Clinical evaluation of established optimal immobilizing doses of medetomidine-ketamine in captive reindeer (*Rangifer tarandus tarandus*)

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**Objective**—To evaluate clinical effects and repeatability of clinical effects for an optimal immobilizing dose of a combination of medetomidine hydrochloride (MED) and ketamine hydrochloride (KET) in reindeer (*Rangifer tarandus tarandus*).

**Animals**—12 healthy 6- to 8-month old reindeer.

**Procedure**—Each reindeer was immobilized once with an initial dose (combination of 0.06 mg of MED/kg of body weight and 0.3 mg KET/kg) and twice with an optimal dose of MED-KET. Reversal was achieved with 5 mg of atipamezole/mg of MED injected 45 minutes after MED-KET administration. Observational variables were recorded. Oxygen saturation of arterial hemoglobin measured by pulse oximetry (SpO2), respiratory rate (RR), heart rate (HR), and rectal temperature (RT) were recorded 10, 25, and 40 minutes after immobilization.

**Results**—Mean time to first sign of sedation and time until a recumbent animal lifted its head were significantly reduced for reindeer given the optimal dose, compared with the initial dose. Mean SpO2 remained > 90% during initial immobilization; this value was significantly lower for the optimal dose, but increased during immobilization from 85 to 89%. At all doses, RR increased significantly throughout the recorded period; however, RT and HR were constant. Except for time until reindeer stood, all time variables, SpO2, RR, RT, and HR were repeatable.

**Conclusion and Clinical Relevance**—Immobilization of captive reindeer achieved by use of the optimal dose established here is clinically acceptable, although SpO2 should be carefully monitored. Administration of the optimal dose produced the same clinical effect during repeated immobilization of the same reindeer. (Am J Vet Res 2001;62:406–413).

On the basis of examination of available literature and our clinical experience, a combination of medetomidine hydrochloride (MED) and ketamine hydrochloride (KET) appears to be suitable for use in inducing immobilization of reindeer (*Rangifer tarandus tarandus*). Furthermore, this combination is attractive because the immobilization can be reversed.

Medetomidine is a highly potent and selective \(\alpha_2\)-adrenoceptor agonist that has been used as a sedative, analgesic, and preanesthetic medication in a wide range of species. Although MED alone will induce moderate to deep sedation in a number of species, immobilization usually is incomplete. Therefore, MED should be combined with a general anesthetic such as KET to ensure safe, reliable, and complete immobilization, especially in nondomestic species.

Ketamine is a dissociative anesthetic that produces taming and immobilizing effects as well as general anesthesia in a dose-determination manner. An \(\alpha_2\)-adrenoceptor agonist used in combination with KET will improve muscle relaxation and analgesia, compared with KET used alone. In addition, potentiated effects are achieved.

Atipamezole, a potent and selective \(\alpha_2\)-adrenoceptor antagonist, is effective in reversing immobilization induced by MED-KET. We are not aware of any antagonists for ketamine and other dissociative anesthetics; therefore, reversal of immobilization induced by MED-KET too soon after induction may cause residual effects of KET to become apparent.

In zoo and wildlife medicine, recommended doses of immobilizing agents often are determined empirically or extrapolated from other species. To our knowledge, clinically controlled dose-response studies have not been reported for MED-KET in reindeer. Accordingly, controlled studies on the clinical effects and how such effects may vary among reindeer administered various doses of this drug combination are limited.

On the basis of an optimal induction time, optimal doses of MED-KET were established and administered in a controlled manner for each of several captive reindeer, using an iteration procedure. The iteration procedure and a new approach to determine the corresponding optimal darting doses have been reported elsewhere.

The first objective of the study reported here was to compare and evaluate clinical effects produced by controlled administration of a low immobilizing dose and an optimal dose of MED-KET to captive reindeer. Our second objective was to investigate the repeatability of the clinical effects produced by administration of the optimal dose.

**Materials and Methods**

**Animals**—Twelve reindeer (10 males and 2 females) were included in the study. The reindeer were brought from a semidomestic reindeer herd to the Department of Arctic Biology, University of Tromsø, Norway. During the first 3...
weeks after arrival, reindeer were housed separately in adjacent semioutdoor paddocks (approx 100 m²/paddock) and allowed to adapt to eating a commercially available pelleted ration. Two weeks prior to the start of the study, reindeer were moved indoors to well-ventilated adjacent stalls in a research facility, and adaptation to indoor feeding and handling were continued. Reindeer remained in the indoor stalls for the subsequent 9 weeks. The study was approved by the Norwegian Animal Research Authority.

At the beginning of the study, reindeer were 6 to 7 months old. Each reindeer was weighed the day before each immobilization. Initial mean body weight was 35.0 kg (range, 29.0 to 40.0 kg), and it increased to 36.7 kg (range, 29.5 to 45.5 kg) for the last immobilization during the dose-determination part of the study. Room temperature at the onset and completion of this part of the study was 7.4 C (range, 5.8 to 11.9 C) and 6.2 C (range, 5.5 to 9.5 C), respectively.

After a 3-week period of rest, the second experimental period began in which 1 repeat immobilization of each reindeer was conducted. Mean body weight for the repeat immobilization was 42.8 kg (range, 35.5 to 52.0 kg), and mean room temperature was 5.8 C (range, 3.7 to 5.9 C). Access to food and water was not restricted prior to or during the indoor experiments.

Anesthetic procedure—A combination of MED\(^4\) and KET\(^5\) in a ratio of 1:5 (wt:wt) were used for immobilization. Atipamezole hydrochloride\(^6\) at a dose of 5 mg/kg of MED was used for reversal.

Each reindeer was initially immobilized with a low immobilizing dose of MED-KET (0.06 mg of MED/kg of body weight and 0.3 mg of KET/kg); this was termed the initial dose. Following washout periods of 7 days, each reindeer was immobilized repeatedly by administration of various doses of MED-KET until an optimal dose was established and administered.\(^7\) Optimal dose was defined as a dose resulting in an induction time of 150 to 210 seconds.

Doses were administered manually in a controlled manner, using a syringe. To establish an optimal dose for each reindeer, the principles of Aitken's iteration procedure were used. Mean optimal dose of MED-KET was 0.10 mg of MED and 0.30 mg of KET, ranging from 0.05 mg of MED and 0.26 mg of KET to 0.2 mg of MED and 1.0 mg of KET.\(^8\) Three weeks after the optimal dose of MED-KET had been established and administered to each of the reindeer, immobilization of each reindeer was repeated, using the same optimal dose determined for each animal.

Clinical procedures—Calculated amounts of MED and KET were transferred to sterile 2-ml syringes, using 0.5-ml insulin syringes with 0.4 X 12-mm needles. Sterile water then was added to achieve a total injection volume of 2 ml. The sequence in which the 12 reindeer were immobilized was determined by drawing lots. All injections were administered into the biceps femoris muscle, using 0.8 X 40-mm needles.

The time until the first sign of sedation, defined as the interval from injection of the drugs until reduced alertness and head drooping, and induction time, defined as the interval from injection of the drugs until the reindeer became recumbent, were recorded, using a digital stopwatch. To allow the drugs to develop a more complete effect, reindeer were left undisturbed for a 2-minute period. The reindeer then was approached and touched on its back near its tail. Results for induction time and its repeatability have been reported.\(^9\)

Variables were recorded 10, 25, and 40 minutes after injection of MED-KET during immobilization achieved by use of the initial dose and during the 2 immobilizations achieved by use of the optimal dose. Rectal temperature was measured, using a clinical digital thermometer. Heart rate was determined, using a stethoscope. Respiratory rate was obtained by observing movements of each reindeer’s flank. Oxygen saturation of arterial hemoglobin as measured by pulse oximetry (SpO\(_2\)) was determined, using a pulse oximeter with the sensor attached to the reindeer’s tongue.

Degree of immobilization was evaluated 10, 25, and 40 minutes after injection of MED-KET and classified as follows: effect not detectable, moderately sedated (not recumbent or recumbent but able to stand up), heavily sedated (recumbent but able to hold its head up), or complete immobilization (sternal or lateral recumbency). Degree of CNS depression was assessed by testing palpebral, corneal, and ear flick reflexes.

For reversal, atipamezole was administered IM in the contralateral biceps femoris muscle 45 minutes after injection of MED-KET. Time from injection of atipamezole until the recumbent reindeer lifted its head and the time until the reindeer was standing were recorded. Degree of reversal was recorded 10 minutes after injection of atipamezole and characterized as still immobilized and head down, sedated, normally alert, or overly alert. Each reindeer was visually examined every hour for 6 hours after administration of atipamezole to detect signs of resedation, defined as a tendency toward sleepiness (characterized by reduced alertness, head drooping, or recumbency combined with reduced alertness) after initial complete recovery.

Reindeer were clinically evaluated throughout the immobilization period. When a reindeer had signs consistent with administration of an overdose during immobilization, it was treated with atipamezole administered IV. Signs of an overdose were defined as severe respiratory depression observed as changes in patterns of respiratory rate, rhythm, and effort of breathing combined with SpO\(_2\) continuing to decrease below 80%.\(^9\)

Statistical analysis—Results were expressed as mean val-

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**Table 1—Variables during immobilizations achieved by use of the initial and first and second administrations of the optimal dose of medetomidine-ketamine in 12 captive reindeer (Rangifer tarandus tarandus)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Initial Value</th>
<th>Optimal 1 Value</th>
<th>Optimal 2 Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time until first sign of sedation (s)</td>
<td>Mean (SD)</td>
<td>175 (68)</td>
<td>109 (22)*</td>
<td>112 (27)*</td>
</tr>
<tr>
<td></td>
<td>95% CI</td>
<td>133–216</td>
<td>96–122</td>
<td>96–130</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>90–335</td>
<td>69–137</td>
<td>80–163</td>
</tr>
<tr>
<td>Time until head up (s)</td>
<td>Mean (SD)</td>
<td>535 (266)</td>
<td>340 (203)*</td>
<td>329 (177)*</td>
</tr>
<tr>
<td></td>
<td>95% CI</td>
<td>386–704</td>
<td>211–469</td>
<td>217–442</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>200–1,035</td>
<td>135–652</td>
<td>135–696</td>
</tr>
<tr>
<td>Time to standing (s)</td>
<td>Mean (SD)</td>
<td>1,138 (405)</td>
<td>962 (476)</td>
<td>696 (449)</td>
</tr>
<tr>
<td></td>
<td>95% CI</td>
<td>880–1,295</td>
<td>659–1,204</td>
<td>413–984</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>357–1,570</td>
<td>288–1,500</td>
<td>220–1,500</td>
</tr>
</tbody>
</table>

*Value is significantly (\(P < 0.05\)) different from value for initial dose.

95% CI = 95% Confidence interval.
ues with 95% confidence intervals (CI). Confidence intervals were constructed, using the Student procedure. Dispersion was expressed by use of SD and range values. Kaplan-Meier plots were used to visualize time to the first sign of sedation, time until a recumbent animal lifted its head, and time until standing. To quantify changes in rectal temperature, heart rate, respiratory rate, and SpO2 during 40 minutes of immobilization, area under the curve for each variable and each reindeer were calculated, using the trapezoidal rule. Agreement between the first and second immobilizations achieved by use of the optimal dose was graphically expressed by regression plots and agreement limits and estimated by the agreement index defined by the following formula:

\[
\text{agreement index} = 1 - \frac{2 \times \text{SD of the difference between the 2 measurements}}{\text{mean of the 2 measurements}}
\]

The Pearson linear correlation coefficient between the difference of the 2 measurements and mean of the same 2 measurements was estimated. All tests were performed as 2-tailed analyses, with significance defined at \( P \leq 0.05 \). Comparisons between the immobilization periods were performed by use of an ANOVA model for crossover trials. An ANOVA model with repeated measurements was used to analyze developments during each immobilization. All calculations were performed by use of commercially available statistical software.

**Results**

Increasing the dose from the initial 0.06 mg of MED/kg and 0.3 mg of KET/kg for all reindeer to a mean optimal dose of 0.1 mg of MED/kg and 0.5 mg of KET/kg caused a mean reduction in induction time from 341 (95% CI, 187 to 496) to 175 seconds (95% CI, 164 to 186 seconds). Time until first sign of sedation and time until a recumbent reindeer lifted its head were significantly shortened for immobilizations achieved by use of the optimal dose (Table 1). Mean reductions in the time to the first sign of sedation and time until a recumbent reindeer lifted its head were 66 (95% CI, 20 to 111) and 195 seconds (95% CI, 59 to 331 seconds), respectively. A reduction, which was not significant, was detected for time until standing (176 seconds, 95% CI, –90 to 441 seconds). Dispersion of these 3 variables was substantially larger when reindeer were immobilized by administration of the initial dose, compared with the optimal dose (Fig 1).

Reindeer remained calm during the induction periods. All reindeer assumed recumbency in a controlled manner for the initial and optimal doses. For the initial dose, 2 reindeer were classified as moderately sedated, whereas 3 reindeer were heavily sedated, 10 minutes after injection of MED-KET. When completely immobilized, all reindeer were in sternal recumbency.

Mild ruminal tympany, although frequently evident, did not develop to a disturbing degree and disappeared rapidly after reversal with atipamezole. Regurgitation was not detected, and myorelaxation was good in all reindeer. Palpebral, corneal, and ear flick reflexes remained detectable during all immobilizations.

The SpO2 remained almost unchanged during immobilization achieved by use of the initial dose of MED-KET (Fig 2). For the optimal dose, the SpO2 increased significantly from a mean of 85% (95% CI, 78 to 91%) after 10 minutes to 89% (95% CI, 83 to 95%) after 25 minutes.
and remained at 89% (95% CI, 81 to 97%) after 40 minutes. The SpO2 value was significantly lower for immobilizations achieved by use of the optimal dose than for those achieved by use of the initial dose.

Respiratory rate increased significantly during immobilization for the initial and optimal doses (Fig 2). After administration of the initial dose, respiratory rate increased from a mean of 16 breaths/min (95% CI, 10 to 21 breaths/min) after 10 minutes to 23 breaths/min (95% CI, 16 to 30 breaths/min) after 25 minutes and further increased to 31 breaths/min (95% CI, 22 to 40 breaths/min) after 40 minutes. This pattern was even more evident for the optimal dose in which respiratory rate increased from a mean value of 14 breaths/min (95% CI, 11 to 18 breaths/min) after 10 minutes to 27 breaths/min (95% CI, 20 to 35 breaths/min) after 25 minutes and to 32 breaths/min (95% CI, 24 to 40 breaths/min) after 40 minutes. Although the difference in respiratory rate between the initial and optimal doses was not significant, analysis of the results indicated a larger increase in respiratory rate during immobilizations induced by use of the optimal dose.

For the initial dose of MED-KET, rectal temperature was unchanged during immobilization (Fig 2). For the optimal dose, rectal temperature increased slightly but significantly from a mean value of 39.1 C (95% CI, 38.9 to 39.3 C) after 10 minutes to 39.2 C (95% CI, 39.0 to 39.4 C) after 25 minutes and to 39.3 C (95% CI, 39.1 to 39.5 C) after 40 minutes. Comparison of values for the initial and optimal doses did not reveal significant differences in rectal temperature during immobilization.

Significant changes were not detected in heart rate during immobilization achieved by use of the initial or optimal doses of MED-KET (Fig 2). Significant differences were not detected in heart rate between the initial and optimal doses.

![Graph](image1.png)  
**Figure 2**—Graph of arterial hemoglobin oxygen saturation measured by use of pulse oximetry (SpO2; top left), respiratory rate (top right), rectal temperature (bottom left), and heart rate (bottom right) in 12 captive reindeer during immobilizations achieved by use of the initial (---) and optimal (first immobilization, - - -; second immobilization, ---) doses of medetomidine-ketamine. Results are expressed as 95% confidence intervals (boxes) and mean values (lines).

![Graph](image2.png)  
**Figure 3**—Time from injection of medetomidine-ketamine until first sign of sedation (top) and from reversal with atipamezole until a recumbent reindeer lifted its head (middle) and was standing (bottom) during the first and second immobilizations achieved by use of the optimal dose of medetomidine-ketamine for 12 captive reindeer. Each dot represents 1 reindeer. Values are plotted against each other around the line of equality.
Signs associated with administration of an overdose were not seen during immobilization achieved by use of the initial dose. Similarly, clinical signs of an overdose were not seen during the first and second immobilizations achieved by use of the optimal dose.

Ten minutes after administration of atipamezole, 5 reindeer immobilized with the initial dose were classified as still immobilized and had their head down, whereas 6 were sedated, and 1 appeared to be normally alert. Ten minutes after administration of atipamezole for the optimal dose, 2 reindeer were still immobilized and had their head down, whereas 7 were sedated, and 3 appeared to be normally alert. All reindeer behaved calmly during reversal.

During the 6-hour period after reversal, resedation was seen in 10 reindeer for the initial dose and 11 reindeer for the optimal dose. During this period, all animals classified as being resedated had a period of recumbency combined with reduced alertness. However, they always remained capable of standing up when approached by a person and were aroused by the slightest stimulus; thus, the degree of resedation was classified as mild to moderate. Six hours after injection of atipamezole, 2 reindeer still had signs of being resedated for the initial dose, whereas 7 reindeer were still resedated for the optimal doses.

Significant differences were not found between the first and second immobilizations achieved by use of the optimal doses regarding time to the first sign of sedation (Table 1). In 2 reindeer, the difference was 94 and 55 seconds, respectively (Fig 3). In only 1 reindeer was the observed difference outside the agreement limits (Fig 4). The other reindeer that had a relatively large discrepancy between the 2 measurements was within the agreement limits. However, when the values for these 2 reindeer were included, it obviously increased the agreement limits and reduced the agreement index. Nevertheless, the agreement index was found to be sufficiently positive (Table 2), although excluding these 2 reindeer gave an increased agreement index of 0.78. We did not detect a significant correlation between the difference and mean of the 2 measurements regarding time to the first sign of sedation.

Significant differences were not detected between the first and second immobilizations achieved by use of the optimal dose (Table 1). In 3 reindeer, the difference was rather large (Fig 3), although in only 1 of these reindeer was the difference outside the agreement limit (Fig 4). Nevertheless, values for these 3 reindeer increased the dispersion of the difference, which resulted in a negative and insufficient agreement index (Table 2). We did not detect a significant correlation between the mean and difference of the 2 measurements regarding time until a recumbent reindeer lifted its head.

Time until standing was significantly less after the second immobilization achieved by use of the optimal dose (Table 1). This strongly indicated a loss of repeatability for this variable (Fig 3), even though only 1 reindeer contributed to a difference outside the agreement limit (Fig 4), and the agreement index was found to be positive (Table 2). We did not detect a significant correlation between the mean and difference of the 2 measurements regarding time until standing.

Significant differences were not detected between
the first and second immobilizations achieved by use of the optimal dose regarding SpO2, respiratory rate, rectal temperature, and heart rate (Fig 2). The largest discrepancy between these 2 immobilizations concerned changes in heart rate. Mean difference between the 2 immobilizations in area under the curve for rectal temperature during the 40-minute period was 1 C (95% CI, –10 to 8 C), and it was 9 breaths (95% CI, –95 to 113 breaths) for respiratory rate during the same period. Mean differences between the 2 immobilizations regarding area under the curve for heart rate and SpO2 were 72 beats (95% CI, 13 to 131 beats) and 108% (95% CI, –38 to 254%), respectively, during the 40-minute period. In all reindeer, observed differences between the first and second immobilizations achieved by use of the optimal dose were within the agreement limits for SpO2, rectal temperature, and heart rate; however, the observed difference in respiratory rate was outside the agreement limits for 1 reindeer. The agreement indices for all investigated variables were sufficiently positive, and significant correlations were not detected between the difference and mean of the 2 measurements (Table 2).

**Discussion**

The observed induction time for the initial dose clearly revealed that this dose was too low to produce immobility within the predefined optimal interval of 150 to 210 seconds. This finding was further supported by the duration of the observed time to the first sign of sedation and the degree of immobilization.

The initial dose of MED-KET chosen in the study reported here was at the lower end of the reported dose range, and it was assumed that this dose would produce an induction time longer or equal to the predefined induction time. The ratio of 1:5 between MED and KET has been successfully used in free-ranging reindeer. Mean SpO2 value during immobilization achieved by use of the initial dose indicated adequate oxygenation of the blood. Although mean SpO2 values found during immobilizations achieved by use of the optimal dose were significantly less than those for immobilizations achieved by use of the initial dose, they increased slightly during the period of immobilization and were considered to be clinically acceptable. Nevertheless, the decrease in the SpO2 for the optimal dose was sufficiently large to warrant careful monitoring of this effect when this dose of MED-KET is used.

During the iteration procedure, 2 reindeer had signs consistent with administration of an overdose. Ten minutes after administration of twice the initial dose, the recorded SpO2 values in the reindeer were 75 and 82%, respectively, and SpO2 decreased in the following minutes. At the same time, respiratory rates were increased, and the respirations became shallower. The trend of oxygen saturation usually is more informative than absolute percentages. The reindeer were given atipamezole, IV, and a rapid and calm recovery was achieved. This finding documents the great variation in the effect that this drug combination may produce in particular reindeer. Because of the signs of an overdose, repeated immobilizations achieved by use of the initial dose were conducted in the 2 reindeer. The further iteration procedure revealed that for 1 reindeer, the initial dose was equivalent to the optimal dose, whereas for the other reindeer, the optimal dose was less than the initial dose.

Lower mean SpO2 values found during immobilizations achieved by use of the optimal dose may have been attributable to the higher dose of MED. Increasing doses of α2-adrenoceptor agonists can result in alteration in perfusion and ventilation, resulting in lowered oxygen saturation and arterial O2 concentrations. Substantial profound hypoxemia has been reported in domestic sheep after administration of 4 α2-adrenoceptor agonists, including MED at dosages of 0.01 mg/kg, IV. In another study in domestic sheep immobilized for 1 hour in sternal recumbency by use of 0.125 mg of MED/kg and 2.5 mg of KET/kg administered IM, oxygen saturation was never < 90%. The various ratios of MED and KET used in that study and the study reported here may explain the differences in the results obtained.

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**Table 2—Agreement between variables for the first and second immobilizations achieved by use of the optimal doses of medetomidine-ketamine in 12 captive reindeer**

<table>
<thead>
<tr>
<th>Variable (s) (s) (s) (s) (%) (breaths/min) (C) (beats/min)</th>
<th>Time to first sign</th>
<th>Time until lifted head</th>
<th>Time to standing</th>
<th>SpO2*</th>
<th>RR* (breaths/min)</th>
<th>RT* (C)</th>
<th>HR* (beats/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean difference between first and second immobilizations</td>
<td>3</td>
<td>11</td>
<td>263</td>
<td>108</td>
<td>9</td>
<td>1</td>
<td>72</td>
</tr>
<tr>
<td>SD of difference between first and second immobilizations</td>
<td>34</td>
<td>189</td>
<td>369</td>
<td>204</td>
<td>164</td>
<td>14</td>
<td>93</td>
</tr>
<tr>
<td>Mean of first and second immobilizations</td>
<td>111</td>
<td>334</td>
<td>830</td>
<td>2591</td>
<td>753</td>
<td>1176</td>
<td>1264</td>
</tr>
<tr>
<td>Agreement index</td>
<td>0.38</td>
<td>–0.13</td>
<td>0.11</td>
<td>0.84</td>
<td>0.56</td>
<td>0.98</td>
<td>0.85</td>
</tr>
<tr>
<td>Number of outliers (%)</td>
<td>1 (8)</td>
<td>1 (8)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>1 (8)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Correlation between mean and difference between first and</td>
<td>–0.21</td>
<td>0.16</td>
<td>0.08</td>
<td>0.39</td>
<td>0.25</td>
<td>–0.58</td>
<td>0.27</td>
</tr>
<tr>
<td>second immobilizations</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

*Values represent area under the curve for each variable.

SpO2 = Oxygen saturation of arterial hemoglobin measured by use of pulse oximetry. RR = Respiratory rate. RT = Rectal temperature. HR = Heart rate.
For the initial and optimal doses, respiration usually was characterized by an initial period of apnea after the reindeer became recumbent, followed by deep respirations increasing in frequency throughout the recorded period. A similar increase in respiratory rate was seen during immobilization induced by MED-KET or MED alone in adult reindeer in winter. These changes may be attributed to drug-induced respiratory depression and hypoxemia. Nevertheless, mean respiratory rates observed from 10 to 40 minutes of immobilization in the study reported here were all clinically comparable to values recorded in adult reindeer in winter at corresponding ambient temperatures. Jalanka and Roekens reported deep respirations and respiratory rates of 10 to 25 breaths/min in reindeer during immobilization induced by MED-KET.

Mean rectal temperature did not change during immobilization achieved by use of the initial dose of MED-KET, and we consider the increase of this variable during immobilizations achieved by use of the optimal dose to be of minor clinical interest. All values recorded for mean rectal temperature in our study were clinically comparable to values measured in adult reindeer in winter at corresponding ambient temperatures.

Mean heart rate was stable during the recorded periods of immobilization achieved by use of initial and optimal doses. In our study, all values recorded for heart rate were in accordance with reference values of 32 to 42 beats/min in resting adult reindeer in winter. Bradycardia is the most prominent cardiovascular effect produced by MED, whereas KET causes an increase in heart rate. Jalanka reported a lack of clinically important bradycardia after MED-KET immobilization in several species, including reindeer.

The palpebral, corneal, and ear flick reflexes appeared more sluggish in some reindeer after administration of the optimal dose. However, the continued detection of these reflexes indicated that they were unsuitable for assessing the degree of CNS depression induced by this dose of MED-KET in reindeer.

On the basis of the significantly shorter time until a recumbent reindeer lifted its head and the degree of reversal 10 minutes after injection of atipamezole, short-term recovery seemed to be more rapid after administration of the optimal (higher) dose of MED-KET, compared with recovery after administration of the initial dose. This finding was unexpected, because the dose of MED was 5 times less than the dose of atipamezole throughout the study. Similar observations also have been made in dogs. Additional investigations are needed to explain this phenomenon.

The study reported here revealed a decrease in mean time until standing between the initial and optimal doses. However, results for this variable should be interpreted with caution, because some reindeer may remain recumbent for both doses, even though they appear able to stand.

Mild to moderate resedation was seen for initial and optimal doses. However, resedation seemed to last for a longer period after reversal from immobilizations achieved by use of the optimal dose of MED-KET.

Resedation has been described in forest reindeer (*Rangifer tarandus fennicus*) after atipamezole was injected IV. Similarly, resedation was seen 0.5 to 1 hour after reversal with atipamezole injected IV in reindeer. The resedation lasted for 3 to 5 hours, which was 2 to 2.5 hours after MED was last detectable in plasma. The same ratio between MED and atipamezole was used in both those studies. Relapse into sedation probably cannot be explained by differences in pharmacokinetics of MED and atipamezole. Although the elimination half-life of MED in reindeer is approximately 10 minutes longer than that of atipamezole, this difference is most likely too small to explain the duration of resedation. Similar resedation in dairy calves treated with MED and atipamezole has been reported. The authors of that report suggested that resedation may have been caused by redistribution of MED into the CNS after injection of atipamezole or by a delayed elimination from its site of action. Clearly, additional studies are required on these issues.

Induction time is repeatable between the first and second immobilizations achieved by use of the optimal dose. Time until first sign of sedation was, as expected, highly correlated with induction time. The predefined optimal induction time used during the iteration procedure in that study implied that the SD of this variable would be underestimated. In the study reported here, this was documented by an increase of the SD for the time until first sign of sedation. Despite this, the time until first sign of sedation was found to be nearly equal between the first and second immobilizations achieved by use of the optimal dose, and the repeatability of this variable seems obvious.

The *SpO₂* values were similar during the 2 immobilizations achieved by use of the optimal dose. Results obtained for this variable when using the higher dose seem to be repeatable.

Respiratory rate, rectal temperature, and heart rate were all clinically equal during the 2 immobilizations for the optimal dose. Repeatability also is highly probable. The largest discrepancy in measured values for clinical variables between the 2 immobilizations was for heart rate. Mean difference between the 2 measurements for heart rate, nevertheless, averaged only 1.8 beats/min. These findings suggest complete repeatability of the clinical picture during immobilization of captive reindeer achieved by administration of the optimal dose of MED-KET.

During reversal, time until a recumbent reindeer lifted its head following injection of atipamezole was clinically comparable between the 2 immobilizations achieved by use of the optimal dose. However, repeatability was doubtful because of the negative agreement index. This was caused by increased dispersion, especially for 1 reindeer, which may be explained by delayed absorption of atipamezole. Excluding values for that reindeer, the time until a recumbent reindeer lifted its head could be assumed to be repeatable.

The significantly shorter time until standing for the second immobilization achieved by use of the optimal dose and the lack of repeatability found for this variable may be explained by external factors. There was a 3-week period with less contact between reindeer and humans prior to the second immobilization achieved by use of the optimal dose.
Using a value of 5% to define SD, we can discover a difference between doses larger than the SD with a power of 90%. However, with regards to repeatability, power will be dramatically reduced. As can be seen from analysis of our results, a sample of 12 reindeer will be highly influenced by individual scores. This causes problems when 1 or 2 observations are classified as outliers. For this reason, inclusion of a larger number of reindeer would have strengthened the results and conclusions regarding the repeatability portion of our study.

RF-80, Stormollen, Storsteinnes, Norway.
1Zalopine, medetomidine hydrochloride 10 mg/ml, Orion Corp Animal Health, Turku, Finland.
2Ketalar, ketamine hydrochloride 50 mg/ml, Parke-Davis, Barcelona, Spain.
3Antisedan, atipamezole hydrochloride 5 mg/ml, Orion Corp Animal Health, Turku, Finland.
4NELCOR N-20P, Nellcor Inc, Pleasanton, Calif.
5Mesteig K. Fôropptak og hjertefrekvens hos norsk rein (Rangifer tarandus tarandus). Sammenheng og sesongmessige variasjoner. [Feed intake and heart rate in Norwegian reindeer (Rangifer tarandus tarandus)]. Correlation and seasonal variations J Cand. scient. thesis, Department of Arctic Biology, Institute of Medical Biology, University of Tromsø, Norway, 1997.
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