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General Articles

Do subcutaneous sutures increase risk of laparotomy wound suppuration?

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Summary

Reasons for performing study: **Incisional drainage and suppuration occurs commonly following exploratory laparotomy; any technique with the potential to reduce the incidence of this complication warrants investigation.**

Objectives: **To determine if abandoning the use of subcutaneous sutures in laparotomy wound closure is safe and whether it reduces the risk of suppuration.**

Methods: **A randomised controlled study was carried out at 2 referral hospitals in the UK, involving 309 horses undergoing exploratory laparotomy; 150 horses underwent '2-layer' closure without a subcutaneous suture, while 159 underwent conventional '3-layer' closure. Information regarding degree of oedema and gross types of discharge was recorded daily; suppuration was defined as discharge of pus. Telephone follow-up was carried out 30 days after hospital discharge to identify those complications occurring after that date and, thereafter, every 3 months. The influence of closure method on risk of wound suppuration was assessed by Chi-squared analysis and by logistic regression. Time to suppuration was modelled using a Cox proportional hazards model.**

Results: **No catastrophic failures of 2-layer closures were recorded. Prevalence of suppuration was not significantly different, being 18.7% and 23.9% for 2- and 3-layer closures, respectively (OR = 1.37, 0.79–2.37, P = 0.263).**

Conclusions and potential relevance: **This study found no significant difference in prevalence or rate of wound suppuration in 2-layer closures compared to conventional 3-layer closure. Two-layer closure is recommended as a safe alternative means of achieving ventral midline abdominal closure in horses.**

Introduction

Post operative wound infection following exploratory laparotomy has always represented a significant problem in equine surgery. Despite advances in surgical technique and post operative survival rates, wound drainage, suppuration and infection are still significant causes of post operative morbidity. This not only causes further pain to the horse, it also increases risk of hernia formation (Gibson *et al*. 1989; French *et al*. 2002) as well as creating significant further cost to the client in terms of time and treatment.

Published laparotomy wound infection rates range from 37% (Phillips and Walmsley 1993) to 7.4% (Freeman *et al*. 2000), but few published studies are completely comparable, due to the wide range of published values and to differences in inclusion criteria, end-point definitions, follow-up, nosocomial bacterial populations, surgical practice and routine use of antimicrobial drugs between hospitals (Trostle and Hartmann 1999).

Foreign material in wounds is well known to increase risk of infection (Elek and Conen 1957). An unnecessary suture layer can have the same effect and human and porcine studies have quantified the increased rates of wound sepsis following subcutaneous suturing (Ferguson 1968; DeHoll *et al*. 1974). In the latter study, 25% of contaminated wounds without subcutaneous sutures became infected compared to 100% with sutures. Many equine laparotomy wounds contain bacteria (Ingle-Fehr *et al*. 1997), yet almost all are still closed with a technique that includes a subcutaneous suture layer.

A randomised controlled trial was carried out at 2 equine referral hospitals, evaluating the effect of abandoning subcutaneous suturing on the development of post operative incisional suppuration. It was hypothesised that carrying out 2-layer closure, without a subcutaneous suture, would be (a) safe and (b) decrease suppuration rates.

Materials and methods

Case selection and study design

This study was prospective in nature and carried out over a period of 2 years, between April 2004 and April 2006, at 2 equine referral hospitals in the UK.

The inclusion criterion was: all horses recovering from exploratory laparotomy for treatment of colic. Cases of equine

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dysautonomia were excluded due to their short expected lifespan, whilst those undergoing repeat laparotomy within 30 days of the first surgery were also excluded due to their known high rates of wound infection (Kobluk *et al.* 1989).

Cases were allocated randomly using a card-index arranged to provide a 50:50 split between closure methods. Randomisation was achieved by spinning a coin. Either a 2-layer closure was carried-out with no subcutaneous suture placement (2-layer), or a 'traditional' 3-layer closure was used with subcutaneous closure (3-layer).

Surgical technique

In an effort to reduce potential dead space, the practice of subcutaneous dissection to expose the *linea alba* was abandoned in favour of minimal or no dissection for all cases. *Linea alba* closure was the same in both groups, consisting of 5 metric braided lactomer 9-1 (Polysorb)[1] in a continuous pattern. Bights were taken at approximately 10 mm intervals, 10–15 mm lateral to the incisional margin. Because no subcutaneous dissection was carried out, bights included some subcutaneous tissue and retroperitoneal adipose tissue. Subcutaneous closure in 3-layer cases was achieved with 2.5 metric braided lactomer 9-1 in a simple continuous pattern. Skin was closed with 4-metric suture material in a Ford interlocking pattern, either using monofilament polypropylene (Prolene)[2] (University of Liverpool) or multifilament polygalactin 910 (Vicryl Rapide)[2] (Bell Equine Veterinary Clinic). Bights were spaced 10 mm apart and 8–15 mm lateral to the incisional margin. Stent bandages or adhesive-type skin dressings placed intraoperatively for recovery were used at the discretion of the individual surgeon; their use was recorded.

Post operative outcomes

For each day of hospitalisation, information on the extent of oedema and presence of suppuration was collected on data-capture forms. Oedema was defined as normal, greater than normal or severe using pictorial descriptors. The maximum oedema score recorded was used in the statistical analysis. The presence and appearance of any discharge was likewise recorded and defined as:

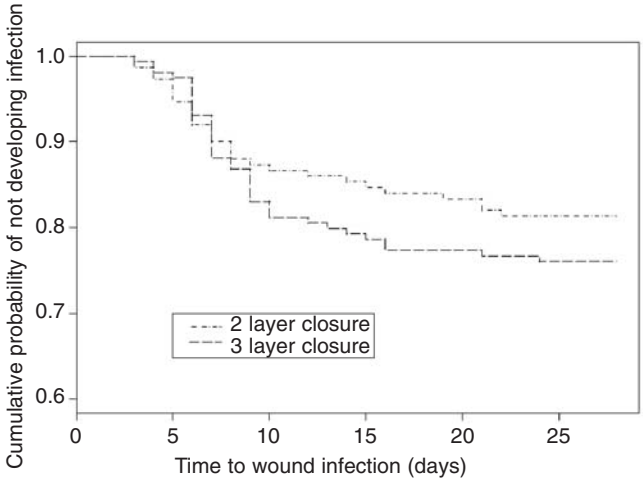

Fig 1: Kaplan-Meier plot comparing the overall rate of wound suppuration for 2- and 3-layer closure. Cox proportional hazards ratio analysis demonstrated this difference to be nonsignificant (HR = 1.31, 0.8–2.1, likelihood ratio test P value = 0.28).

(1) haemorrhagic: blood-coloured turbid nonviscous fluid; (2) serous: nonturbid nonviscous nonhaemorrhagic fluid; or (3) pus: viscous turbid fluid. Suppuration was defined as the gross drainage of pus from the wound; when it occurred the number of whole days to suppuration was recorded.

After hospital discharge, follow-up telephone consultations were carried out at 1, 3, 6 and 12 months post operatively to identify wound complications, including suppuration and hernia formation. Any horse with which contact was lost or which died after hospital discharge, was censored in subsequent analysis i.e. data were excluded from the date at which contact was lost.

Statistical analysis

Power calculations were carried out at the start of the study, using a predicted suppuration rate of 20% and n = 260. Based on logistic regression analysis with equal numbers in each group and a significance level of $P<0.05$, the study gave 80% power to detect a relative risk of 2.4 or greater.

Data were collated using Microsoft Excel[3] spreadsheet software and analysed using Minitab[4] statistical software. Survival analysis was carried out using S-Plus[5] statistical software (version 6:1). Prevalence of suppuration in different treatment groups was compared using a Pearson Chi-square statistic. Odds ratios (OR) between treatment group and wound suppuration were calculated using univariable logistic regression, 95% confidence intervals and likelihood ratio test statistic P values are cited where appropriate. A Cox proportional hazard model was used to compare the rate of suppuration between the 2 groups.

Results

Two- vs. 3-layer closure

A summary of suppuration prevalence is presented in Table 1. No significant difference in suppuration rate was found between the 2 types of closure (Chi-square P = 0.262). No significant association between closure method and risk of suppuration was detected by logistic regression analysis (OR 1.37, 0.79–2.37, P = 0.263). No catastrophic side-effects of 2-layer closure were observed. No significant difference in wound suppuration rate was detected between the 2 centres (OR 0.78, 0.44–1.38, P = 0.400).

Median time to incisional suppuration was 7 days (range = 3–22) for 2-layer, and 7.5 days (range = 3–24) for 3-layer. Mean time to incisional suppuration was 9.3 and 9.1 days, respectively. The rate of suppuration for the 2 closure types is demonstrated in

TABLE 1: Prevalence of post operative laparotomy wound suppuration in 309 horses undergoing colic surgery at 2 referral hospitals (University of Liverpool and Bell Equine Veterinary Clinic). Horses categorised by method of wound closure, 2-layer vs. 3-layer technique (see text for details)

Groups		No suppuration	Suppuration (%)	Total
Liverpool	2-layer	85	18 (17.5)	103
	3-layer	83	24 (22.4)	107
	Total	168	42 (20.0)	210
Bell	2-layer	37	10 (21.3)	47
	3-layer	38	14 (26.9)	52
	Total	75	24 (24.2)	99
Overall	2-layer	122	28 (18.7)	150
	3-layer	121	38 (23.9)	159
	Total	243	66 (21.4)	309

Figure 1. When tested in a Cox proportional hazards model, the difference in rate of suppuration was nonsignificant (hazards ratio [HR] = 1.31, 0.8–2.1, LRTS P value = 0.28). Maximum post operative oedema scores for the 2 types of closure were compared using logistic regression analysis; no difference was found (OR 0.96, 0.63–1.47, P = 0.852).

A number of other related factors were tested for association with the type of closure and were found to be nonsignificant, including wound oedema score, serous or haemorrhagic discharge and risk of developing incisional hernia.

Other findings

The presence of wound oedema was associated strongly with the subsequent development of suppuration (OR 3.49, 2.28–5.34, P = <0.001). Post operative medical colic occurred in 63 horses (20.4%). Among horses that had post operative colic the prevalence of suppuration was 30.2%, vs. 19.1% for horses that did not develop colic (OR 1.83, 0.98–3.42, P = 0.058). Wound discharge was not always associated with suppuration: 46 cases (22 two-layer cases and 24 three-layer cases) developed serous discharge that did not become purulent; these were not classified as suppuration.

A range of other factors were tested for association with wound suppuration and found to be nonsignificant. These included: weight of horse; cleanliness on arrival; surgical time; whether or not the surgery was performed out-of-hours; surgeon; whether or not enterotomy or resection was carried out; and the use of protective dressings such as stents or adhesive membranes during recovery.

Discussion

Two-layer closure proved to be a safe and practical means of achieving abdominal wall closure following exploratory laparotomy. However, this study provides no evidence for reduced risk of wound suppuration following 2-layer closure. Power calculations carried out at the start of the investigation had indicated that only differences of 2.4 or greater could be reliably detected with the number available. *Post hoc* power calculations suggest that the observed treatment effect of 1.4 would only be significant under present study conditions (80% power, P<0.05) with a total sample size of 1707, which would take 12 years to obtain under the current caseload! Despite this, the time and effort saved in abandoning a subcutaneous closure, in combination with the absence of ill effects, has made this technique popular at both hospitals where it is now standard practice.

Avoiding subcutaneous dissection was considered an integral part of abandoning subcutaneous suturing in order to prevent dead space generation. Dissection is carried out by some surgeons to facilitate suturing of the *linea alba*. Abandoning this practice may have reduced overall suppuration rates through reduced dead space. Comparison of prevalence of suppuration to published values in equivalent studies is favourable. However, suppuration rates were higher during the study period when compared to previously published values for the same centre. For example, 16% at the University of Liverpool (Proudman *et al*. 2002) vs. 22.4% in this study, despite the previous value including repeat laparotomies, which have far higher rates of infection (Kobluk *et al*. 1989). This difference was not tested statistically, but runs contrary to studies in man where surveillance programmes increase awareness of problems and bring about improvements (Olson *et al*. 1984). The apparent difference may be nonsignificant or due to increased awareness and reporting of wound suppuration.

We used the end point of gross drainage of pus as our definition of wound suppuration. A clinical argument could be levelled that the majority of these cases were actual infections. While this may be true, it is known that purulent discharge can also occur in the absence of active infection. Furthermore, infection can precede external drainage of pus. Some previously published studies have used the term ‘infection’, defined as drainage of pus, as their end-point (Kobluk *et al*. 1989). However, without evidence of active infection i.e. bacteriological analysis, defining suppuration as infection would have been imprecise and potentially misleading.

The prevalence and severity of oedema was unaffected by the presence of subcutaneous sutures. This is contrary to studies in cats that have shown that subcutaneous sutures increase early incisional swelling compared to those with no subcutaneous suture (Freeman *et al*. 1987). Wound discharge of serum or pus was unrelated to the presence or absence of subcutaneous sutures, although fast dripping amber or sanguineous fluid was observed in a small number of 2-layer closures (n = 23). This event generally occurred in the first 24 h and lasted up to 48 h. Given the rate of production, it was concluded that this was most likely peritoneal fluid. Fluid analysis in a small number of these cases demonstrated a protein concentration of around 50 g/l, which was consistent with peritoneal drainage. Fluid sequestration in tissue planes in 3-layer closures could increase tissue pressure through oedema or seroma formation, reduce perfusion and therefore predispose to wound suppuration.

Incisional oedema is associated with a higher risk of laparotomy wound suppuration, a feature not quantified to the same extent in any previous published study. Horses with excessive wound oedema in the absence of any other signs ran a nearly 3.5 times greater risk of developing wound suppuration. Why oedema is associated with wound suppuration is debatable; it could be cause or effect. Increased oedema was noted prior to discharge of pus in most cases, but also occurred in a minority of cases that did not become suppurated. It is possible, therefore, that oedema forms in response to the inflammatory stimulus of trapped infection within the wound, or itself causes reduced tissue perfusion around the wound, thereby inhibiting defence mechanisms and increasing risk of suppuration (Lees *et al*. 1989). Whatever the underlying mechanism, clinicians should be vigilant for increased incisional oedema due to the attendant risk of undiagnosed infection.

Horses with post operative medical colic demonstrated an increased prevalence of wound suppuration, but the difference was not statistically significant. Previous studies have highlighted the increased risk of wound infection in horses undergoing repeat laparotomy for colic (Kobluk *et al*. 1989). It was assumed that intraoperative factors in the second surgery increased susceptibility to infection. However, the finding in the present study suggests that preoperative factors related to the physical act of colicking may be contributory. It is possible that colic causes increased movement and tension across the wound, factors known to inhibit wound healing (Kent Lloyd 1999). Also, horses showing colic signs may spend more time in recumbency, causing direct wound contact with the stable floor and increasing risk of contamination and infection.

A number of other factors were investigated that are hypothesised to influence the risk of wound infection, but which were found to be unrelated. Previous studies have shown duration of surgery to be an important risk factor for infection, with longer surgeries at much greater risk (Wilson *et al*. 1995; Trostle and Hartmann 1999). This observation was not supported by the present study, possibly because average duration of surgery was shorter than as described by Wilson *et al*. (1995) where 47% (35/74) of surgeries lasted longer than 2 h, compared to 19% in the present study (58/309). It may also reflect modern improvements in preoperative stabilisation and anaesthetic technique. It was anticipated that the cleanliness of the horse on arrival would affect suppuration rates, since 'dirtier' horses would have higher surface bacterial loads. However, this proved not to be the case, supporting the conclusions of a previously published bacteriological study (Ingle-Fehr *et al*. 1997).

In conclusion, the technique of 2-layer closure described provided a safe means of achieving ventral midline abdominal closure in horses. Increased rates of wound complications were not seen. A lower prevalence of wound suppuration was observed in horses with a 2-layer closure, although the difference was not statistically significant. This technique is recommended to surgeons as a safe and effective method of closing equine laparotomy wounds.

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Manufacturers' addresses

[1]Vetoquinol UK Limited, Buckingham, UK.
[2]Ethicon, Johnson & Johnson Medical Ltd., Kirkton Campus, Livingston, UK.
[3]Microsoft Corporation, Redmond, Washington, USA.
[4]Minitab Inc., State College, Pennsylvania, USA.
[5]S-PLUS, Insightful Corporation, Basingstoke, Hampshire, UK.

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