RESEARCH PAPER

Pressure algometry for assessment of abdominal wall sensitivity in horses after ventral midline coeliotomy

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Abstract

Objective To assess the clinical course of abdominal wall sensitivity after ventral midline coeliotomy in horses by determining mechanical nociceptive thresholds (MNTs) during hospitalization, and to determine the inter-observer reliability of pressure algometry on the abdominal wall.

Study design Observational, cohort study.

Sample population A total of 13 horses presenting with signs of abdominal pain/colic undergoing ventral midline coeliotomy and 10 healthy horses without an abdominal incision.

Methods Measurements were performed on days 1, 3, 5, 7 and 9 postoperatively using a pressure algometer. Measurement sites were marked left and right, abaxial to the abdominal incision. Cranial to the incision, two control points were marked. Measurements were made by one observer, blinded to the recorded MNT values. To determine inter-observer reliability, five horses (surgical group $n = 2$; nonsurgical group $n = 3$) were measured by two observers in a randomized order.

Results Mean MNT values on days 5 and 7 were 9.61 Ncm^{-2} and 10.14 Ncm^{-2} in the operated group ($p = 0.009$; $p = 0.005$) respectively *versus* 13.00 Ncm^{-2} on day 1. Wound-associated points showed lower values than control points ($p = 0.002$). The nonsurgical group did not show a difference between control points and wound-associated points ($p = 0.06$). No significant differences were found between the surgical and the nonsurgical groups at the wound-associated points on any days measured. The inter-observer reliability was low (intraclass correlation coefficient of 0.26; Cronbach's alpha of 0.27).

Conclusion Operated animals showed a reduction in MNT values on days 5 and 7 when compared with day 1 and lower values for the wound-associated points when compared with the control points. Inter-observer reliability was low. Pressure algometry could be a useful tool for assessing wound sensitivity after ventral midline coeliotomy in horses, which may improve pain management postoperatively.

Keywords abdominal wall sensitivity, horse, pressure algometry.

Introduction

In horses, surgery for abdominal pain or colic is an important part of emergency surgeries performed in referral equine hospitals (Freeman 2018). Determining short- and long-term postsurgical complications and survival rates are important factors for both horses and clients and for improving the surgical care and intensive care performed. Multiple retrospective studies have described postsurgical complications and short- and long-term survival rates after colic surgery (Mair and Smith, 2005a,b,c). Surgical site infection (SSI) is a common complication, and reported prevalence rates vary between studies, ranging from approximately 7% to 37% (Colbath et al. 2014) and from 15% to 27% (Tnibar et al. 2013). SSI after coeliotomy is often not life-threatening; however, it does play an important role in the return to presurgical performance levels or the athletic career of horses (Davis et al. 2013; Christophersen et al. 2011). It also influences the duration of the rehabilitation period. In clinical practice abdominal wall sensitivity is considered to be one of the predictive factors for the development of SSI. However, palpation is a subjective method for quantifying sensitivity in the horse. In order to objectively quantify abdominal wall sensitivity, other measurement techniques may be employed. Pressure algometry has been used to determine mechanical nociceptive thresholds (MNTs) in horses and thereby to quantify sensitivity in different anatomical locations (Haussler & Erb 2006b; Varcoe Cocks et al. 2006; Haussler et al. 2007, 2008; Sullivan et al. 2008; Loon et al. 2012; Pongratz & Licka 2017). MNT values are defined as the minimum pressure required to evoke an avoidance reaction (Menke et al. 2016). A pressure algometer is a force gauge with a probe area that can be used to measure the pressure needed to evoke a reaction, and thus determine MNTs. Avoidance reactions include for example: skin twitching, local muscle fasciculations, lifting the limbs or stepping away from the applied pressure (Haussler et al. 2007). The reliability and validity of pressure algometry have been evaluated in horses, dogs and humans (Finocchietti et al. 2015; Graven Nielsen et al. 2015; Lane & Hill 2016; Menke et al. 2016; Tallant et al. 2016). Previous studies in horses describe algometry of the axial and appendicular skeleton (Haussler & Erb 2006a,b; Varcoe Cocks et al. 2006; Haussler et al. 2007, 2008; Sullivan et al. 2008; Heus et al. 2010; Loon et al. 2012; Menke et al. 2016; Pongratz & Licka 2017). Several studies have described the use of pressure algometry to determine wound sensitivity following ovariohysterectomy in dogs (Tallant et al. 2016; Kalchoffner Guerrero et al. 2016). To the authors' knowledge, no previous studies have described the use of pressure algometry following abdominal surgery in horses.

This study aimed to describe the clinical course of abdominal wall sensitivity following ventral midline coeliotomy by determining MNTs during hospitalization and to compare them to unoperated horses. A second aim of this study was to determine the inter- and intra-observer reliability. The clinical importance of of pressure algometry may lie in its ability to predict the development of complications in wound healing. Furthermore, it could aid in improving analgesic protocols postoperatively. Finally, it could be used to monitor the efficacy of locoregional anaesthetic techniques to desensitize the surgical site during surgery.

Based on clinical experience and previous research of pressure algometry, we hypothesized that there would be a significant difference in the measured MNTs between the surgical group and the nonsurgical group. Furthermore, we hypothesized that MNTs would decrease over time until day 5 in the surgical group and there would be no significant increase or decrease in the nonsurgical group.

Materials and methods

Study design

The animals were divided into a surgical group ($n = 13$) and a nonsurgical group ($n = 10$). The surgical group consisted of horses that underwent a ventral midline coeliotomy, and the nonsurgical group consisted of healthy horses that did not have surgery and were free from clinical problems. The study was conducted in a single veterinary teaching hospital. Horses in the nonsurgical group were owned by the veterinary teaching hospital and the study design was approved by the Animal Ethics Committee of Utrecht University, The Netherlands. Operated animals were all client-owned horses. The owners of the participating horses signed a consent form after they were informed about the purpose of the study.

Data collection

MNTs were obtained with a handheld pressure algometer. The tip of the probe area was 4 mm in diameter and had a range of 0.5−25 N (Topcat Metrology Ltd, UK). A pilot study was performed in order to determine the required size of the population group. In this pilot study, the observer (observer 1) was trained in use of the of algometer by an equine physiotherapist (EM) experienced in this technique. In order to measure the same points over time, sites were marked using white paint. In a cranio-caudal direction, measurements sites on the abdominal wall were marked starting at the umbilicus and continuing in a cranial direction 10 cm from each other. Points were marked bilaterally at a distance of 2 cm abaxial to the incision. In the surgical group the most cranial site was variable and was determined by the length of the surgical incision. Therefore, the distance between the most cranial point of the incision and the point caudal to it was not the standardized 10 cm. This variable length was recorded for each patient (Fig. 1). All horses had two control points 10 cm cranial to the most cranial wound-associated points; therefore, these points were not situated in the abdominal surigcal site. At each site three consecutive MNT values were obtained. The order of measurements was as follows: starting on the left and most cranial site, working caudally and then measuring the right side in the same order. Pressure was applied with the algometer until an avoidance reaction was shown by the horse. This could be one of the following reactions: skin twitching, a visible increase in muscle tone, tail movement, kicking with one of the legs or stepping away. Measurements were performed on days 1, 3, 5, 7 and 9 postoperatively and were conducted by one observer who was blinded to the values obtained. The nonsurgical group was also measured following this time frame and using similar marked measurement sites. However, as no incision was present, a fixed number of six points were bilaterally marked from the ventral midline. The five abaxial caudal points were called wound-associated points, comparable to the surgical group, whereas the two most cranial abaxial points were demarcated as control points. The distance between all points was 10 cm in a cranio-caudal direction, and they were placed 2 cm abaxial from the midline, as in the surgical group. Measurements were performed with the horses in their own stable at the clinic while a research assistant restrained the horse. A second research assistant was responsible for recording the measured values. In order to determine inter-observer reliability, two horses from the surgical group and three nonsurgical horses were measured on days 1 and 7 by the two observers in a randomized order. Observer 2 received an introduction to the use of pressure algometry but did not have extensive experience in using the device beyond this introduction. Observer 1 had previously undergone a longer training period and had more experience. Observer 1 was

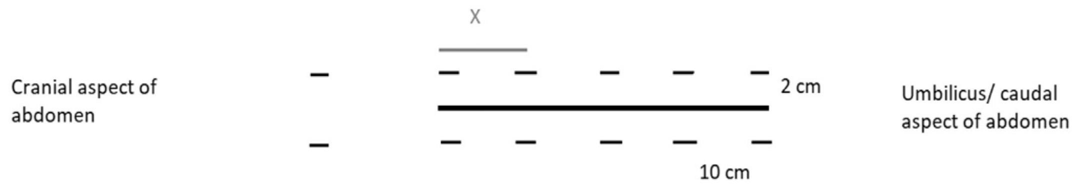

Figure 1 Schematic drawing of the location of the measurement points around the ventral midline incision in the surgical group admitted after exploratory laparotomy, in order to perform repetitive measurements using the pressure algometer on days 1, 3, 5, 7 and 9 postoperatively. The black continuous line represents the incision. The short black lines indicate measurement points in a cranio-caudal direction 10 cm apart and 2 cm lateral to the site of the incision. X and the grey line indicate the variable distance between the most cranial wound-associated points, as the length of the incision varied between operated animals. The two points, cranial to the incision, were the control points, cranial to the incision, were the control points. These were located 10 cm cranial to the most cranial aspect of the incision in line with the other measurement points.

blinded to the horses' reactions, whereas observer 2 was conducting the measurements and *vice versa*. A 5-minute break was inserted between the measurement sessions of the two observers. Both observers were right-handed and used the right hand for holding the algometer and performing the measurements. Measurements were performed at approximately the same time of day throughout the study.

At the end of the surgery, in the surgical group only, a small piece of adhesive tape was placed over the incision. After recovery, this was immediately removed, following the standard protocol in this clinic. Abdominal incisions were not cleaned postoperatively. Records of nonsteroidal anti-inflammatory drugs (NSAIDs) and other analgesic drug administration and clinical course of the intensive care period were kept. Immediately after surgery all horses from the surgical group were admitted to the intensive care unit (ICU), where Composite Pain Scores (CPS) according to Bussières et al. (2008) were obtained every 4 hours. After discharge from the ICU, CPS scores were recorded twice daily.

Statistical analysis

A pilot study and power analysis ($n = 3$ surgical horses; $n = 2$ nonsurgical horses) were performed prior to starting data collection, in order to determine the sample size needed and accepting statistical significance at $p < 0.05$. Values for the power analysis were: mean difference in MNT of 3.3 with a standard deviation (SD) of $\pm$ 2.4, a power of 0.9 and an alpha of 0.05. Therefore, this analysis showed that a minimum of 11 horses were needed in each group. MNTs were recorded in N cm^{-2}, and three measurements were performed at each measurement point following previously published studies (Menke et al. 2016; Haussler et al. 2007). Descriptive data were obtained using Excel by making tables for breed, age, sex, diagnosis and incision length (version 2016, Microsoft Office 365). A Kolmogorov–Smirnov test was used to determine if data were normally distributed. Normally distributed data are shown as mean $\pm$ SD. A paired sample *t*-test, analysis of variance, two-way random model, intraclass correlation coefficient (ICC) and Bland–Altman plot were performed using SPSS (IBM SPSS version 24; IBM Corp, NY, USA). A linear mixed model analysis was performed using R studio software (version 3.3.1; MA, USA). The latter software was also used to further analyse the entire data set.

The inter-observer reliability was assessed by means of a scatterplot and a Bland–Altman plot. A two-way random model was used to calculate Cronbach's alpha and ICC. For all measurements (surgical group and nonsurgical group) performed by observer 1, the mean and SD of the range of three consecutive MNTs at each time point were calculated to determine intra-observer reliability. The range was defined by determining the highest and lowest values of the three measurements taken at one point. For each set of three consecutive measurements, the direction of the three consecutive MNTs compared to the previous one was expressed as sensitization when MNT values decreased over the three measurements. It was expressed as habituation when MNT values increased. No consistent change was used when no consistent increase or decrease was found over three measurements. Best fit in the linear mixed model was evaluated by plotting the residuals *versus* fitted values to ensure homoscedasticity. Normal distribution of the residuals was verified using Q–Q and boxplots. Statistical significance was accepted at $p < 0.05$.

Results

Descriptive data

The surgical group ($n = 13$) consisted of 10 Dutch Warmbloods (DWB), two Haflingers and one Oldenburger. The nonsurgical group ($n = 10$) had a breed distribution of eight DWB and two Friesians. The surgical group had the following inclusion criteria: exploratory laparotomy related to either a small or large intestinal problem. Only horses older than 1 year were included. In the surgical group, two of the horses were excluded from the statistical analysis because of missing data. Of these two horses, one was a mare with foal and received an abdominal bandage in the ICU to protect the abdominal incision. The other horse kicked while measurements were being obtained; therefore, further measurements were not considered safe. The mean incision length was 30 ± 7 cm. The mean surgery time was 149 ± 58 minutes. Of the 13 surgeries performed, eight animals were diagnosed with small intestinal problems and five with large intestinal problems. A total of six enterotomies and three resections were performed (Table 1). None of the operated horses developed an SSI in the hospitalization period.

Distribution of data

MNT data were normally distributed. MNT values of the left abaxial measurement points and the right abaxial measurement points of the incision showed a significant difference from one another ($p = 0.015$). Therefore, the MNT values on the left and right sides of the incision were not evaluated as pooled data. When comparing the MNT values on the left side of the incison, no difference was found between these separate MNT values ($p = 0.95$). This was also true for the MNT values on the right side ($p = 0.44$). Therefore, the MNT values on the left side of the incision could be evaluated as pooled data and the MNT values on the right side could also be pooled. Figure 2 shows the mean MNT values for the wound-associated points, and Figure 3 shows the control points. In both Figures, both groups are included. Panel A shows the left abaxial points and panel B shows the right abaxial points.

MNT values for the surgical group showed a reduction on days 5 and 7 when compared to day 1 ($p = 0.009$; $p = 0.005$ respectively). This reduction was seen in both the wound-associated points and the control points. The nonsurgical group showed a reduction in MNT values on days 3 and 7 when compared with day 1 ($p = 0.0004$; $p = 0.0001$). This reduction was seen for the fixed wound-associated points. Wound-associated points of operated horses showed no significant difference with those of the nonsurgical group (days 1 and 5, $p = 0.07$; day 3, $p = 0.44$; day 7, $p = 0.22$; day 9, $p = 0.33$).

In the surgical group, the wound-associated points showed lower MNT values than the control points for all days measured ($p = 0.002$). The nonsurgical group did not show a significant difference in MNT values for the control points *versus* the fixed wound-associated points ($p = 0.06$).

Intra-observer reliability

The mean range over three consecutive measurements was 6.60 ± 7.03 N cm^{-2}. The repeated measurements taken by observer 1 showed no consistent change in 83.3% of the MNT measurements within the surgical and the nonsurgical group; sensitization was observed in 13.3% of the MNT measurements and habituation in the remaining 3.4%.

Inter-observer reliability

A two-way random model calculated a Cronbach's alpha of 0.27 and an ICC of 0.26 (Fig. 4). The Bland−Altman plot is shown in Figure 5 (mean difference = −1.38; upper limit of agreement = 14.62; lower limit of agreement = −17.40).

CPS and NSAID administration

The lowest mean CPS scores were recorded on day 5, with a mean score of 2 ± 0.71. On postoperative day 5, nine horses were administered NSAIDs once daily and NSAID administration had ceased in four horses. No statistical analysis could be performed to determine the influence of NSAIDs on the MNT values over time because of missing data.

Table 1 Descriptive data for the surgical group, which includes: age (years); breed [Dutch Warmblood (DWB)]; sex [gelding (G), mare (M), stallion (S)]; bodyweight (BW in kg); diagnosis and surgical procedure [Small intestine (SI); large intestine (LI); enterotomy (E); resection (R); no resection (N) or colon amputation (A); surgical time (ST) in minutes (min); and incision length (IL) (cm)

Patient	Age (years)	Breed	Sex	BW (kg)	Diagnosis	ST (min)	IL (cm)
1	9	DWB	G	551	LI/E	123	25
2	24	DWB	G	582	SI/R	115	26
3	15	DWB	G	470	LI/E	135	37
4	3	DWB	S	528	SI/N	75	39
5	14	DWB	M	543	LI/E	125	35
6	15	DWB	M	558	LI/E	108	36
7	17	Haflinger	G	498	LI/A	290	36
8	7	Haflinger	M	440	SI/R	220	20
9	8	Oldenburger	S	525	SI/N	165	29
10	9	DWB	M	575	SI/E	115	28
11	14	DWB	M	630	LI/E	144	37
12	4	DWB	G	540	SI/E	118	25
13	10	DWB	G	660	SI/R	200	19

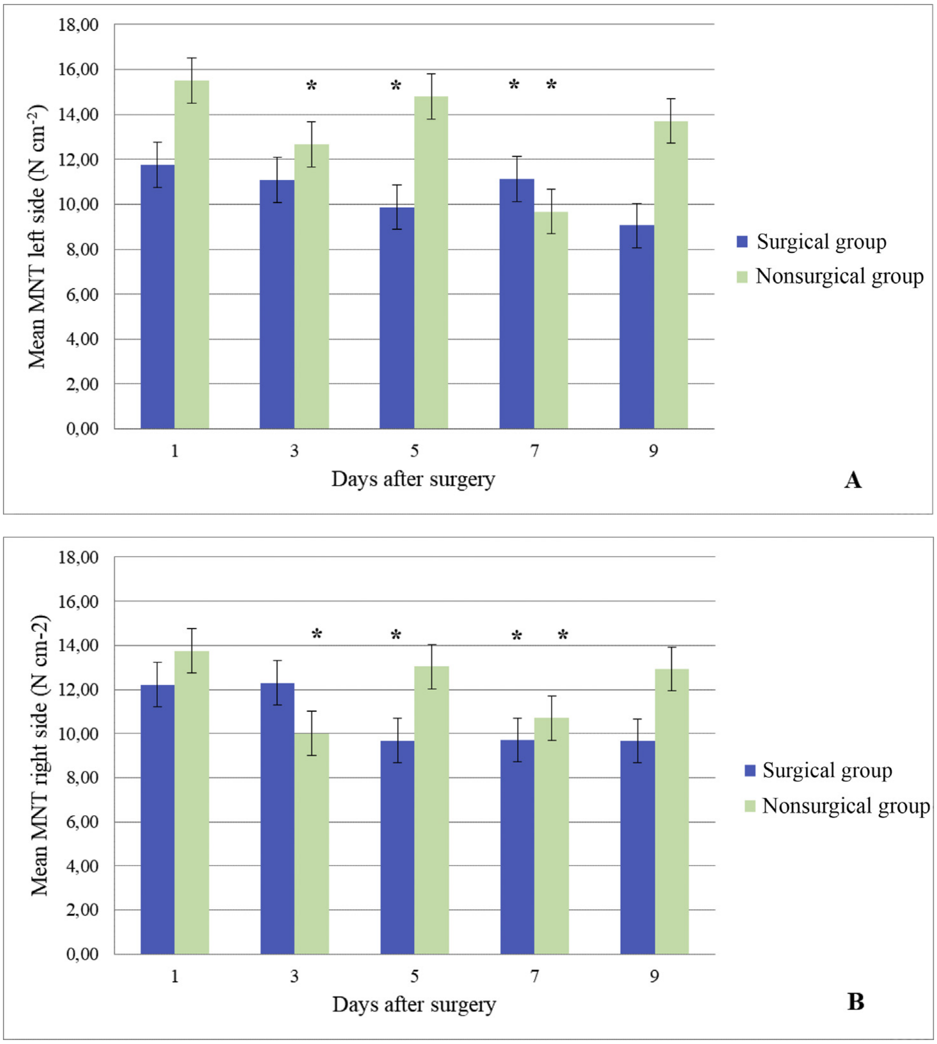

Figure 2 Mean nociceptive thresholds (MNT) values for the surgical group (n = 13) and the nonsurgical group (n = 10). MNT values for the wound-associated points are shown (graph A, left points; graph B, right points). Measurement points were located on the left and right side of the abdominal body wall 2 cm abaxial to the incision or the ventral midline, for the surgical group or nonsurgical group respectively. Measurement points were 10 cm apart in a cranio-caudal direction. The error bars show the standard deviation (SD). 1, day 1 after surgery; 3, day 3 after surgery; 5, day 5 after surgery; 7, day 7 after surgery; 9, day 9 after surgery. For the surgical group MNT values on day 5 and 7 were lower compared to day 1 (p = 0.009; p = 0.005). MNT values in the nonsurgical group were lower on day 3 and 7 when compared to day 1 (p = 0.0004; p = 0.0001). These significant values are shown with an asterisk.

Discussion

The most important finding in this study was related to the clinical course of abdominal wall sensitivity during days 1 to 7 postoperatively in the surgical group. We found reduced MNT values on days 5 and 7 after surgery when compared to day 1. In addition, the MNT values in operated horses were lower for wound-associated points compared to the control points; therefore, we can conclude that increased wound sensitivity was found after ventral midline coeliotomy. In the nonsurgical horses, no significant differences in MNTs between control points and wound-associated points were found. No significant difference was found between the surgical group and the nonsurgical group MNTs measured at the wound-associated points on any day.

The reduction in MNT values on days 5 and 7 in the surgical group could be explained by the dynamic process of wound healing and the different phases involved in this process. In the inflammatory phase, prostacyclin and histamine are released directly after acute vasoconstriction. The inflammatory response proceeds with macrophages releasing molecular

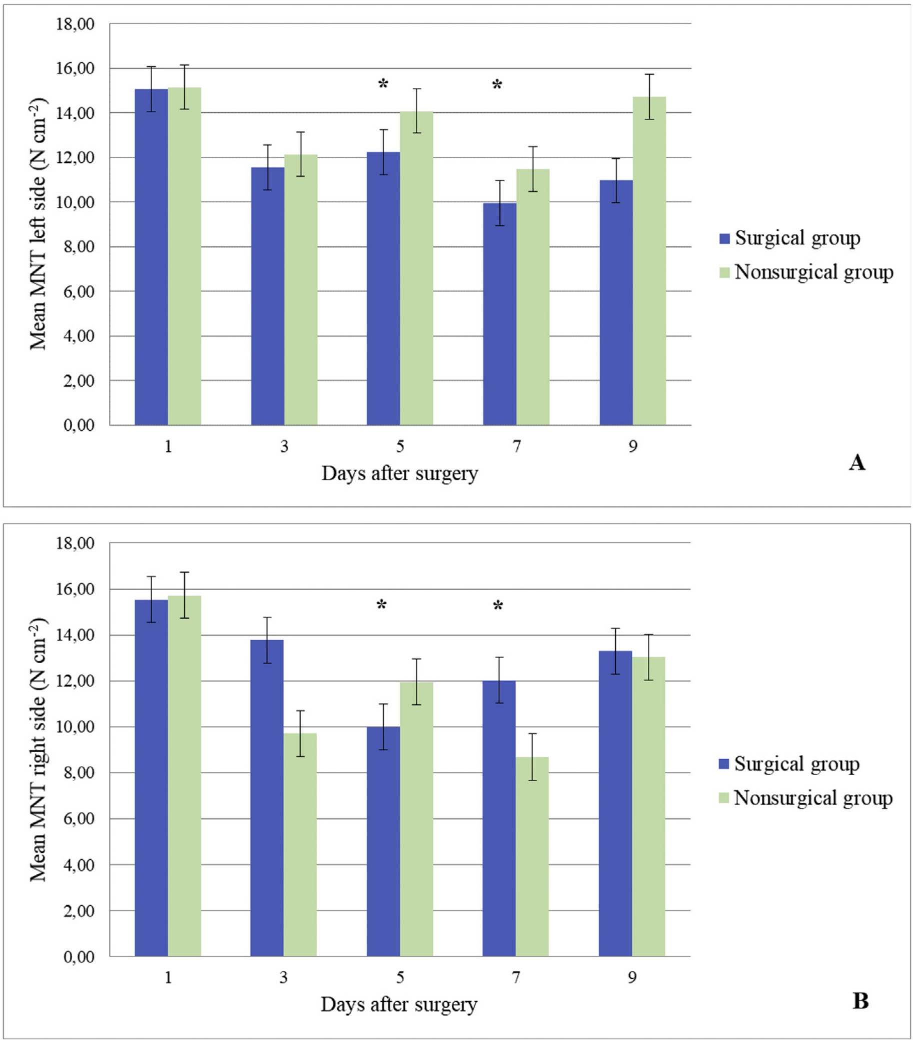

Figure 3 Mean nociceptive threshold values for control points are shown. The control points were located 2 cm abaxial from the incision and 10 cm cranial to the most cranial part of the abdominal incision (graph A, left points; graph B, right points). The mean nociceptive threshold (MNT) values shown are of the surgical group ($n = 13$) and the nonsurgical group ($n = 10$). The error bars show the standard deviation (SD). 1, day 1 after surgery; 3, day 3 after surgery; 5, day 5 after surgery; 7, day 7 after surgery; 9, day 9 after surgery. The control points in the surgical group also showed a reduction in MNT values on days 5 and 7 when compared to day 1 ($p = 0.008$; $p = 0.004$). These significant values are shown with an asterisk.

signals responsible for cytokine release and tissue growth factors (Wilmink et al. 2003; Auer & Stick 2012). In this study measurements were performed until day 9 after surgery, a period in which the acute inflammatory phase plays an important role. This might explain the lower measurements on days 5 and 7 when compared to day 1.

The MNT values of the wound-associated points were lower than the control points in the surgical group. However, the control points also showed a reduction in MNT values on days 5 and 7 when compared to day 1. The reduced MNT values for the wound-associated points appear to reflect primary hyperalgesia during the measuring period. A possible explanation for the reduction in MNT values for the control points could be secondary hyperalgesia (Ortner et al. 2013). Secondary hyperalgesia is characterized by increased sensitivity to tactile stimuli by both a reduced inhibitory and an enhanced excitatory response involving the central nervous system (Ortner et al. 2013). The control points were 10 cm cranial to the abdominal incision, but were still located in the abdominal area. Based on the difference between wound-associated and control points in operated animals, primary hyperalgesia seems to be the most probable cause of this finding. This appears to fit

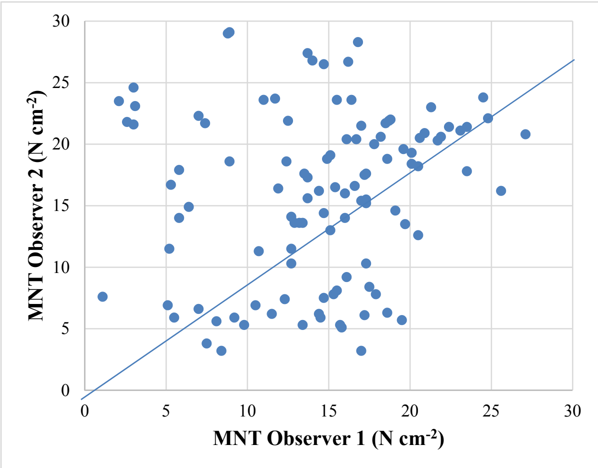

Figure 4 Scatterplot for the inter-observer reliability [intraclass correlation coefficient (ICC) = 0.27]. Mean nociceptive thresholds (MNT) values measurements obtained by two observers using pressure algometry in randomized order. A total of five horses were measured by these two observers on days 1 and 7 postoperatively (n = 2 operated horses; n = 3 nonsurgical horses; n = 108 MNT values obtained in total).

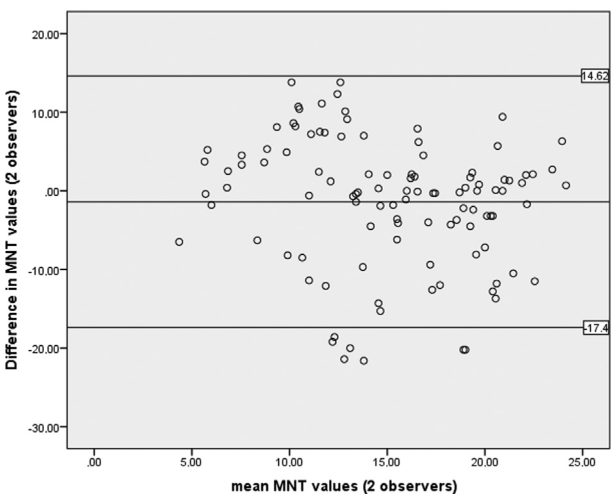

Figure 5 Bland Altman plot for inter-observer reliability. Mean nociceptive threshold values (MNT) measurements obtained by two observers using pressure algometry, in randomized order. A total of five horses were measured by these two observers on days 1 and 7 postoperatively (n = 2 operated horses; n = 3 nonsurgical horses; n = 108 MNT values obtained in total). The middle line represents the mean difference between observer 1 and observer 2 (−1.38). The upper limit is 14.62 and lower limit is −17.40. Upper/lower limit = mean difference (standard deviation (SD) × 1.96).

with the time course of the development of primary hyperalgesia, being most prominent during the acute phase of postoperative follow-up.

No difference was seen in MNT values for the wound-associated points when comparing the surgical group with the control group. However, on days 1 and 5, the difference between operated animals and unoperated animals approached statistical significance (p-values between 0.05 and 0.1). A *post-hoc* power analysis of the MNT values at the wound-associated points on day 5 for both groups indicated a population size of 15 animals per group. The power analysis performed before the study calculated a sample size of 11 animals per group. However, only 10 healthy animals were available at the time the study was conducted. The lack of statistical significance probably represents a Type II error because the study was underpowered. However, on days 3 and 7 the mean MNT values of the nonsurgical group at the fixed wound-associated points showed markedly lower MNTs compared with their baseline values. Outliers were found in this group on these 2 measurement days. However, without these outliers, mean MNTs for the nonsurgical group were still lower than their baseline values (<10 N cm^{-2}). Therefore, these low values cannot be explained by outliers. A structural measurement error on these days may be a possible explanation. Other explanations could be technical problems with the pressure algometer or environmental influences such as noises from other horses. However, no confirmatory information for these explanations could be identified. The horses in the nonsurgical group were considered healthy horses at the time the study was performed.

Several studies which used pressure algometry describe decreases or increases in MNT values following repetitive measurements, known as sensitization or habituation (Haussler and Erb, 2006b; Heus et al. 2010). A reduction on all days might be anticipated when considering sensitization or a learning effect. Sensitization can occur because of repetitive stimulation of the measuring points. A learning effect may occur as a result of cognitive cognitive processing when the procedure is repeated over several days. In the current study a reduction in MNT values within the control group was only seen on days 3 and 7 and therefore sensitization of the tissues of the ventral abdominal wall is a less likely explanation. To the authors' knowledge, no research has previously been performed investigating the MNT values over time in the abdominal area in healthy horses or in horses with a surgical abdominal wound.

MNT values on the left side of the surgical incision showed a difference when compared to MNT values on the right side of the incision. Measurements always began on the left side of the horse in both groups. Horses might change their avoidance reactions as repetitive measurements are performed. This could lead to left and right differences in measurements, which may influence reliability.

In this study approximately 83% of the repeated measurements performed by observer 1 showed no indication of

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sensitization or habituation. A high mean range (6.60 N cm^{-2}), suggestive of moderate intra-observer reliability was found over the three consecutive measurements. Previous studies found a mean range of 2.0 ± 1.4 kg cm^{-2} (Haussler and Erb, 2006b) when performed on the thoracic limb and 2.1 ± 1.6 kg cm^{-2} (Haussler et al. 2008) when performed in the proximal interphalangeal joint region. A low inter-observer reliability was found in this study when compared with the study reported by Menke et al. (2016). Observer 1 was the principal observer and had received training from an equine physiotherapist experienced with the technique of pressure algometry. Observer 2 had received a short introduction to the use of pressure algometry before this study was conducted. The difference in experience with the technique of algometry between the two observers could potentially influence the inter-observer reliability leading to poor agreement in this study.

The use of NSAIDs after exploratory laparotomy surgery is common in equine hospitals. Studies investigating the possible positive and negative effects of the use of NSAIDs after gastrointestinal surgery have been performed in human medicine (Chapman et al. 2014; Martinou et al. 2018). In the current study, operated horses were administered NSAIDs twice daily during the first 4 postoperative days. However, on day 5 the analgesia protocol was altered to administration of NSAIDs once daily only. One explanation for the lower MNT values between days 5 and 7 in the surgical group could be the inflammatory response causing more abdominal wound sensitivity. Together with this ongoing inflammatory response, the analgesic protocol was altered, and thereafter most animals were administered NSAIDs once daily on days 5 and 7 ($n = 9$; $n = 6$, respectively). From these data, it seems that NSAIDs may influence abdominal wound sensitivity, but no definite conclusions can be drawn because of the small sample size and missing data. The effect of a standard protocol for NSAID administration or the inclusion of locoregional anaesthetic techniques (such as transverse abdominis plane block or rectus abdominis sheath block) on abdominal wound sensitivity measured by pressure algometry could be assessed in future studies.

None of the 13 operated horses in this study developed an SSI. Therefore, no conclusion could be drawn from this study about the use of pressure algometry as a predictor of the development of an SSI. In the future, more extensive and long-term studies should be conducted to investigate the possible role of pressure algometry in early detection of SSI after ventral midline laparotomy in horses.

Little is known about abdominal wound sensitivity after a ventral midline coeliotomy and how this may affect horses' return to their athletic careers. This study provides the first step in the investigation of this issue. Objective predictive values for the development of an SSI of the abdominal wound may improve animal care. Analgesic plans could be adjusted, and early detection may aid local drainage of wound discharge. Further understanding of the role abdominal wound sensitivity plays in the overall clinical progress of operated horses in the ICU may enable individual treatment plans instead of general protocols.

Conclusion

The results of the current study show that horses which underwent exploratory laparotomy surgery were more sensitive abaxially to the abdominal incision on days 5 and 7 post-operatively when compared to day 1. This may be indicative of primary hyperalgesia of the surgical incision. Furthermore, the wound-associated points overall showed lower values than the control points for the surgical group, validating pressure algometry as an outcome measure for wound sensitivity after ventral midline coeliotomy. A point cranial to the incision can be used as a reference value for the wound-associated measurements for an individual animal. Intra- and interobserver reliability were moderate to low in this study, possibly because of a difference in the level of training between the two observers. Measurements performed by different observers cannot be compared based on our findings. Pressure algometry may be a useful tool in the objective assessment of the abdominal wall palpation sensitivity.

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Authors' contributions

EV: conduct of the pilot study, data collection, data management, statistical analysis and prepared the manuscript. JL: substantial contributions to the conception and design of the study, and editing of the manuscript. EM: conduct of the pilot study and critical editing of the article. All authors approved the final manuscript. No grant or financial support was offered to conduct this study. The authors' declare no conflict of interest.

Conflicts of interest

The authors declare no conflict of interest related to this report.

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