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Comparison between head-tail-rope assisted and unassisted recoveries in healthy horses undergoing general anesthesia for elective surgeries

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Abstract

Objective: To compare attempts to stand, duration, quality, and occurrence of injuries between head-tail rope assistance and unassisted recoveries in healthy horses undergoing general anesthesia for elective surgeries.

Study design: Randomized, prospective, clinical trial.

Methods: Three hundred one healthy horses undergoing elective surgeries were randomly assigned to recover with head-tail rope assistance (group A) or unassisted (group U); 305 recoveries (group A, n = 154; group U, n = 151) were analyzed. Anesthesia was maintained with isoflurane and triple drip. For each recovery, attempts to stand, duration, quality, and recovery-associated injuries were recorded. Data were analyzed by linear regression and analysis of covariance.

Results: Anesthesia duration was similar between groups (mean ± SD, 70 ± 29 minutes). Compared with group U, group A had fewer attempts to stand (median [range], group A = 1 [1-7] vs group U = 3 [1-34]) and shorter duration of recovery (mean ± SD, A = 36 ± 12 minutes vs U = 41 ± 15 minutes). Recovery quality in group A (28 points [15-70]) was better than that in group U (38 points [11-87]). More horses had recovery-associated injuries in group U (9 horses) compared with group A (2 horses). One horse per group was euthanized.

Preliminary results of this study were presented as an oral abstract presentation at the Meeting of Anesthesiologists (Veterinärmedizinische Anästhesie, Intensivmedizin, Notfallmedizin und Schmerztherapie); October 29, 2016; Berlin, Germany and the content of this study was presented as an oral abstract presentation at the Association of Veterinary Anaesthetists Spring Meeting; April 26-28, 2017; Manchester, Great Britain.

Conclusion: Head-tail rope assistance reduced standing attempts, shortened recovery duration, improved recovery quality, and reduced recovery-associated minor injuries after general anesthesia for elective surgery in healthy horses. Fatalities could not be prevented.

Clinical significance: Head-tail rope assistance may improve recovery in healthy horses after short-duration elective surgeries with isoflurane and triple drip.

1 | INTRODUCTION

Recovery is a critical period of general anesthesia in horses. In comparison to other species, the mortality rate in horses undergoing general anesthesia is high; it is reported to be 0.9% for noncolic cases.[1] A recent single-center study reported a mortality rate of 1.1% during the recovery phase after general anesthesia; 71.4% of these deaths were due to recovery-associated fractures and joint dislocations.[2] Other reported fatal anesthesia recovery-related problems are myopathies, neuropathies, spinal cord malacia, and respiratory obstruction.[2,3] There currently is no general consensus nor are there evidence-based recommendations for the best technique to recover horses after general anesthesia. Many hospitals prefer not to assist anesthesia recovery at all or provide assistance only after specific high-risk surgical procedures or in horses with full-limb casts or with proprioceptive deficits.[4,5]

Assisted methods for equine recovery include hand assistance, sling systems, inflated air pillow, tilt table, recovery pools, and head-tail rope assistance.[6-11] Hand-assisted recovery is possible in well-behaved horses, small horses, and foals.[12] One or two personnel stay with the horse in the recovery stall to assist it to a standing position.[13] This technique poses a high risk for staff helping with the recovery. Sling systems have the advantage of lifting a horse that is unable to support its own weight; however, limitations include horse size, requirement for additional equipment, and availability of trained personnel.[7,14,15] Ray-Miller et al[8] evaluated the use of the inflatable air pillow for equine anesthetic recovery and found an increase in recovery duration, but with improvement in quality of recovery.[8] One disadvantage is that shoes must be removed in every horse prior to recovery.[8,12] The use of a tilt table and different recovery pools are described for recovery in high risk horses[6,9,10]; however, those systems are staff and time intensive and are not practical to use on a routine basis.

Head-tail rope assistance is the most commonly used method to assist recovery in equine hospitals.[4] The principle underlying head-tail rope assistance is provision of stability and direction to the horse during attempts to stand.[16] This system consists of two ropes; one rope is attached to the halter with the purpose of controlling direction of the horse's standing attempts, and the other rope is tied to the tail as point of anchor with the purpose of assisting and stabilizing attempts to stand. The ropes can be managed by one or two persons, and the persons assisting the recovery can be outside or inside the recovery stall.[16-19] The ropes may be used alone or may be supplemented by the addition of pulley systems and self-braking descender devices.[16-18] Compared with some of the other assisted recovery techniques, head-tail rope assistance can be safer for the staff as long as they are not inside the recovery stall, safer for the horse, and easier to implement[16,18]; however, the reported advantages of this technique are not uniformly accepted. Some authors have suggested that the method may contribute to safer recoveries in all horses, whereas others see a benefit only in older, heavier, or systemically ill horses or after prolonged anesthesia.[16-18,20-22] Equipment or technique failures for head-tail rope assistance recovery are reported to be rare, occurring in 0.08% of assisted recoveries, and can include twisted ropes, tail knot slippage, loose head collars, facial nerve paralysis, and broken tail hair.[17,21,22]

Prospective, randomized, clinical studies comparing head-tail rope assistance vs unassisted recovery after general anesthesia for elective surgeries in healthy horses are lacking. The objective of this study was to compare recovery with head-tail rope assistance vs unassisted recovery by investigating quantitative and qualitative recovery parameters in horses undergoing elective surgeries. We hypothesized that the use of head-tail rope assistance for recovery after general anesthesia would shorten time to standing, decrease the number of attempts to stand, improve quality of recovery, and decrease incidence of minor recovery-associated injuries.

2 | MATERIALS AND METHODS

The study was reviewed and approved by the institutional ethical committee of the University of Veterinary

Medicine Hannover, Foundation, Germany. Owner consent was obtained verbally.

2.1 | Animals

The study included 301 horses that underwent elective surgery under general anesthesia between May 2015 and June 2016 at a private equine hospital in Germany. The study was designed as a prospective, randomized, clinical trial.

Inclusion criteria were American Society of Anesthesiologists (ASA) physical classification status I or II and age between 1 and 23 years. Exclusion criteria consisted of an estimated weight less than 200 kg or small heads such that the halter could not be placed (eg, Shetland ponies). Horses undergoing nonelective procedures (eg, exploratory celiotomy) and horses with ASA physical status ≥III were also excluded. Horses were randomly assigned to recover either with head-tail rope assistance (group A, 154 horses) or unassisted (group U, 151 horses) by the flipping of a coin. Horses were further stratified into four surgical groups for statistical analysis according to their surgical procedure:

- ART: arthroscopy/tenovaginoscopy/annular ligament desmotomy
- CAS: castration/cryptorchidectomy/spermatic cord fistulectomy
- SPL: splint bone surgery/sequestrectomy
- HS: head surgery (vitrectomy, enucleation, prosthetic laryngoplasty, sinus cyst removal, keratectomy, upper eyelid sarcoid removal)

2.2 | Anesthesia

All horses were premedicated in their stall with detomidine (10-30 μg/kg IV). A 14G catheter was placed into the right or left jugular vein. After having been moved to the induction stall, horses were sedated with xylazine (0.6-1.0 mg/kg IV) to effect and levomethadone (0.05 mg/kg IV). Approximately 30 minutes elapsed between detomidine and xylazine administration. Anesthesia was induced with ketamine (2-3 mg/kg IV) and diazepam (0.04 mg/kg IV). Horses were orotracheally intubated and connected to a large animal anesthetic machine, and lungs were mechanically ventilated. Anesthesia was administered and monitored by two experienced technicians. Anesthesia was maintained by using isoflurane in oxygen, which was administered to effect and adjusted to achieve surgical depth of anesthesia. Partial IV anesthesia was performed by using a triple drip infusion (guaifenesin 37.5 g, ketamine 750 mg, xylazine 300 mg in 500 mL 0.9% saline solution). The initial infusion rate was 1 mL/kg/hour IV for the first 10 minutes, followed by 0.3 mL/kg/hour IV. The infusion was administered by a gravity flow through a fluid administration drip set and adjusting drops per second. All horses received Ringer's solution at 5 mL/kg/hour IV and dobutamine 0.5 μg/kg/minute IV. Depth of anesthesia was assessed by using ocular reflexes (palpebral reflex, pupillary reflex, and eye position), lacrimation, and presence or absence of nystagmus. Spontaneous movements resulted in administration of a bolus xylazine (0.04-0.08 mg/kg IV) with or without ketamine (0.2-0.5 mg/kg IV). Within 10 minutes of induction of general anesthesia, flunixin meglumine (1.1 mg/kg IV) was administered. No extra analgesia was given except for 200 mg of mepivacaine injected into each spermatic cord prior to all castrations. The triple drip infusion was stopped 30 minutes before the end of anesthesia.

Postoperative antimicrobial and analgesic treatment were variable at the discretion of the surgeon, depending on the surgical procedure.

2.3 | Recovery from anesthesia

As soon as the horses started to breath spontaneously, they were transferred to a 2.30 × 2.36-m padded recovery stall and placed in a diagonal position. All horses were sedated with xylazine (0.2-0.25 mg/kg IV) in the recovery stall as soon as nystagmus was observed, and a urinary catheter was placed in all horses to empty the bladder. After they had been positioned in the recovery stall, all horses in group A had a special, purpose-made halter with a rope attached to the nose band secured on their head and a second rope was knotted around the tail. Two diagonally positioned rings, which were installed at a height of 2.50 m, were used to direct the head and tail rope to the opposite side of the recovery stall. The ropes were managed by two individuals standing outside the long side of the recovery stall on a balustrade. The head rope was always managed by the same experienced person and the tail rope was managed by a less experienced person who was instructed by the more experienced person. As soon as the horse made an attempt to stand, first the head rope and then the tail rope were tightened to lead direction with the head rope and control stability with the tail rope. Ropes were removed if the halter slipped off the head, if the head rope detached from the halter, or if the horse did not tolerate the head-tail rope assistance. Horses in group U recovered unassisted. Horses in group U were assisted with a head-tail rope if any of the following criteria were met: more than 15 attempts to stand, horses not standing by 65 minutes after the end of anesthesia, or horses that did not stand 50 minutes after their first attempt at standing. Data were analyzed according to the original group assignment.

2.4 | Postoperative monitoring

The recovery phase was evaluated by the same observer (S.A.), who was not involved in the anesthetic monitoring but did manage the head rope during the head-tail rope assistance. For each recovery phase, the time to first activity (lifting the head and/or leg movement), time to reach sternal position, duration of sternal phase, time to first attempt to stand, and duration of recovery (time from turning the vaporizer off to safe standing) were recorded. The end of recovery (safe stand) was defined as standing steadily with minimal risk of falling. Moreover, the number of attempts required to achieve a safe standing position were counted. Quality of recovery was scored by the person assisting the head rope by using a composite score system (CSS) described by Clark-Price et al,[23] which ranged from 11 points for the best recovery and 100 points for the worst recovery. After horses were standing steadily, the tail rope was first removed, followed by the head rope, and these time points were recorded. All horses were examined for recovery-associated injuries immediately after standing and one day after surgery.

2.5 | Data analysis

Data were analyzed in SAS version 9.3 (SAS Institute, Cary, North Carolina). Normal distribution of the data was assessed by using the Kolmogorov–Smirnov test and visual assessment of the q-q plots. Because of the right-skewed distribution, the data on duration of the sternal phase, number of attempts to reach safe stand, and quality of recovery were logarithmically transformed. After exponential retransformation, the results were presented according to the original scale. Age, breed, estimated weight, and duration of anesthesia were analyzed by using linear regression for their effect on time to first activity, time to reach sternal position, duration of sternal phase, time to first attempt, and duration of recovery as well as number of attempts to stand and quality of recovery in group A and group U. The effect of surgical procedure, head-tail rope assistance vs unassisted recovery (groups A and U, respectively), and sex on the variables mentioned above was calculated by using four-way analysis of covariance including interactions, considering age and weight as covariates. After elimination of the nonsignificant effect of sex, a three-way analysis of covariance was used with post hoc Tukey test for multiple pairwise comparisons, considering experiment-wise error rate. The effect of head-tail rope assistance on recovery-

TABLE 1 Number of recoveries for horses undergoing recovery with head-tail rope assistance and unassisted recovery

Surgery type	Group	Total recoveries, n	Recoveries per group, n	Age, mean ± SD, y	P, n	OB, n	T, n	WB, n	Duration of anesthesia, mean ± SD, min
All	A	305	154	7 ± 5	23	14	16	101	70 ± 28
	U		151	6 ± 5	20	12	24	95	70 ± 27
ART	A	190	95	6 ± 4	10	7	11	67	77 ± 26
	U		95	5 ± 4	11	7	19	58	75 ± 26
CAS	A	44	22	4 ± 3	5	3	2	12	38 ± 26
	U		22	4 ± 5	1	2	3	16	43 ± 23
SPL	A	47	24	10 ± 5	8	4	1	11	71 ± 17
	U		23	11 ± 4	7	3	1	12	71 ± 26
HS	A	24	13	7 ± 4	0	0	2	11	73 ± 21
	U		11	9 ± 6	0	0	1	9	82 ± 11

Note: Recovery after general anesthesia with isoflurane and triple drip for elective surgical procedures as well as number of recoveries within each surgical procedure (ART, CAS, SPL, HS).

Abbreviations: A, head-tail rope assistance group; ART, arthroscopy/tenovaginoscopy/annular ligament desmotomy; CAS, castration/cryptorchidectomy/spermatic cord fistulectomy; HS, head surgery (vitrectomy, enucleation, prosthetic laryngoplasty, sinus cyst removal, keratectomy, upper eyelid sarcoid removal); OB, other breeds (thoroughbreds [6], Arabian horses [4], Friesian horses [3], quarter horses [3], pura raza española [3], Lusitano [2], paint horse [1], Barock pinto [1], Criollo [1], Morgan horse [1], Irish tinker [1]); P, pony; SPL, splint bone surgery and sequestrectomy; T, trotter; U, unassisted recovery group; WB, warmblood.

TABLE 2 Different stages of the recovery phase for healthy horses with head-tail rope assistance recovery unassisted recovery

Surgery type	Group	Time to first activity, mean ± SD, min	Time to reach sternal position, mean ± SD, min	Duration of sternal phase, median (range), min	Attempts to stand, median (range), n	Time to first attempt, mean ± SD, min	Duration of recovery, mean ± SD, min	CSS, median (range)
Combined surgeries and groups		26 ± 11	26 ± 15	4 (0-40]	2 (1-34]	34 ± 13	39 ± 14	32 (11-70]
All	A	26 ± 9	25 ± 15	4 (0-35)	1 (1-7)[a]	33 ± 13	36 ± 12[b]	28.5 (15-70)[c]
	U	27 ± 10	27 ± 15	4 (0-40)	3 (1-34)	35 ± 14	40 ± 15	38 (11-87)
ART	A	26 ± 10	24 ± 16	4 (0-35)	1 (1-7)[a]	35 ± 12	37 ± 13	29 (19-70)[c]
	U	27 ± 12	28 ± 16	4 (0-40)	3 (1-34)	35 ± 14	41 ± 16	36 (13-87)
CAS	A	25 ± 7	31 ± 12	3 (0-15)	1 (1-4)[a]	35 ± 10	37 ± 12	27 (15-57)
	U	28 ± 8	29 ± 15	4 (0-20)	2 (1-7)	37 ± 14	41 ± 16	31.5 (11-62)
SPL	A	24 ± 9	22 ± 12	3 (0-9)	2 (1-4)[a]	28 ± 10	31 ± 9[b]	28 (19-51)
	U	27 ± 10	25 ± 15	4 (0-27)	3 (1-13)	33 ± 11	38 ± 11	41 (21-80)
HS	A	27 ± 9[d]	31 ± 10	4 (0-15)	2 (1-4)[a]	34 ± 10	38 ± 12	37 (24-46)
	U	19 ± 10	22 ± 12	5 (0-18)	8 (1-28)	26 ± 12	39 ± 18	55 (18-78)

Note: Recovery after general anesthesia with isoflurane and triple drip for elective surgical procedures.

Abbreviations: A, head-tail rope-assisted recovery; ART, arthroscopy/tenovaginoscopy/annular ligament desmotomy; CAS, castration/cryptorchidectomy/spermatic cord fistulectomy; CSS, composite recovery score system; HS, head surgery (vitrectomy, enucleation, prosthetic laryngoplasty, sinus cyst removal, keratectomy, upper eyelid sarcoid removal); SPL, splint bone surgery and sequestrectomy; U, unassisted recovery.

[a]Group A required fewer attempts to stand in comparison to group U (All, $P < .0001$; ART, $P < .0001$; CAS, $P = .015$; SPL, $P = .002$; HS, $P = .003$).

[b]Difference in duration of recovery between group A and U ($P = .003$; SPL, $P = .014$).

[c]Group A had a better recovery quality than group U ($P < .0001$).

[d]For group HS, time to first activity was longer in group A than in group U ($P = .048$).

associated injuries was tested by using Fisher's exact test. Significance was set at $P \leq .05$.

3 | RESULTS

In total, 305 recoveries in 301 horses were analyzed. There were 106 mares, 98 stallions, and 97 geldings with a mean age of 6.6 ± 4.5 years. Breeds included 196 warmbloods, 43 ponies, 40 trotters, and 26 horses from other breeds (six thoroughbreds, four Arabians, three Friesians, three quarter horses, three pura raza española, two Lusitanos, one paint, one Barock pinto, one Criollo, one Morgan, and one Irish tinker; Table 1). Estimated mean weight was 517 ± 100 kg. Surgical procedures are listed in Table 1.

3.1 | Recovery from anesthesia

The recovery results are presented in Table 2 and in Figures 1 and 2. The median (range) number of attempts to stand for all recoveries was two (1-34). The number of attempts to stand for horses in group A was fewer (1 [1-7]) than that for horses in group U (3 [1-34]; $P < .0001$; Table 2). This result remained when compared between surgical procedures (Table 2). Ponies, warmbloods, and other breeds required fewer attempts to reach safe stand in group A compared with horses in group U ($P = .021$; $P < .0001$; $P < .0001$, respectively). Duration of recovery (mean ± SD) was shorter in group A (36 ± 12 minutes) than in group U (41 ± 15 minutes; $P = .003$; Table 2).

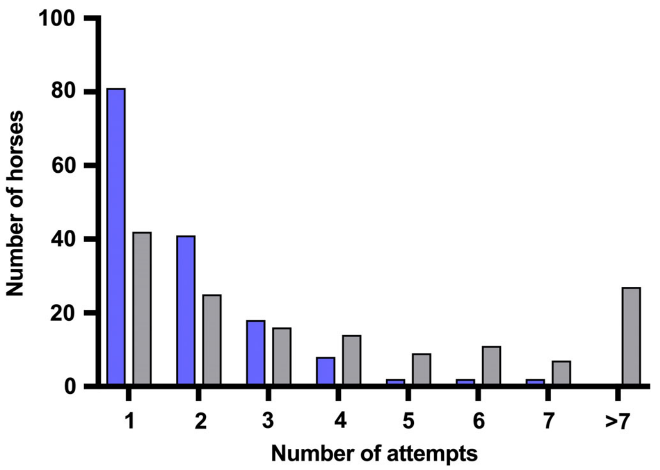

FIGURE 1 Bar graphs illustrating the number of horses requiring 1 to ≥7 attempts until safe stand in horses with head-tail rope assistance recoveries (group A, n = 154, blue bars) and horses with unassisted recoveries (group U, n = 151, gray bars) after general anesthesia with isoflurane and partial intravenous anesthesia for elective surgical procedures in healthy horses

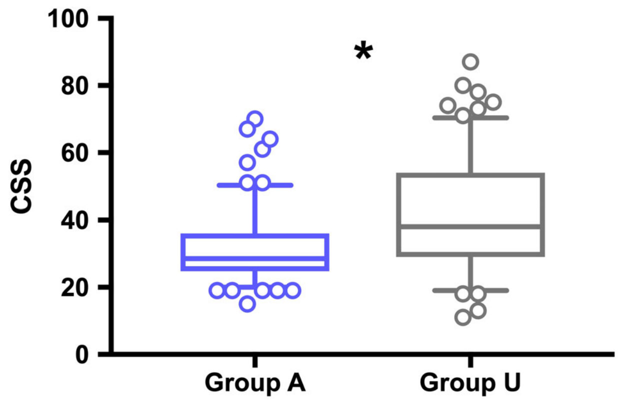

FIGURE 2 Boxplot illustrating the median recovery quality score assessed with the composite recovery score system (CSS)[23] for recoveries in horses with head-tail rope assistance (group A, n = 154, blue box) and in horses with unassisted recoveries (group U, n = 151, gray box) after general anesthesia with isoflurane and triple drip for elective surgical procedures in healthy horses. With this scoring system, an ideal recovery would have a score of 11 points, whereas the most uncoordinated recovery would be scored 100 points. The box encompasses the interquartile range with the intersecting line as the median. The vertical lines (whiskers) below and above the box are the fifth and 95th percentiles, respectively. Outliers are the individual circles outside the box. Total recovery quality scores in horses with head-tail rope assistance (group A, blue box) were lower (better) than those in horses with unassisted recoveries (group U, gray box; $P < .002$)

Warmbloods reached safe stand earlier with head-tail rope assistance than without assistance ($P = .004$).

Quality of recovery according to the CSS was better in group A (28.5 points [15-70]) than in group U (38 points [11-87]; $P = .002$; Figure 2) for all surgeries combined and for the ART subgroup ($P < .0001$; Table 2). In the HS subgroup, time to first activity was longer in group A compared in group U ($P = .048$). Duration of anesthesia had an inverse effect on first activity ($P = .007$) in that longer durations of anesthesia were associated with shorter times to first activity.

3.2 | Recovery-associated injuries and recovery problems

Nine horses in group U and one horse in group A acquired skin abrasions during recovery. Two horses in group U had postrecovery lameness. Overall, incidence of recovery-associated injuries was higher in group U than in group A ($P = .035$). One recovery-associated fatality occurred in each recovery group. In group A, a 9-year-old warmblood mare was euthanized after developing a tibial fracture during a sixth attempt to stand after an uneventful left metacarpophalangeal joint arthroscopy and

62-minute duration of anesthesia. In group U, a 5-year-old warmblood mare was euthanized because of the inability to stand after uneventful bilateral tibiotarsal joint arthroscopy and 87-minute duration of anesthesia.

Three unassisted recoveries (group U) required conversion to head-tail rope assistance. Two horses stood after one attempt with head-tail rope assistance. In these two horses, head-tail rope assistance was applied 65 minutes and 74 minutes after the end of anesthesia. One horse did not reach safe stand despite head-tail rope and sling assistance and was ultimately euthanized (horse described previously). This horse made her first attempt 29 minutes after the end of anesthesia and made multiple attempts until exhaustion. Intervention to provide assistance or reanesthetize the horse prior to this time was not possible because of safety concerns. At 57 minutes after the first attempt, it was safe to enter the recovery stall and attach the ropes. Head-tail rope assistance did not achieve safe stand, and a sling system was attempted. The mare stood and fell again a total of four times. After 6.5 hours, the owner was contacted, and euthanasia was elected. The reason for the inability to stand remained unknown because necropsy was not performed.

In group A, intervention was required in the recovery phase in four horses. For one horse, the ropes had to be released and replaced three times because the ropes got tangled around the legs. One horse had to be repositioned because of its close position to the wall. In a third horse, the carabiner locked to one of the wall rings so that the horse was tied with its head. It was possible to release this horse without complications. In the fourth horse, the head rope fell off because of an unlocked carabiner. The recovery stall was entered to detach the tail-rope so that the horse could get up without assistance. This horse required seven attempts and reached safe stand 30 minutes after the end of anesthesia with a recovery quality score of 49 points. After this incident, the original carabiner was replaced by a carabiner with a locking device. Two horses lost their balance and fell after reaching safe stand because of interference by the person operating the tail-rope. In 12 horses, the ropes were released immediately after safe stand because the horses started head shaking, pawing, and rearing. None of these cases required the head-tail rope to be detached prematurely before reaching a safe stand.

4 | DISCUSSION

In our population of horses, head-tail rope assistance decreased the number of attempts to stand, accelerated and improved the quality of recovery, and reduced the incidence of recovery-associated minor injuries. The mortality rate was the same in both groups, and head-tail rope assistance did not prevent the occurrence of fractures. While a difference in the number of attempts between head-tail rope assistance and unassisted recoveries has not been detected in other studies, horses receiving head-tail rope assistance in our study required fewer attempts to stand than those recovering without assistance.[24,25] Huber[20] suspected that head-tail rope assistance decreased the number of attempts in high risk horses after surgeries longer than 90 minutes duration; however, our study found that head-tail rope assistance decreased the number of attempts in healthy horses independent of the duration of anesthesia. It should be noted that the overall median number of attempts to stand in our study was low. Reasons for this finding could be the good general condition of all horses,[26] young mean age, and inclusion of elective surgical procedures, which resulted in short duration of anesthesia. To avoid the influence of general physical condition and health status on recovery in this study,[2,27] only horses with ASA physical status I and II were included. Horses were equally distributed between the groups according to signalment such as age, sex, breed, and estimated weight, minimizing these variables as confounding factors. Trotters were the only breed in which head-tail rope assistance did not reduce the number of attempts, which could be related to the calm and sensible behavior as well as athletic body conformation of this breed. Warmbloods especially appeared to benefit from head-tail rope assistance. Our clinical impression is that recoveries in warmbloods are less coordinated compared with other breeds. Use of head-tail rope assistance in warmblood horses may aid their stability and may result in earlier achievement of a safe standing position. Body weight correlates with the breed[2] and is likely a confounder of this observation in addition to differences in temperament and behavior.

Horses with head-tail rope assistance had a shorter duration of recovery than horses with unassisted recoveries. One explanation could be that horses with unassisted recoveries required more attempts to standing, which potentially required more time. This is in contrast to the report of a recently published study by Rüegg et al[17] in which a difference in recovery duration between assisted and unassisted recoveries was not found. The main differences between the Rüegg et al[17] study and our study are the case populations evaluated in each study (emergency abdominal surgeries vs elective surgeries), which may have led to different results.

In contrast to other authors' impressions,[23] horses in our study did not appear to be stimulated by head-tail rope assistance as used in our study. We found that horses with head-tail rope assistance did not have a difference in time to first activity, time to reach sternal position, duration of sternal phase, and time to first attempt to stand compared with horses with unassisted recoveries.

The different surgical subgroups did not differ in time to first activity, time to reach sternal position, duration of sternal phase, number of attempts, or quality of recovery, which might be explained by the similarities in anesthesia protocols, duration of anesthesia, and analgesic medication among horses. Regardless, surgical procedures varied in degree of invasiveness, and, as such, the influence of differing degrees of surgically induced pain on recovery measures cannot completely be excluded. We did observe an inverse relationship between anesthesia duration and time to first activity (longer surgeries may be more invasive and painful, which may shorten time to first activity), and sympathetic stimulation caused by inadequate analgesia might be a potential explanation for this observation.

Recovery quality as assessed by the CSS was better in group A than in group U, which supports the impression that fewer attempts correlate to better recovery quality. However, the CSS might not completely reflect recovery quality. The recovery quality scale of Clark et al[23] was chosen because of its practicability and acceptable interobserver agreement. A limitation of this scale is the inaccuracy in predicting outcome. For example, a horse with only minor recovery-associated abrasions was scored 87 points for recovery, whereas another horse that was not able to get up and had to be euthanized was scored 75 out of 100 possible points. Therefore, it might be useful to include recovery-associated injuries and complications, such as the inability to stand, into a future scoring system.

Head-tail rope assistance significantly reduced and prevented recovery-associated abrasions and postanesthetic lameness compared with unassisted recoveries in the study reported here. This is echoed in the report of another study[28] in which it was found that head-tail rope assistance prevented minor recovery-associated injuries, such as hematomas and minor lacerations. Recovery-associated hematomas, minor lacerations, and skin abrasions are clearly recovery-associated, while the cause of postrecovery lameness is not as obvious. Although the exact cause of lameness could not be determined, lameness was not present before anesthesia in these horses. Postrecovery lameness due to neuropathy/myopathy syndrome secondary to hypoperfusion or malpositioning during anesthesia cannot be excluded.

The recovery-associated fatality rate in this study was 0.66% (2/305), which did not differ between head-tail rope assistance and unassisted recoveries. This recovery-associated fatality rate is comparable to studies citing 0.9% to 1.1% fatality rates.[1,2] However, comparison between studies is difficult because of the different animal populations and surgical procedures and differences in anesthetic management and recovery methods. The development of a fracture in a horse with an assisted recovery confirms that head-tail rope assistance does not completely prevent the occurrence of fractures.[19] The incidence of recovery-associated fractures is low.[29] Statistical analysis to detect differences in fracture complications is difficult to perform because trials with case numbers similar to our study are underpowered due to the infrequent occurrence of this complication. The ability of head-tail rope assistance to reduce the number of repeated, unsuccessful attempts followed by repeated rising and exhaustion strongly implies the potential to reduce the risk of major recovery-associated injuries.[4] This hypothesis must be assessed by future, large scale, multicenter studies.

Three horses' unassisted recoveries were deemed unsuccessful, and head-tail rope assistance was initiated. This is comparable to results of the Rüegg et al study[17] in which four horses required support by head-tail rope assistance after unsuccessful unassisted recovery. In our study, head-tail rope assistance after failure of unassisted recovery was successful in two of three cases. Failure in one case might have been caused by delayed attachment of the ropes. Because of personnel safety concerns, earlier attachment of the ropes was not possible, which may have resulted in the horse being exhausted by the time head-tail rope assistance was provided. No head-tail rope-assisted recoveries were unsuccessful due to intolerance of the horses to assistance during recovery attempts. Twelve horses had to have the ropes released immediately after safe stand; however, these horses accepted the head-tail rope assistance during standing attempts and successfully achieved safe stand with the assistance.

A few complications and technical problems associated with head-tail rope assistance were observed. Loss of the halter and detachment of the ropes were not observed with the same frequency as previously reported.[17] Twisting of the ropes was seen once.[17] In the Rüegg et al[17] study, the halter fell off three horses, and ropes became twisted around each other in nine horses and around the legs in one horse. It is important to check the correct attachment (halter, head, and tail-rope) prior to recovery to avoid preventable causes for equipment failure. Twisted ropes during recovery can be addressed either by switching the positioning of the head rope and the tail rope in the wall rings or by removal of the ropes to convert to an unassisted recovery. Complications, such as facial nerve paralysis or broken tail hair, did not occur in our study.[21,22] Operator failure was observed in two horses, which was attributed to lack of experience in managing the tail rope. Differences in horse population, surgical procedures, technical equipment, and recovery box design as well as availability of personnel trained and experienced in head-tail rope assistance may explain the differences between previously described complications[17] and our experience during this study.

There are several limitations related to the design of this clinical trial that was performed in a private equine hospital setting. One limitation of the study is that a single observer scored all horse recoveries. This observer was not involved in anesthesia management but was involved in the recovery process by managing the head rope. Regardless, the nature of the study prevented blinding to the type of assistance; therefore, a subjective bias on evaluation of recovery cannot be excluded. While measurement of quantitative variables (eg, duration of recovery, number of attempts, etc) is objective, assessment of quality of recovery by quality scales[23] is not. It can be assumed that the same error was introduced across both recovery groups, and no attempt is made to make general comparisons of recovery quality to other studies. Use of video-recordings of the recoveries and accelerometry might have increased validity of the recovery scoring.[30] A recent report described poor agreement among American College of Veterinary Anesthesia and Analgesia diplomates when they evaluated recovery with subjective scoring, which initiated studies investigating the reliability of accelerometry as a tool for objective evaluation of recovery.[30] Another limitation is the estimation of body weight instead of measurement of body weight on a scale. Although estimation of body weight is not as accurate as using a scale, it was performed by the same experienced person. As such, any errors in weight estimation were expected to affect all horse weight estimates equally. It could be critiqued that anesthesia management was not ideal. Low perfusion pressure and hypoxemia cannot be excluded because of insufficient sensitivity of the chosen monitoring equipment (eg, noninvasive blood pressure measurement). However, it is anticipated that major effects of the cardiovascular status during anesthesia on the subsequent recovery may have been minimized because only ASA physical status I and II horses were included in the study, anesthesia times were short, and no major complications were recorded during anesthesia in both groups.

In conclusion, head-tail rope assistance after short-duration elective surgical procedures in healthy horses anesthetized with isoflurane and triple drip anesthesia decreased number of attempts to stand, shortened duration of recovery, and improved recovery quality. It also reduced the occurrence of minor recovery-associated injuries, but it did not prevent the occurrence of fractures or recovery-associated fatalities.

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CONFLICT OF INTEREST

The authors declare no competing interests related to this report.

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