Evaluation of esophageal pressure in healthy horses under general anesthesia

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Introduction

In human medicine, the use of oesophageal pressure optimises mechanical ventilation, but this approach is unexplored in veterinary medicine [1].Monitoring oesophageal pressure (Pes) could provide a better understanding of ventilatory dynamics in horses and help to optimise ventilation strategies, particularly in critical conditions. The aim of this study was to develop a catheter to measure oesophageal pressure and to assess its feasibility in horses undergoing scheduled surgery.

Materials and methods

The oesophageal catheter was composed of a silicone balloon and a plastic tube (5 x 2000 mm). Its pressure/volume curve and ability to measure pressure in a silicone box were evaluated through in vitro testing [2].Following this evaluation, the catheter was utilised in elective surgical procedures on healthy horses. Horses were sedated using 20 mcg/kg acepromazine, 20 mcg/kg detomidine, and 100 mcg/kg morphine, all administered intravenously. The catheter was inserted into a nasogastric tube, and anaesthesia was induced with 2.5 mg/kg ketamine and 0.05 mg/kg midazolam all IV, with isoflurane used to maintain anaesthesia. Mechanical ventilation was initiated immediately to maintain normocapnia. The catheter balloon was then advanced out of the tube, inflated and moved until cardiac artefacts appeared on the pressure waveform. Oesophageal pressure was collected in two conditions: dynamic ($\mathrm{Pes_{dyn}}$) and static ($\mathrm{Pes_{st}}$), using 30 seconds of inspiratory pause.

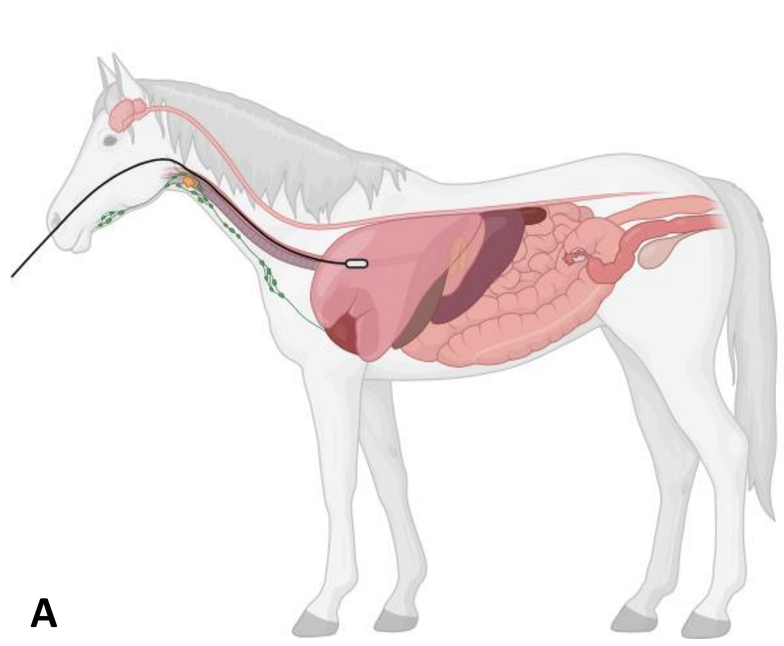

Figure 1. A) *Diagram illustrated the position of the balloon catheter: nasogastric tube with oesophageal catheter inside* B) *The pitot tube based sensor (H-lite) is interposed between the endotracheal tube and the Y-piece of a circle system during equine anaesthesia.*

Results

This study included 15 horses (10 yearling male and 4 female), of which one was excluded for a suspect of pulmonary diseases (average age 21,2 ±4,8 months, weight 401 ± 64,2kg). Under in vitro conditions, it was observed that the catheter showed no pressure change when filled with less than 88 ml. Conversely, filling the balloon above 98 ml resulted in a sharp increase in pressure. Filling volumes between 88 ml (V_{min}) and 98 ml (V_{max}) provide the best conditions for pressure measurement (linearity range).

$\mathrm{P_{peak}}$, $\mathrm{Pes_{dyn}}$, $\mathrm{Pes_{st}}$ were respectively 23 (19-27) $\mathrm{cmH_2O}$, 12,24 (4,08-14,95) $\mathrm{cmH_2O}$, 6,80 (5,44-9,52) $\mathrm{cmH_2O}$.

The following data were also measured: heart rate (HR), respiratory rate (RR), tidal volume (TV), minute volume (MV), end-tidal CO_2 (etCO_2), whose medians and ranges were respectively 35 (31-43) bpm, 9,5 (7-14) atm, 5,65 (4,5-9) l, 11,15 (8-26,6) l/min, 43 (39-47) mmHg.

Patient	Age (month)	Sex	Weight (kg)	$\mathrm{P_{peak}}$ ($\mathrm{cmH_2O}$)	$\mathrm{Pes_{dyn}}$ ($\mathrm{cmH_2O}$)	$\mathrm{Pes_{st}}$ ($\mathrm{cmH_2O}$)	RR (atm)	TV (l)	MV (l/min)	End-tidal CO_2 (mmHg)
1	36	M	570	27	9,52	9,52	10	9	26,6	40
2	20	M	420	25	12,24	7,48	9	6,4	24,2	45
3	19	F	320	19	5,44	6,80	13	4,5	8,8	41
4	22	F	400	21	12,24	6,80	13	6,9	12,8	42
5	23	M	410	23	12,24	8,16	8	5,4	11,2	45
6	21	M	405	24	10,88	6,80	14	5,6	11,1	46
7	20	M	415	24	12,24	5,44	7	5,7	8,1	47
8	20	M	420	25	13,60	6,80	9	6,4	24	45
9	19	M	390	22	12,24	8,16	9	6,9	11,9	40
10	18	F	350	20	12,24	8,16	9	6,8	11,9	45
11	18	F	400	22	10,88	6,80	10	4,5	8	43
12	19	M	320	23	4,08	6,80	9	5	9	40
13	Excluded patient									
14	19	M	340	25	8,157	6,8	10	5,2	10,2	39
15	20	M	450	23	14,95	10,88	10	5,2	11,1	41

Table 2. Data and ventilation parameters of fifteen horses anaesthetized

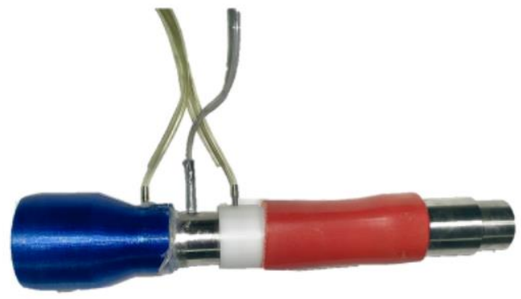

Figure 2. Design of the sensor head (H-lite)

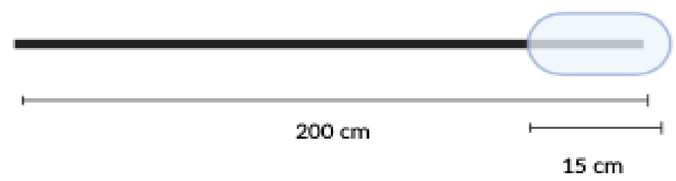

Figure 3. Diagram of the polyethylene catheter and its dimensions

Discussion

The primary finding of this study is that the mechanical properties (elasticity and fragility) of the catheter balloon material significantly influence pressure recordings. The pressure curve does not exhibit a well-defined plateau zone and is non-linear. Additionally, excessive inflation volumes can cause considerable balloon deformation, leading to inaccurate pressure transduction and reducing the device's reliability. Notably, the oesophagal pressure measurement in healthy anaesthetized horses has never been conducted before. A standardized protocol is being developed to compare healthy horses and those affected by colic syndrome.

Conclusions

Manufacturing an oesophageal catheter for horses is feasible using readily available components. However, the catheter's fragility remains a significant challenge, necessitating frequent replacements. This study evaluated the correct positioning and function of the catheter in anaesthetised horses in dorsal recumbency, with preliminary results indicating promising outcomes. Further investigation with the use of oesophagal pressure on patients with colic syndrome could be conducted to thoroughly understand the influence of this monitoring on ventilation and oxygenation treatment.

REFERENCES

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2. Walterspacher, S., Isaak, L., Guttmann, J., Kabitz, H. J., & Schumann, S. (2014). Assessing respiratory function depends on mechanical characteristics of balloon catheters. Respiratory care, 59(9), 1345–1352.