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Dissociative Anaesthesia During Field and Hospital Conditions for Castration of Colts

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Marntell S, Nyman G, Funkquist P: Dissociative anaesthesia during field and hospital conditions for castration of colts. Acta vet. scand. 2006, 47, 1-11. – The principal aim of this study was to evaluate dissociative anaesthesia for castration of colts during field conditions. Three dissociative anaesthetic protocols were evaluated during castration of colts in an animal hospital. The protocol considered to be the most suitable was thereafter evaluated during castration of colts under field conditions. Respiratory and haemodynamic parameters and the response to surgery were determined during anaesthesia. All horses breathed air spontaneously during anaesthesia. Under hospital conditions 26 colts were randomised to receive one of three anaesthetic protocols: Romifidine and tiletamine-zolazepam (RZ); acepromazine, romifidine and tiletamine-zolazepam (ARZ); or acepromazine, romifidine, butorphanol and tiletamine-zolazepam (ARBZ). The surgeon was blinded to the anaesthetic protocol used and decided whether supplemental anaesthesia was needed to complete surgery. Under field conditions 31 colts were castrated during anaesthesia with the ARBZ protocol. All inductions, anaesthesia and recoveries were calm and without excitation under both hospital and field conditions. Surgery was performed within 5-20 minutes after the horses had assumed lateral recumbency during both hospital and field castrations. Under hospital conditions some horses needed supplemental anaesthesia with all three anaesthetic protocols to complete surgery. Interestingly, none of the horses castrated with protocol ARBZ under field conditions needed additional anaesthesia. Cardiorespiratory changes were within acceptable limits in these clinically healthy colts.

Intravenous dissociative anaesthesia, field conditions, horse, mixed venous oxygen tension, jugular venous oxygen tension, castration.

Introduction

Anaesthesia studies often concern cardiorespiratory conditions in healthy horses not subjected to surgery and there have been few reports on cardiovascular data obtained during anaesthesia in clinical cases in field practise. Intravenous anaesthesia has been advocated on the basis of cardiorespiratory findings (*Luna et al.* 1996, *Taylor et al.* 1992, 1998), and a prospective enquiry has suggested that intravenous anaesthetics may be safer than volatile agents for short-term anaesthesia in horses (*Johnston et al.* 2002). Intravenous anaesthesia is usually the option under field conditions and it was thought important to investigate intravenous protocols during surgical procedures, as there have been reports of inadequate anaesthesia/analgesia in such cases. In a study with a comparison of four intravenous anaesthesia combinations for surgical removal of an abdominal testis, 8 out of 32 horses had to be changed to inhalation anaesthesia because of inadequate analgesia (*Muir et al.* 2000). In reports of dissociative anaesthesia for field castrations of ponies a combination of xylazine and ketamine resulted in a need for supplemental thiopentone in 7 of 10 cases to complete surgery, and thiopentone had to be added in 5 of 10 cases during detomidine/ketamine anaesthesia (*Clarke et al.* 1986). *Tranquilli et al.* (1983) found indications that analgesia was enhanced during castration of colts when butorphanol was added to xylazine/ketamine anaesthesia. Tiletamine-zolazepam results in longer recumbency time than ketamine (*Matthews et al.* 1991) and was used in the present investigation, as duration sufficient for inexperienced surgeons to perform castrations of colts was anticipated.

The principal aim of this study was to evaluate dissociative anaesthesia for castration of colts during field conditions. Three dissociative anaesthetic protocols were evaluated during castration of colts in an animal hospital. The protocol considered to be the most suitable was thereafter evaluated during castration of colts under field conditions and compared to hospital conditions.

Material and methods

Practical procedure

The same practical procedure was followed under both hospital and field conditions. Clinical examination was performed on all horses. An infusion catheter (14G, Intranule, Vygone, Ecouen, France) was placed in the left jugular vein in the standing horse. Before induction, pads of cotton wool were placed in the horse's ears to reduce external stimuli. During induction one person held the halter and one person held the tail or a tail rope in order to balance the horse and prevent it from falling forwards. After induction the horse was left undisturbed in lateral recumbency for one minute. The horse's head and neck were extended to help to maintain a patent airway. An endotracheal tube was always available, but no horse was intubated and all breathed air spontaneously. The eyes were protected from light with a piece of cloth. The horse was placed in dorso-lateral recumbency for surgery with the chest mainly in the lateral position and the hindquarters more in a dorsal position. Each hind leg was held with a rope or supported with straw bales, a safety precaution that also keeps the horse in balance and gives the surgeon access to the surgical area. When surgery was completed, the horse was returned to lateral recumbency and the lower limbs were pulled forward. The ear pads were removed at approximately 45 minutes after induction. The horses were never forced to stand. When the horse attempted to stand under field conditions, one person held the halter and another person held the tail. The respiratory and heart rates were measured in all horses before sedation (Baseline), 5, 15, 25 and 35 minutes after induction of anaesthesia, and 5 minutes after the horse returned to a standing position (Post). Arterial blood samples for measurements of oxygen and carbon dioxide tensions (PaO_2, $PaCO_2$) and jugular venous blood samples for measurements of oxygen tensions ($PjvO_2$) were drawn anaerobically into heparinised syringes and stored on ice until analysed by conventional electrode techniques (ABL 5, Radiometer, Copenhagen, Denmark). The duration of surgery and the lengths of time in lateral and sternal recumbency were recorded. The surgeon was blinded with respect to the anaesthetic protocol and decided whether supplemental anaesthesia was needed to complete the surgical procedure. If considered necessary supplemental anaesthesia was induced with thiopentone (Pentothal® Natrium, Abbott Scandinavia AB, Solna, Sweden) in an average dose of 1.4 mg /kg i.v. per horse.

The reaction to surgery was also graded subjectively on a 1 to 5 scale, where 1=kicking, 2=a distinct limb movement, 3=reaction during skin incision and/or clamping of the spermatic cord, 4=minimal reaction during skin incision and/or clamping of the spermatic cord, and 5=no reaction. The quality of induction, anaesthesia and recovery were assessed subjectively using a 0 to 3 scale, where 0=poor, 1=fair, 2=good and 3=excellent. Postoperatively the horses were given tetanus toxoid (Tetanusvaccin™ vet., Intervet, Stockholm, Sweden) and flunixine meglumine 1.1 mg/kg (Finadyne® vet., Schering-Plough, Stockholm, Sweden).

Hospital conditions

Twenty-six colts brought to the equine clinic at the Swedish University of Agricultural Sciences for castration were included. The weight of the horses was measured with a horsescale, mean weight 420 kg (range 153-623 kg), and an average age of 2.5 years (1.5-5 years). Seven different breeds were represented: 13 Swedish warmbloods, six Standardbred trotters, five ponies (Dartmoor, Shetland, Welsh), one Coldblood trotter and one Lippizaner. The colts were randomised into three groups, to receive one of the following protocols:

Protocol RZ (n=6): This group consisted of two Swedish warmbloods, two Standardbred trotters and two ponies, mean weight 380 kg (203-510 kg). The horses were sedated with romifidine 0.11 mg/kg (range 0.1-0.14 mg/kg) (Sedivet® vet., 10 mg/ml, Boehringer Ingelheim Vetmedica, Malmö, Sweden) given intravenously (i.v.). Seven minutes after romifidine administration, anaesthesia was induced i.v. with 1.4 mg/kg Zoletil® (0.7 mg/kg tiletamine + 0.7 mg/kg zolazepam) (Zoletil 100®, 100 mg/ml, Virbac, Carros, France).

Protocol ARZ (n=11): In this group there were eight Swedish warmbloods, one Standardbred trotter, one pony and one Lippizaner, mean weight 430 kg (165-530 kg). The horses were premedicated with acepromazine 0.033 mg/kg (range 0.025-0.05 mg/kg) (Plegicil® vet., 10 mg/ml, Pharmacia & Upjohn Animal Health, Helsingborg, Sweden) given intramuscularly (i.m.) 30-45 minutes before i.v. injection of romifidine 0.11 mg/kg (range 0.1-0.15 mg/kg). Seven minutes after romifidine administration, anaesthesia was induced i.v. with 1.4 mg/kg Zoletil®.

Protocol ARBZ (n=9): This group consisted of three Swedish warmbloods, three Standardbred trotters, two ponies and one Coldblood trotter, mean weight 430 kg (153-623 kg). The horses were premedicated with acepromazine 0.045 mg/kg (range 0.045-0.05 mg/kg) i.m., and 30-45 minutes later romifidine 0.1 mg/kg was given i.v., followed after one minute by butorphanol 0.025 mg/kg i.v. (Torbugesic®, 10mg/ml Fort Dodge Animal Health, Fort Dodge, IA, USA). Seven minutes after romifidine administration, anaesthesia was induced i.v. with 1.4 mg/kg Zoletil®.

Anaesthesia and surgery were performed in a padded recovery room. After induction of anaesthesia, a catheter was introduced percutaneously into the facial artery (18G, Hydrocath TM arterial catheter, Omeda, Swindon, UK). Measurements and blood sampling were performed at 5, 15, 25 and 35 minutes of anaesthesia and approximately 5 minutes after the horse had returned to a standing position (Post). Systemic arterial blood pressure (SAP) was measured via a fluid-filled line connected to a calibrated pressure transducer (Baxter Medical AB, Kista, Sweden), positioned at the level of the scapulo-humeral joint when the horse was standing and at the level of the sternal manubrium in lateral recumbency. Blood pressure and ECG were recorded on an ink-jet recorder (Sirecust 730, Siemens-Elema, Solna, Sweden). The haemoglobin concentration (Hb) was determined spectrophotometrically (Cel-Dyn 3500, Abbott Scandinavia AB, Solna, Sweden).

Field conditions

Thirty-one colts with an estimated average weight of 450 kg (390-600 kg) and an average age of 1.5 years (1.5-2.5 years) were included. The weight estimation was based on tape measuring and/or experience. This part of the study comprised 28 Swedish warmbloods, one Arab crossbreed, one New Forest pony and one Coldblood draft horse. The procedures were carried out on the farms where the horses were stabled, 25 outdoors in grasspaddocks and six in a large box indoors. All horses were first sedated with a small dose of acepromazine 0.035 mg/kg i.m. and left undisturbed for at least 20 minutes. Romifidine 0.1 mg/kg was administered i.v., followed about one minute later by butorphanol 0.025 mg/kg i.v. After 5 to 7 minutes anaesthesia was induced i.v. with 1.4 mg/kg Zoletil® (0.7 mg/kg tiletamine + 0.7 mg/kg zolazepam). In 11 horses PaO_2, $PaCO_2$ and $PjvO_2$ were determined. In 6 horses blood pressure was measured non-invasively.

Mixed venous oxygen tension compared to jugular venous oxygen tension
Six clinically healthy Standardbred trotters, four geldings and two mares, aged between 3 and 12 years (mean 6 years) and weighing 423-520 kg (mean 470 kg) were anaesthetised with protocol ARBZ at the animal hospital. Mixed venous blood from the pulmonary artery and jugular venous blood from the jugular vein were simultaneously drawn anaerobically into heparinised syringes and stored on ice until analysed by means of conventional electrode techniques for oxygen tensions ($P\bar{v}O_2$ and $PjvO_2$) (ABL 5, Radiometer, Copenhagen, Denmark). Blood samples were taken at 5, 15, 25 and 35 minutes after induction of anaesthesia.

Calculations and statistics
In the following abbreviations y denominates either arterial, or jugular venous. Arterial or jugular venous oxygen content (CyO_2) and Arterial-jugular venous oxygen content difference ($C(a\text{-}jv)O_2$) were calculated using the following equations:

$$(CyO_2) = (Hb\ (g\ 100ml^{-1}) \times 1.39 \times SyO_2) + (PyO_2 \times 0.00225)$$

$$(C(a\text{-}jv)O_2) = CaO_2 - CjvO_2.$$

For statistical analysis the Statistica software package (Statsoft Inc., Tulsa, OK, USA) was used. Physiological data were analysed in a General Linear Model with repeated measures ANOVA. When a significant difference or interaction was obtained Tukeys HSD post hoc test or planned comparison as appropriate was applied. Nonparametric analyses were applied to scoring result and supplementation of anaesthesia. The reaction to surgery is presented as the mean value of reaction for both testes. For difference between groups Mann-Whitney U test was applied. A p value of <0.05 was considered significant in all tests. The correlation between mixed venous oxygen tension and jugular venous oxygen tension was tested and plotted according to *Bland & Altman* (1986).

Table 1. Reaction to surgery and the percent of horses that needed supplemental anaesthesia for completion of surgery.

Protocol	Surgery score median (range)	Supplemental anaesthesia percent of horses receiving
Hospital - RZ	1.5 (1-2.5)	50%
Hospital - ARZ	3.5 (1-5) #	27% #
Hospital - ARBZ	3.5 (2-4.5) #	22% #
Field - ARBZ	5 (3-5) # *	0% # *

Reaction to surgery was scored from 1 to 5, were 5 is no reaction to surgery. Romifidine and tiletamine/zolazepam (RZ); acepromazine, romifidine and tiletamine/zolazepam (ARZ); acepromazine, romifidine, butorphanol and tiletamine/zolazepam (ARBZ). Hospital = surgery performed under hospital conditions, Field = surgery performed under field conditions # = Significantly different from RZ, * = Field-ARBZ significantly different from Hospital-ARBZ.

Table 2. Cardiorespiratory data from castrations performed in animal hospital.

Variables	Protocol	ANE 5´	ANE 15´	ANE 25´	ANE 35´	Post	Within protocol	Between protocols
HR	RZ	34 (4)	36 (3)	34 (2)	32 (0)	34 (6)	NS	NS
Beats/min	ARZ	35 (4)	35 (4)	35 (4)	36 (7)	37 (3)	NS	
	ARBZ	33 (5)	32 (4)	33 (6)	34 (7)	33 (7)	NS	
SAP mean	RZ	157 (27)*	142 (26)	131 (30)	118 (16)	107 (10)	0.03	RZ-ARZ 0.023
mm Hg	ARZ	136 (11) #	123 (16)* #	106 (17) #	100 (11) #	104 (6)	<0.01	RZ-ARBZ 0.048
	ARBZ	128 (20) #	126 (16) #	124 (22) #	110 (19) #	115 (22)	NS	
RR	RZ	24 (15)	32 (13)	24 (10)	22 (4)	17 (8)	NS	NS
Breaths/min	ARZ	24 (10)	33 (12)	26 (8)	27 (9)	[12 (4)]	NS	
	ARBZ	17 (6)	19 (7)	20 (7)	19 (5)	14 (3)	NS	
$PaCO_2$	RZ	5.9 (0.3)	5.6 (0.5)*	5.6 (0.4)*	[5.7 (0.2)]	6.1 (0.3)	<0.01	NS
kPa	ARZ	6.2 (0.4)	6.1 (0.6)	6.0 (0.5)	6.2 (0.4)	6.0 (0.4)	NS	
	ARBZ	6.4 (0.5)	6.1 (0.5)	6.4 (0.3)	6.3 (0.3)	6.2 (0.4)	NS	
PaO_2	RZ	7.7 (1.0)*	7.4 (1.0)*	7.4 (1.5)*	[6.9 (0.3)]	12.5 (0.8)	<0.01	NS
kPa	ARZ	8.0 (1.0)*	8.0 (1.2)*	8.1 (1.4)*	8.6 (1.5)*	12.9 (1.3)	<0.01	
	ARBZ	8.3 (1.6)*	8.4 (1.9)*	7.5 (1.8)*	8.4 (2.0)*	13.5 (1.4)	<0.01	
$PjvO_2$	RZ	4.2 (0.4)	4.2 (0.3)	4.2 (0.4)	[4.6 (0.4)]	4.4 (0.6)	NS	RZ-ARBZ 0.003
kPa	ARZ	4.4 (0.4)	4.5 (0.4)	4.7 (0.5)	4.7 (0.5)	4.7 (0.6)	NS	
	ARBZ	5.0 (0.5) #	4.9 (0.4) #	4.8 (0.6) #	5.0 (0.4)	5.3 (0.5) #	NS	
$C(a\text{-}jv)O_2$	RZ	5.0 (1.0)	4.5 (1.5)	4.1 (2.2)	[2.8 (0.5)]	5.0 (1.6)	NS	NS
ml/100 ml	ARZ	4.4 (1.1)	3.8 (1.0)	3.4 (1.0)	3.3 (1.0)	4.0 (1.2)	NS	
	ARBZ	3.8 (0.8)	3.7 (0.7)	3.2 (0.5)	2.9 (0.8)	3.8 (1.1)	NS	

Data presented as mean (SD) for heart rate (HR), mean systemic arterial pressure (SAP mean), respiratory rate (RR), arterial carbon dioxide tension ($PaCO_2$), arterial oxygen tension (PaO_2), jugular venous oxygen tension ($PjvO_2$) and arterial - jugular venous oxygen tension difference ($C(a\text{-}jv)O_2$). Protocol = anaesthetic protocol: romifidine and tiletamine/zolazepam (RZ); acepromazine, romifidine and tiletamine/zolazepam (ARZ); acepromazine, romifidine, butorphanol and tiletamine/zolazepam (ARBZ). ANE 5´, 15´, 25´ and 35´ = measurements at 5, 15, 25 and 35 minutes of anaesthesia. Post = 5 minutes after the horse had regained the standing position. Within protocol = p value for 1-way ANOVA run for each protocol from ANE 5' to Post. * = Significant different compared to Post. Between protocol = p value for 2-way ANOVA during anaesthesia. # =significantly different from RZ. Values within brackets [ ] not included in statistical analysis (n=3-5). NS = not significant.

Results are given as mean (SD) unless otherwise stated.

Results

Hospital conditions

All inductions, anaesthesias and recoveries were calm and without excitation. Surgery was performed within 5-20 minutes after the horses had assumed lateral recumbency. In the RZ group additional anaesthesia was needed in 3 of 6 horses, in the ARZ group 3 of 11 horses and in the ARBZ group 2 of 9 horses (Table 1). Cardiorespiratory data from animals castrated at the animal hospital are presented in Table 2. During anaesthesia the mean arterial blood pressure was significantly higher in the RZ group than in both the ARZ group and the

Table 3. Cardiorespiratory data from castrations performed in field conditions compared to hospital conditions with protocol ARBZ (acepromazine, romifidine, butorphanol and tiletamine/zolazepam).

Variables	Protocol	n	Baseline	ANE 5´	ANE 15´	ANE 25´	ANE 35´	Post
HR	Hospital	n=9	39 (3)*	33 (5)B*	32 (4)B*	33 (6) B*	34 (7)*	33 (7)B*
Beats/min	Field	n=31	44 (6)	39 (6)	41 (6)	40 (5)	40 (5)	43 (10)
SAP mean mm Hg	Hospital (invasive	n=9	ND	128 (20)	126 (16)	124 (22)	110 (19)	115 (22)
	Field (non-invasive)	n=6	ND	108 (16)	114 (14)	113 (21)	114 (34)	ND
RR	Hospital	n=9	18 (8)	17 (6)	19 (7)	20 (7)	19 (5)	14 (3)
Breaths/min	Field	n=31	15 (3)	14 (6)	19 (8)	22 (7)B	24 (7)B	14 (6)
PaCO2	Hospital	n=9	ND	6.4 (0.5)	6.1 (0.5)	6.4 (0.3)	6.3 (0.3)	6.2 (0.4)
kPa	Field	n=11	ND	6.7 (0.8)	6.4 (0.6)	[6.1 (1.0)] (n=4)	ND	ND
PaO2	Hospital	n=9	ND	8.3 (1.6)	8.4 (1.9)	7.5 (1.8)	8.4 (2.0)	13.5 (1.4)
kPa	Field	n=11	ND	7.6 (0.8)	8.1 (1.1)	[8.3 (0.7)] (n=4)	ND	ND
PjvO2	Hospital	n=9	ND	5.0 (0.5)	4.9 (0.4)	4.8 (0.6)	5.0 (0.4)	5.3 (0.5)
kPa	Field	n=9	ND	5.0 (0.5)	5.1 (0.8)	[5.4 (0.6)] (n=3)	ND	ND

Data presented as mean (SD) for heart rate (HR), mean systemic arterial pressure (SAP mean), respiratory rate (RR), arterial carbon dioxide tension (PaCO2), arterial oxygen tension (PaO2), jugular venous oxygen tension (PjvO2). Baseline = measurements performed in the standing unsedated horse. ANE 5´, 15´, 25´ and 35´ = measurements at 5, 15, 25 and 35 minutes of anaesthesia. Post = 5 minutes after the horse had regained the standing position.* = Field conditions significantly different from hospital conditions. B = Significantly different from Baseline. ND = not determined. Values within brackets [ ] not included in statistical analysis.

ARBZ group. $PjvO_2$ was significantly lower in the RZ group than in the ARBZ group. The quality of induction was good to excellent in all groups (score range 2-3). The median score for quality of anaesthesia was 0.5 in the RZ group (range 0-2), 1 in the ARZ group (range 0-3), and 2 in the ARBZ group (range 0-3). All horses stood at the first attempt except one horse, which made four calm attempts to stand before standing successfully. For recovery the median score was 3 for all three groups, with a range of 2-3 in the RZ group, 0-3 in the ARZ group and 2-3 in the ARBZ group. The time spent in lateral recumbency was 48 (18) minutes in RZ, 52 (7) minutes in ARZ and 61 (13) minutes in ARBZ. The time from induction until standing again was 58 (24) minutes in RZ, 74 (22) minutes in ARZ and 73(18) minutes in ARBZ. One horse in the ARZ group that had received 1.2 mg/kg thiopentone after 17 minutes of anaesthesia was very tired during recovery and received a score of 0 for recovery. Seventy minutes after induction this horse turned from the lateral to the sternal position several times. After 99 minutes the horse was resting steadily in sternal recumbency and after 133 minutes it was encourage to stand. The horse did stand at the first attempt but its hind legs were weak.

Field conditions

All inductions, anaesthesias and recoveries were calm and without excitation and none of the horses needed supplemental anaesthesia under field conditions. Surgery was performed within 5-20 minutes after induction, in average the first spermatic cord was clamped at 9.5 minutes of anaesthesia and the second one at 12.5 minutes. Surgery score is given in Table 1. Cardiorespiratory data from horses castrated in field practice are presented in Table 3, where they are compared with data from protocol ARBZ at the animal hospital. The heart rate was stable during anaesthesia under field conditions and higher than that recorded in the animal hospital. No other significant differences in cardiorespiratory parameters were found between the procedures carried out under field conditions and those in the animal hospital. Under field conditions the respiratory rate increased at 25 and 35 minutes of anaesthesia compared to baseline. The mean arterial blood pressure was stable during anaesthesia. The median score for reaction to surgery was 5 for both testes, and the median score was 3 for quality of induction, anaesthesia and recovery, with a range of 1-3. All horses reached a standing position at the first attempt, except the draft horse, which made a frog-like jump before standing successfully. The induction time was 41 (13) seconds, the time spent in lateral recumbency was 49 (11) minutes and the time from induction until standing was 55 (12) minutes. There was an individual difference in the time spent in lateral recumbency, with a range of 31 to 73 minutes.

Mixed venous oxygen tension compared to jugular venous oxygen tension

The results of this comparison are presented in figure 1. During anaesthesia the oxygen tension in mixed venous blood obtained from the pulmonary artery was on average 0.8 kPa (6 mm Hg) lower than that in blood obtained from the

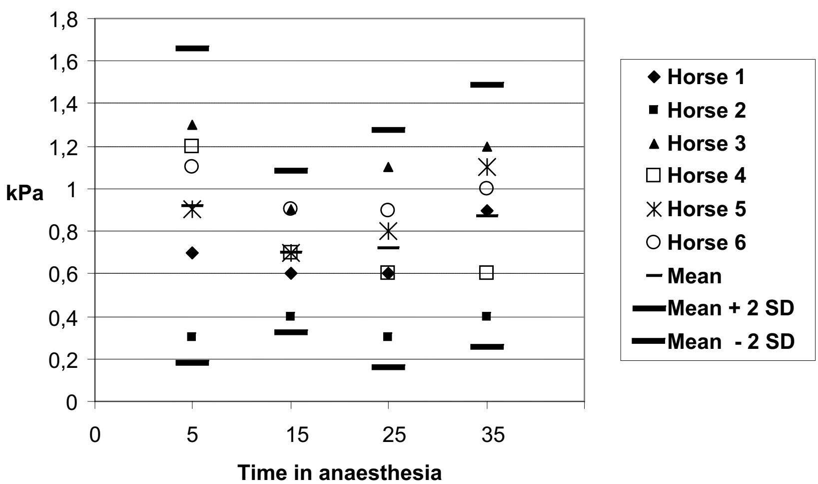

Figure 1. Difference between jugular venous oxygen tension ($PjvO_2$) and mixed venous oxygen tension ($P\bar{v}O_2$) during anaesthesia with protocol ARBZ (acepromazine, romifidine, butorphanol and tiletamine-zolazepam). Difference between jugular and mixed venous oxygen tension in kPa is plotted on the y-axis and time spent in anaesthesia is plotted at the x-axis.

jugular vein. The oxygen tension was approximately 5 kPa (37.5 mm Hg) in the jugular venous blood during anaesthesia. The correlation between mixed venous oxygen tension and jugular venous oxygen tension was significant (r = 0.90) during anaesthesia.

Discussion

Hospital conditions

In this clinical investigation the horses could not serve as their own controls and individual variations may have influenced comparisons between protocols. The analgesia was not sufficient in the RZ protocol and half of the colts in this group needed further anaesthesia to complete the surgery (Table 1). The analgesia was better in the other two groups including acepromazine. Acepromazine, without analgesic properties of its own, is reported to give significantly longer analgesia in dogs when combined with oxymorphone compared to oxymorphone alone (*Barnhart et al.* 2000). A combination of butorphanol, an opioid analgesic, and romifidine in horses is reported to reduce the reaction to touch and audiovisual stimuli more than romifidine on its own (*Clarke et al.* 1991). Acepromazine, but also butorphanol, may have contributed to the decreased need of additional anaesthesia in the two groups ARZ and ARBZ during castration.

The significantly higher systemic arterial pressure during protocol RZ compared to the protocols including acepromazine (Table 2) is in accordance with findings in an earlier cross over study (*Marntell et al.* 2005). The arterial oxygen tension tended to be lower in the group without acepromazine, but did not reach statistical significance in the present investigation. In an earlier cross over study (*Marntell et al.* 2005), including acepromazine resulted in significantly higher PaO_2. In the present investigation the horses in the group without acepromazine were in average 50 kg lighter than those in the other two groups. This together with individual variations may have contributed to that the difference in PaO_2 was not statistically significant. In the group without acepromazine, jugular venous oxygen tension was significantly lower compared to the other two groups. This may be more relevant to the tissue oxygenation than arterial oxygen tension. Hypoxaemia has long been recognised as a common and potentially hazardous side effect of anaesthesia in horses, although a link between death and hypoxaemia has not been demonstrated (*Taylor* 2002). The effect of non-fatal hypoxaemia is difficult to assess and the time factor may play an important role. During inhalation anaesthesia in ponies, 20 minutes of PaO_2 between 4.4 and 5.8 kPa (33-44 mmHg) did not have any detectable deleterious effect on recovery or postoperative well-being (*Taylor* 1998). In an investigation by *Whitehair et al*. (1996), horses were exposed to three hours of hypoxaemia (PaO_2 6.7±0.7 kPa (50±5 mm Hg)) during inhalation anaesthesia with isoflurane or halothane. The horses were reported to be lethargic to various degrees with decreased appetite after halothane anaesthesia. After three hours of isoflurane anaesthesia the horses appeared to show normal behavior, but some had a decreased appetite. Arterial oxygen tension gives information on the pulmonary gas exchange but only minor information about oxygenation of the tissue. Additional information may be obtained from mixed $P\bar{v}O_2$, as this will be influenced by PaO_2, Hb, blood flow, oxygen extraction and consumption. Further, mixed $P\bar{v}O_2$ was found to be a better predictor of hyperlactataemia and death than either arterial PaO_2 or cardiac output alone in critically ill human patients (*Kasnitz et al.* 1976). Consciousness is usually lost when the internal jugular venous oxygen tension falls below 2.7 kPa (20 mmHg), whatever the cause (*Nunn* 1993). In the present investigation with client-owned horses, a central venous catheter was not placed, instead jugular venous blood was sampled. A comparison between $P\bar{v}O_2$ and $PjvO_2$ during the ARBZ protocol was therefore made in horses owned by the department. A drawback is that the comparison is only made for protocol ARBZ and result may be different in the other groups. On average $PjvO_2$ was 0.8 kPa higher than $P\bar{v}O_2$ during anaesthesia. Thus jugular venous oxygen tension did overestimate the mixed venous oxygen tension, but the comparison between groups in the present investigation is probably valid since jugular venous oxygen tension was used within all groups. Group RZ showed significantly lower oxygen tension in jugular venous blood compared to group ARBZ (Table 2). This suggests that the horses without acepromazine have an overall larger extraction of oxygen when the blood passes through the tissue. A decrease in $P\bar{v}O_2$ has been reported after sedation with romifidine, and the value continued to be significantly decreased during the 2 hours of observation (*Freeman et al.* 2002). During anaesthesia with air breathing, the protocol ARBZ resulted in $P\bar{v}O_2$ similar to standing unsedated values, indicating that the oxygen delivery was sufficient to cover the overall tissue demand (*Marntell et al.* 2003). The results of the present investigation including surgery suggest a similar situation, with sufficient oxygen delivery.

It is concluded from the castrations under hospital conditions, that premedication with acepromazine and butorphanol in addition to romifidine before anaesthesia with tiletamine-zolazepam improves the anaesthesia and analgesia without having adverse effects on the cardiorespiratory function or on the quality of induction and recovery in healthy horses.

Field conditions

Since the ARBZ protocol was considered to be the most suitable for castrations under hospital conditions, it was chosen for castration of colts in field practice. As 22% of the horses needed further anaesthesia when this protocol was used at the animal hospital, it might have been expected that approximately 7 of the 31 colts castrated under field conditions would need supplemental anesthesia. However, none of the 31 colts castrated in the field needed supplemental anaesthesia (Table 1). One explanation for this result may be that the colts operated on in the animal hospital had a higher sympathetic tone before sedation and anaesthesia. The colts had previously been transported to the animal hospital, some for the first time. In this new environment they were placed in boxes within sight and hearing distance of other, unknown colts. These environmental changes may have induced a flight-fight response in the horses. Under field conditions the colts were kept in their own environment and together with colts of their own known herd, where a hierarchy was already established. The novelty stimuli during field castration were less pronounced than during the procedure at the animal hospital. It was our subjective perception that the sedation of the colts was deeper and more pronounced under field conditions, resulting in better anaesthesia and adequate analgesia for surgery.

With the ARBZ protocol no significant differences were found in arterial oxygen tension, jugular venous oxygen tension or carbon dioxide tension between colts castrated either in the animal hospital or under field conditions. There was a difference in heart rate, which may have been due to the age difference between the two groups. Yearlings are reported to have a higher heart rate than older horses (*Rossdale & Wreford* 1989, *Visser et al.* 2002). On average the colts in field practice were 1.5 years old and those in the animal hospital 2.5 years, and at baseline the heart rate was higher in the younger group.

One disadvantage of the use of a bolus dose of dissociative anaesthetic is the individual differences in the duration of anaesthesia and the often abrupt recovery. In the present investigation anaesthesia and analgesia were sufficient for clamping of the second spermatic cord at 12.5 minutes after induction, which also allowed less experienced surgeons enough time to perform the castration procedure under field conditions. However, veterinarians planning to use this anaesthetic protocol in field practice must take into consideration the individual variation of time spent in lateral recumbency, in this study 30-70 minutes. The time from completion of surgery to return of the horse to standing position was sometimes unnecessarily long. Other drug combinations and/or other proportions of dissociative anaesthetic and benzodiazepine might result in anaesthesia sufficient for castration and with a shorter recovery time. Prolongation of the anaesthesia was not necessary under field conditions. The recommendation to avoid field anaesthesia lasting more than 60 minutes without a possibility of giving supplemental oxygen (*Matthews & Hartsfield* 1993) is still accepted, but further research is of interest in this area. As with all dissociative anaesthesia in horses, a successful result requires deep sedation, undisturbed time after induction, proper placing to avoid muscle ischemia and unforced recovery.

In conclusion, the present investigation of tiletamine-zolazepam anaesthesia, after premedication with acepromazine, romifidine and butorphanol, resulted in anaesthesia sufficient for castration of colts under field conditions. The cardiorespiratory changes were within acceptable limits in these clinically healthy colts. Under hospital conditions some horses from all three anaesthetic protocols needed supplemental anaesthesia to complete surgery. The most interesting finding in the present study was the more pronounced reaction to surgery and need of supplemental anaesthesia under hospital conditions compared to field conditions. This aspect needs further investigation. Perhaps the hospital environment as such induces a high sympathetic tone in the horse which may contribute to the high mortality rate seen in horses during anaesthesia.

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Sammanfattning

Dissociativ anestesi för kastration av hingst på klinik och i fält.

Huvudmålet med denna undersökning var att utvärdera dissociativ anestesi för kastration av hingst under fältmässiga förhållanden. Tre olika dissociativa anestesiprotokoll utvärderades vid kastration av hingst på djursjukhus. Protokollet som ansågs lämpligast användes därefter vid kastration av hingst under fältförhållanden. Under djursjukhusförhållanden fördelades 26 hingstar slumpmässigt till ett av följande tre anestesiprotokoll: RZ = romifidin och tiletamin-zolazepam, ARZ = acepromazin, romifidin och tiletamin-zolazepam, ARBZ = acepromazin, romifidin, butorfanol och tiletamin-zolazepam. Trettioen hingstar kastrerades under fältförhållande med protokoll ARBZ. Hästarna spontanandades luft under anestesin. Respiratoriska och hemodynamiska parametrar samt responsen på kirurgi utvärderades. Kirurgen, som var ovetande om vilket anestesiprotokoll som använts, bedömde om ytterligare anestetika behövde ges för att genomföra kirurgin. Alla induktioner, anestesier och resningar var lugna utan excitation både på djursjukhus och i fält. Kirurgin utfördes mellan 5-20 minuter efter det att hästen lagt sig i sidoläge. Under djursjukhusförhållanden behövde ytterligare anestesi ges till vissa hästar från alla tre grupperna för att kunna genomföra kastrationen. Det mest intressanta fyndet var att ingen häst som kastrerades i fält behövde ytterligare anestesimedel för kirurgins genomförande. Variationer i cirkulation och respiration var acceptabla hos dessa kliniskt friska hästar.

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