</td>
<td>110 ± 5</td>
<td>107 ± 6</td>
<td>T &lt; 0.006</td>
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<tr>
<td></td>
<td>XLR</td>
<td>116 ± 6</td>
<td>106 ± 3</td>
<td>130 ± 5</td>
<td>107 ± 5</td>
<td>120 ± 6</td>
<td>113 ± 6</td>
<td>111 ± 6</td>
<td>111 ± 6</td>
<td>105 ± 5</td>
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<tr>
<td></td>
<td>XSt</td>
<td>115 ± 4</td>
<td>104 ± 3</td>
<td>99 ± 3</td>
<td>103 ± 4</td>
<td>103 ± 5</td>
<td>101 ± 5</td>
<td>110 ± 6</td>
<td>110 ± 5</td>
<td>109 ± 3</td>
<td>TxG &lt; 0.001</td>
</tr>
</tbody>
</table>

G = Treatment effect. NS = Not significant. T = Time effect. TxG = Time × treatment effect.

See Table 1 for remainder of key.
In contrast to the significant increase observed in SAP, DAP, and MAP during the period of lateral recumbency (30 to 60 minutes), blood pressure values were significantly decreased in XSt-treated cows. In XLR-treated cows, no significant increase in SAP, DAP, and MAP, compared with baseline values, was observed, but values at 30 and 45 minutes were significantly decreased, compared with that of PLR-treated cows.

Mean respiratory rate increased significantly in PLR-treated cows during lateral recumbency, compared with baseline, and was significantly increased in relation to that of XLR-treated and XSt-treated cows, in which a decrease in respiratory rate occurred after xylazine treatment (Table 2).

Lateral recumbency alone (PLR-treated cows) and xylazine treatment alone (XSt-treated cows) induced a significant decrease from baseline for PaO\(_2\) and SaO\(_2\), compared with baseline values. Mean PaO\(_2\), and SaO\(_2\) were significantly lower during the period of lateral recumbency in cows that were pretreated with xylazine (XLR-treated cows), compared with that of PLR-treated and XSt-treated cows (Table 3). While none of the XSt-treated and PLR-treated cows developed a SaO\(_2\) of < 92%, the SaO\(_2\), in 4 of 6 XLR-treated cows decreased to values below 92% (minimum SaO\(_2\), 90%).

Mean PaCO\(_2\) increased significantly by approximately 10% after xylazine administration (XLR-treated and XSt-treated cows), compared with baseline values. This effect was more prominent in XLR-treated cows than in PLR-treated cows for which mean PaCO\(_2\) remained almost unchanged (Table 3).

Mean arterial pH remained almost unchanged during all treatment protocols throughout the experimental period. No changes in mean arterial BE were seen in PLR-treated cows, whereas a significant increase in BE and SID was seen after xylazine treatment in cows that remained standing (XSt-treated cows) or underwent lateral recumbency (XLR-treated cows; Table 3).

**Endocrine stress response**—Mean plasma cortisol concentrations were significantly higher during lateral recumbency in PLR-treated cows, compared with those in XLR-treated and XSt-treated cows, while plasma cortisol concentrations in XLR-treated cows were higher during the period they spent in lateral recumbency, compared with that of XSt-treated cows. Mean plasma insulin concentrations of PLR-treated cows remained almost unchanged during the experimental period, although xylazine induced a transient but significant decrease in the insulin concentration, starting 15 to 30 minutes after administration and lasting for 75 and 60 minutes in XLR-treated and XSt-treated cows, respectively (Table 4).

**Metabolic stress response**—While mean plasma concentrations of glucose and NEFA remained unchanged during lateral recumbency after placebo administration (PLR-treated cows; Table 4), glucose concentrations were significantly increased and NEFA concentrations were significantly decreased by xylazine treatment in cows restrained in lateral recumbency and those that remained standing (XLR-treated and XSt-treated cows). Furthermore, significantly higher mean plasma lactate concentrations were seen in PLR-treated cows during lateral recumbency, compared with both xylazine-treatment protocols (XLR-treated and XSt-treated cows).

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**Table 3:** Mean ± SEM values of PaO\(_2\), PaCO\(_2\), SaO\(_2\), pH, BE, and SID in cows that were placed in lateral recumbency (time, 30 to 60 minutes) following IM injection (time 0) of placebo (PLR treatment) or xylazine (XLR treatment) or that remained standing after xylazine administration (XSt treatment). A crossover study was performed in which 6 cows were paired, and each pair received 3 treatments in a different sequence; the interval between treatments was 3 weeks.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Treatment</th>
<th>-15</th>
<th>15</th>
<th>30</th>
<th>45</th>
<th>60</th>
<th>75</th>
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<th>Effect</th>
<th>P value</th>
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<tbody>
<tr>
<td>PaO(_2) (mm Hg)</td>
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<td>97.2</td>
<td>97.2</td>
<td>96</td>
<td>95.5</td>
<td>96</td>
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<tr>
<td>PaCO(_2) (mm Hg)</td>
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<tr>
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<td>PLR</td>
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See Tables 1 and 2 for key.
implying a decreased stress experience in the sedated cows, compared with that of PLR-treated cows, although painless, may have provoked a stronger stress response. The opposing results in the present study may be due to the low dose of xylazine used, allowing cows to stand, walk, and respond to human contact and handling and therefore may have perceived manipulations as less stressful than did calves.

In the present study, the PLR-treated cows had an almost unchanged heart rate but a significant increase in SAP, MAP, and DAP during lateral recumbency. The mild hypertension may be attributed to the stress-induced secretion of catecholamine during restraint and may be a consequence of visceral organs during lateral recumbency. The cows returned to the stable. The ruminal bloat was still able to stand and walk. After xylazine treatment, lasting for 1 to 2 hours. With the low xylazine dose, cows were still able to stand and walk. After xylazine treatment, only mild signs of ruminal bloat were seen, which disappeared without further intervention shortly after the cows returned to the stable. The ruminal bloat was most likely attributed to the inhibitory effect of xylazine on rumen motility by stimulation of the α2-adrenergic receptors in the forestomach musculature.9

The increase in plasma cortisol concentrations in PLR-treated cows confirmed the results of previous reports8,11 that placing cows in lateral recumbency on a surgical tipping table, which itself is a painless procedure, is nevertheless stressful to cows. In cows sedated with xylazine before lateral recumbency (XLR-treated cows), the increase in plasma cortisol was significantly decreased, compared with that of PLR-treated cows, implying a decreased stress experience in the sedated cows during lateral recumbency. Thus, similarly, Flecknell et al.11 attributed the lower plasma cortisol concentrations in xylazine-treated calves during and after disbudding to the sedative and analgesic effects of xylazine.

In the present study, xylazine treatment per se left plasma cortisol concentrations unchanged in cows that remained standing. In contrast, Stilwell et al.12 who studied the effects of different protocols of analgesia for dehorning calves on plasma cortisol concentrations, found an increase in plasma cortisol concentration in xylazine-sedated calves before any procedures had been performed. The authors hypothesized that the effect of muscle relaxation by xylazine induced stress to the calves by limiting their ability to react to human proximity and contact. The opposite results in the present study may be due to the low dose of xylazine used, allowing cows to stand, walk, and respond to human contact despite a slight attenuation through the mild sedation. Moreover, cows in the present study were used to human contact and handling and therefore may have perceived manipulations as less stressful than did calves.

The authors assumed the decrease in MAP to be caused by increased venous blood return to the heart due to compression of large abdominal vessels by the weight of visceral organs during lateral recumbency. The cows in the present study did not have food restricted before the procedure and thus had a completely filled rumen when the experimental procedures started. However, in accordance with Wagner et al.13 the divergent results in MAP in the present study may be due to the fact that cows were placed in left lateral recumbency to avoid or at least to reduce the compression of large abdominal vessels by the rumen. Another explanation may be the additional claw trimming performed in our cows during lateral recumbency. The manipulation at the claws, although painless, may have provoked a stronger stress effect on MAP.
response in our cows, compared with those in the study by Wagner et al. In comparison with baseline values and that of PLR-treated cows, mean heart rate of cows during both xylazine-treatment protocols (XLR-treated and XSt-treated cows) decreased significantly by approximately 30% for > 3 hours, irrespective of whether cows remained standing or were placed in lateral recumbency. A decrease in heart rate is considered a common response after administration of α₂-adrenoceptor agonists in cattle and is caused by a CNS decrease in sympathetic activity, leading to a relative increase in vagal tone. Despite the considerably decreased heart rate after xylazine treatment, MAP increased slightly after cows were placed in lateral recumbency, which is presumably mediated by a stress-induced release of catecholamine and thereby increased systemic vascular resistance.

In the present study, lateral recumbency resulted in polypnea in cows, which may be related to excitement, discomfort, or struggling during restraint as previously reported for cattle and ponies. In contrast, Wagner et al recorded no significant changes in respiratory rate during dorsal and lateral recumbency in conscious cattle. Despite the increased respiratory rate in PLR-treated cows during lateral recumbency, Pao₂ and SaO₂ decreased, whereas the PaCO₂ remained almost unchanged. Large animals such as horses and cattle are particularly susceptible to compression of the lung because of the weight of abdominal viscera pressing against the diaphragm during lateral recumbency. Hypoventilation of compressed lung areas and ventilation-perfusion mismatch during lateral recumbency may lead to insufficient oxygenation of the blood. To shunt the blood into well-ventilated areas of the lung, vasoconstriction will occur in the hypoxic lung areas, which may result in mixing unoxygenated blood from hypoxic lung areas and oxygenated blood from well-ventilated lung areas in the left side of the heart. As a result, the Pao₂ can decrease by 35% in adult cows positioned in dorsal or lateral recumbency.

The decrease in respiratory rate following treatment with xylazine in cows either in a standing position or in lateral recumbency might be attributed to the direct depression of xylazine on respiratory centers in the brain of cattle. Similar observations had been obtained before in cattle, sheep, and calves. Xylazine administration alone induced hypoventilation and led to mild hypoxemia and hypocapnia. When xylazine-treated cows were placed in lateral recumbency, a further decrease of Pao₂ and an increase of PaCO₂ were observed. The mean SaO₂ of approximately 93% during lateral recumbency was slightly yet significantly lower in XLR-treated cows than in PLR-treated and XSt-treated cows. To maintain adequate oxygenation of peripheral tissues in cattle, SaO₂ values > 92% are considered to be sufficient. However, in 4 of 6 XLR-treated cows, the SaO₂ decreased marginally below this threshold, while in PLR-treated and XSt-treated cows, values never decreased to < 92%. Thus xylazine treatment, even in the low dose of 0.03 mg/kg, slightly aggravates the respiratory depression effect of lateral recumbency. As higher doses of xylazine are associated with profound hypoxemia and hypercapnia, the use of xylazine in higher doses than administered to cows in the present study cannot be recommended without providing extra oxygen to avoid insufficient tissue oxygenation.

While mean plasma lactate concentrations in PLR-treated cows significantly increased during lateral recumbency, compared with baseline values, lactate concentrations in cows during both xylazine-treatment protocols remained almost unchanged. Lactate is a metabolic product of anaerobic glycolysis and thus an insufficient oxygenation of peripheral muscular tissues are not induced by the low-dose xylazine treatment. On the other hand, hypoinsulinemia was observed in the present study in all cows after xylazine treatment. This is a well-known effect of xylazine and is attributable to inhibition of the insulin release by activation of α₂-receptors on pancreatic β-cells, which consequently leads to hyperglycemia. Thus, the unchanged mean plasma lactate concentration in XLR-treated cows may be a result of decreased glucose use in peripheral tissues. Although SaO₂ was significantly higher in PLR-treated cows than in XLR-treated cows during lateral recumbency, in PLR-treated cows, mean lactate concentrations increased significantly, indicating anaerobic glycolysis and decreased oxygenation in peripheral tissues. We assume that the higher plasma lactate concentrations were caused by stress-induced catecholamine release in PLR-treated cows, provoking vasoconstriction and, in turn, decreased oxygen delivery to peripheral tissues. Another explanation could be the stress during lateral recumbency, possibly inducing a higher toxicity and thereby metabolism of muscles with enhanced metabolic glucose consumption.

During both xylazine-treatment protocols, whether cows remained standing or were placed in lateral recumbency on the tilt table, we found that xylazine induced a mild and fully metabolically compensated respiratory acidosis as indicated by an unchanged blood pH and an increase in Pao₂, BE, and SID. No imbalance in the acid base status was observed in PLR-treated cows.

Cattle respond to stress challenges with an increase in blood glucose and NEFA concentrations as a result of the activation of the hypophysial-pituitary axis and catecholamine release. Although we found a distinct increase in plasma cortisol concentration in PLR-treated cows during lateral recumbency, no significant changes were found for plasma glucose and NEFA concentrations, indicating that restraint in lateral recumbency is not experienced as considerable stress by cows that are used to human contact and handling. After cows were pretreated with xylazine, plasma NEFA concentrations even decreased, compared with baseline and placebo controls during lateral recumbency. The decrease in plasma NEFA concentration reflects a decrease in stress-mediated lipolysis, which may be caused by activation of both central and peripheral α₂-adrenoceptors, as previously reported for humans and calves. This xylazine effect is particularly advantageous in cows in early lactation, which are commonly in negative energy balance and are affected by enhanced lipid mobilization and fatty liver.

The procedure of placing XLR-treated and PLR-treated cows in lateral recumbency on the tilt table was
uncomplicated and possible without the use of force, presumably because the cows used in the present study were well acclimatized to human contact. In our opinion, for cows accustomed to calm and gentle handling from an early age as suggested by Waiblinger et al., the use of xylazine is not implicitly indicated for restraining in lateral recumbency on hydraulic surgery tables. Nevertheless, our results indicated that cows experience restraint in lateral recumbency as mild stress even when handled appropriately, and this stressful experience can be decreased by pretreatment with xylazine.

According to results of cardiovascular (MAP), hormonal (cortisol), and metabolic (lactate and NEFA) stress response, the preemptive low-dose xylazine treatment (0.05 mg/kg) of adult dairy cows can alleviate stress experienced during claw trimming while in lateral recumbency on a hydraulic tipping table. Taking into account the cow’s individual temperament and handling experience, the desired effects of sedation and analgesia have to be carefully weighed against the adverse effect of a further decrease of Pao2 and increase in Paco2 induced by lateral recumbency in dairy cows.

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ride and their reversal with atipamezole hydrochloride in calves. 

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**From this month’s AJVR**

**Comparison of four ventilatory protocols for computed tomography of the thorax in healthy cats**

Natalia Henao-Guerrero et al

**Objective**—To identify ventilatory protocols that yielded good image quality for thoracic CT and hemodynamic stability in cats.

**Animals**—7 healthy cats.

**Procedures**—Cats were anesthetized and ventilated via 4 randomized protocols (hyperventilation, 20 seconds [protocol 1]; single deep inspiration, positive inspiratory pressure of 15 cm H2O [protocol 2]; recruitment maneuver [protocol 3]; and hyperventilation, 20 seconds with a positive end-expiratory pressure of 5 cm H2O [protocol 4]). Thoracic CT was performed for each protocol; images were acquired during apnea for protocols 1 and 3 and during positive airway pressure for protocols 2 and 4. Heart rate; systolic, mean, and diastolic arterial blood pressures; blood gas values; end-tidal isoflurane concentration; rectal temperature; and measures of atelectasis, total lung volume (TLV), and lung density were determined before and after each protocol.

**Results**—None of the protocols eliminated atelectasis; the number of lung lobes with atelectasis was significantly greater during protocol 1 than during the other protocols. Lung density and TLV differed significantly among protocols, except between protocols 1 and 3. Protocol 2 TLV exceeded reference values. Arterial blood pressure after each protocol was lower than before the protocols. Mean and diastolic arterial blood pressure were higher after protocol 3 and diastolic arterial blood pressure was higher after protocol 4 than after protocol 2.

**Conclusions and Clinical Relevance**—Standardization of ventilatory protocols may minimize effects on thoracic CT images and hemodynamic variables. Although atelectasis was still present, ventilatory protocols 3 and 4 provided the best compromise between image quality and hemodynamic stability. (Am J Vet Res 2012;73:646–653)