
INTRAVENOUS BUTORPHANOL IMPROVES MIXED VENOUS OXYGEN CONTENT IN ETORPHINE-IMMOBILIZED WHITE RHINOCEROS (*Ceratotherium simum*) PRIMARILY BY DECREASING TISSUE OXYGEN CONSUMPTION RATHER THAN BY INCREASING TISSUE OXYGEN DELIVERY

Jordyn M. Boesch, DVM, PhD, DACVAA,^{1,2} Robin D. Gleed, BVSc, MA, DACVAA, DECVAA, DVA, MRCVS, MRCA,¹ Peter Buss, BVSc, MMedVet, PhD,³ Adrian Tordiffe, BVSc, MSc, PhD,² Gareth Zeiler, BVSc Hon, MMedVet, DECVAA, DACVAA,⁴ Michele A. Miller, DVM, MS, MPH, PhD, DipECZM (Zoo Health Management),³ and Leith C. R. Meyer, BVSc, BSc Hon, PhD²*

¹Department of Clinical Sciences, Cornell University College of Veterinary Medicine, Ithaca, NY 14853 USA; ²Department of Paraclinical Sciences, University of Pretoria Faculty of Veterinary Science, Onderstepoort 0110 South Africa; ³Veterinary Wildlife Services, South African National Parks, Kruger National Park, Skukuza 1350 South Africa; ⁴Department of Companion Animal Clinical Studies, University of Pretoria Faculty of Veterinary Science, Onderstepoort 0110 South Africa

Abstract

Butorphanol increases arterial oxygen partial pressure (PaO₂) in etorphine-immobilized white rhinoceros (*Ceratotherium simum*), hence the hypothesis it would increase oxygen delivery to tissues (DO₂).¹ Six sub-adult, male, white rhinoceros were administered each of two treatments in random order, 2 wk apart: etorphine-saline and etorphine-butorphanol. Rhinoceros were darted intramuscularly with etorphine^a (2.6 ± 0.1 µg/kg) (mean ± SD), intubated nasally in sternal recumbency (time = 0 minutes [t = 0]), positioned in lateral recumbency, and connected to a breathing system with pneumotachometer.^b Peripheral arterial and balloon-tipped thermodilution pulmonary arterial catheters were inserted.^c Baseline data were collected at t = 30, butorphanol^d (0.026 ± 0.001 mg/kg) or saline was administered intravenously at t = 37, and data were collected at t = 40 and 50. A linear mixed effect model was used to determine differences between treatments. At t = 40 and 50, PaO₂ and arterial oxygen content (CaO₂) were greater after butorphanol than after saline (each P < 0.0001). Cardiac output (Qt) was lower after butorphanol at both times (each P < 0.0001). There was no difference in DO₂ between treatments. However, at both times, oxygen consumption (VO₂) was lower (P = 0.0009 and 0.0029, respectively) after butorphanol than after saline. Mixed venous oxygen partial pressure and content (P_̄VO₂ and C_̄VO₂, respectively) were greater after butorphanol at both times (each P < 0.0001). Despite the increased CaO₂ after butorphanol, DO₂ did not increase because Qt decreased; however, the simultaneous decrease in VO₂ increased P_̄VO₂ and C_̄VO₂, indicating improved oxygen supply-and-demand balance.

^aVoluplex, Mnandi, Centurion 0157 South Africa

^bADInstruments Pty Ltd, Bella Vista, New South Wales 2153 Australia

^cGaeltec Devices Ltd, Dunvegan, Isle of Skye, IV55 8GU, Scotland

^dWildlife Pharmaceuticals Pty Ltd, White River, Mpumalanga 1240 South Africa

Key words: Butorphanol, *Ceratotherium simum*, etorphine, hypoxemia, oxygen delivery, white rhinoceros

ACKNOWLEDGMENTS

The authors thank the John T. and Jane A. Wiederhold Foundation, the South African Veterinary Association Wildlife Group, the South African National Research Foundation, Veterinary Wildlife Services, South African National Parks, Leana Rossouw, Guy Haussler, Thembeke Mtetwa, Penelope Miya, and Gaeltec Devices.

LITERATURE CITED

1. Buss P, Miller M, Fuller A, Haw A, Stout E, Olea-Popelka F, Meyer L. Postinduction butorphanol administration alters oxygen consumption to improve blood gases in etorphine-immobilized white rhinoceros. *Vet Anaesth Analg.* 2018;45:57-67.