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## Hypothesis on the pathophysiology of small intestinal strangulation by a pedunculated lipoma

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1 **Hypothesis on the pathophysiology of small intestinal strangulation by a pedunculated**  
2 **lipoma**

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24 **Background:** The current hypothesis proposed for strangulation of small intestine by a  
25 pedunculated lipoma in horses involves movement of the lipoma around the small intestine until  
26 it loops through its own pedicle. This mechanism is difficult to demonstrate during surgical  
27 correction.

28 **Objectives:** To examine an alternative explanation for strangulation by pedunculated lipoma that  
29 is logical and consistent with intraoperative findings. **Methods:** Analysis of the anatomical features  
30 of 11 cases of lipoma strangulation in horses. **Results:** In the proposed hypothesis, the stalk of  
31 the lipoma is tensed by the weight of the lipoma alone or by external forces on it from adjacent  
32 intestine. This produces a slit-like aperture formed by the stalk and the contiguous mesentery. One  
33 or more loops of intestine pass across the lateral edge of the stalk before turning into this aperture,  
34 either because of lack of space in the abdominal cavity or through the effects of peristalsis. The  
35 weight of the intestine itself causes the loop to “fall” into the aperture and become entrapped. This  
36 creates a half-hitch knot in which the loop of intestine uses the lipoma pedicle as a “post” around  
37 which it becomes strangulated.

38 **Conclusions:** The proposed hypothesis differs from the existing by requiring intestinal movement  
39 to create the strangulation, which is more plausible than the current proposal that the strangulation  
40 is caused by movement of the lipoma itself. It is also more consistent with surgical findings.

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49 In horses, small intestinal strangulation by a pedunculated lipoma is a common cause of  
50 obstruction, representing 3 to 7% of all colic cases and, 7 to 13% of all horses undergoing  
51 exploratory laparotomy for investigation of colic signs.<sup>1</sup> The pathogenesis of pedunculated lipoma  
52 strangulation has been attributed to movement of the lipoma around a loop of intestine, wrapping  
53 it with its stalk <sup>2</sup> to form a “bola” (from Spanish, meaning “ball”; it is a type of  
54 throwing weapon made of weights on the ends of cords, used to capture animals by entangling their  
55 legs ). Spontaneous movement of the lipoma around the loops of intestine to become entangled  
56 as described is unclear.<sup>2,3</sup> Also, if the lipoma were to move around the long segments of intestine  
57 and mesentery as seen in many clinical cases, the pedicle would be too short to allow enough room for  
58 the lipoma to pass under it, as is typically illustrated. Furthermore, it is not clear why some lipomas  
59 tend to lie dormant and others lead to intestinal strangulation.<sup>3</sup> A lipoma originates from plaques  
60 of fat between the two serosal layers of the mesentery. As it grows, its weight stretches the serosa  
61 to form a pedicle that attaches it to the mesentery. In the study by Edwards and Proudman<sup>2</sup>, the  
62 authors found that strangulating lesions were significantly associated with the weight of the  
63 lipoma. They found that lipomas causing strangulating lesions were in the range of 33 to 688 g,  
64 while those causing nonstrangulating lesions ranged from 3 to 259 g. These findings led the  
65 authors to state that “Any lipoma heavier than 33 g has the potential to cause intestinal  
66 obstruction”.<sup>2</sup> The length of the stalk or pedicle of a lipoma could also play a role in the  
67 pathogenesis of strangulation,<sup>4</sup> because generally strangulating lesions are caused by lipomas  
68 with a long pedicle. Nonstrangulating lesions are caused by lipomas with a pedicle that originates  
69 close to the junction between mesentery and intestine in most cases.<sup>2</sup> There are some cases, where  
70 a short stalked lipoma can cause strangulation of a loop of intestine <sup>2</sup>(Fig 1). The length of the  
71 intestine that becomes entrapped by the lipoma can vary considerably and many loops of intestine  
72 can be entrapped by one pedunculated lipoma. This is difficult to explain with the existing “bola”

73 model. Strangulation by lipoma can take several forms, including strangulation by omental lipoma  
74 or mesenteric lipoma, strangulation of small intestinal mesentery only, strangulation of multiple  
75 loops or loops of variable lengths, and involvement of lipomas of variable size. The mechanism  
76 hypothesized in this report could be compatible with all these different forms. The anatomo-  
77 pathological features of cases of pedunculated lipoma in horses submitted to colic surgery  
78 provided the basis to the proposed hypothesis to explain how a lipoma can strangulate the small  
79 intestine. In one clinical case, our hypothesis was supported by finding that the lipoma strangulation  
80 could be corrected by reversing the mechanism proposed for movement of the intestine relative to  
81 the lipoma pedicle (Fig 1-7) Furthermore, in several other cases we found that the stalk of the  
82 lipoma was of such a length that the lipoma extended ventral to the length of the mesentery and  
83 intestine combined at that location. We hypothesize that the stalk is kept under tension by the  
84 weight of the lipoma or by ventral traction on it exerted by surrounding intestinal loops. The  
85 tension on the stalk produces a slit-like aperture or narrow gap between the stalk itself and the  
86 adjacent, usually contiguous mesentery, or the small intestine (Fig. 1). The position of the lipoma  
87 relative to the intestine may also play a role. If the stalk is of such a length that the lipoma lies  
88 ventral to the small intestine, a larger slit-like aperture is created that could accommodate long  
89 segments of small intestine. At this point, one or more loops of intestine that are initially found  
90 lateral to the stalk (Fig. 2), can turn into this aperture under the influence of peristalsis or to  
91 occupy the available space created (Fig. 3). Peristaltic waves then travel from proximal to distal  
92 when this loop becomes obstructed by the mesentery and the lipoma stalk. As the entrapped loop  
93 fills with fluid, it draws progressively more intestine into the gap between pedicle and  
94 mesentery.<sup>4</sup>The peristalsis of the proximal portion of intestine that entered the slit opening will  
95 pull the loop out of the incarceration. In addition to fluid distention, peristalsis of the distal portion  
96 will pull the intestine into the opening. The increased weight of the segments that enter the opening  
97 act to overcome the effect of peristalsis in drawing intestine out of the incarceration. The balance

98 between distention drawing intestine into the entrapment and peristalsis pulling intestine out of it  
99 could determinate the length entrapped, eventually reaching a point at which the degree of  
100 entrapment is complete. These forces lead to the involvement of a length of entrapped intestine  
101 that can be a few centimeters to several meters by the time peristalsis ceases and distention reaches  
102 its limit. This mechanism can also explain how strangulation by lipomas of the distal jejunum  
103 often involve the ileum<sup>4</sup>. These mechanism have been proposed by Kopf<sup>4</sup> for inguinal hernia  
104 incarceration, but may also apply to lipoma strangulation. At this stage, the weight of the intestine  
105 that passes into the opening will cause it to “fall” through the loop, thereby “cinching” the  
106 incarceration. (Fig. 4) In fact, until occlusion of the lumen is complete, the peristaltic wave forces  
107 contents into the incarcerated segment thereby increasing its weight and ultimately causing the  
108 strangulation. Peristalsis of the distal segment can, by that point, reach a limit and cease to  
109 contribute to further incarceration of bowel. The tightness of the incarceration is determined by  
110 the lipoma becoming entrapped within a distended intestinal segment compressed by the stalk so  
111 that it forms two points of distention too close to each other to allow the lipoma to retract from  
112 between them. The weight and the distension of the entrapped loop influences the system by  
113 causing the “post” formed by the stalk of the lipoma to turn in a half-hitch that strangulates the  
114 loop of intestine (Fig. 5-6), thus causing the lipoma to wrap on its own stalk and making the  
115 reverse process impossible (Fig. 7). At this stage the intestine starts to undergo ischemic changes.  
116 In the same manner in which one loop of intestine can enter the aperture and become strangulated,  
117 so can a second loop of intestine, thus explaining the incarceration of multiple loops by a single  
118 lipoma stalk. The above hypothesis can also explain why lipomas of different size and weight can  
119 entrap the intestine. In fact in both cases produce strangulation because, in our opinion, they are  
120 less likely to produce a fixed post. In our hypothetic model, the relative length of the stalk is  
121 more critical than the weight of the lipoma to produce the strangulation. When the stalk is of such  
122 a length that it allows the formation of a long aperture, the possibility of the intestine becoming

123 securely entrapped increases. If the stalk originates close to the intestine, but is of such a length to  
124 allow the lipoma to be blocked underneath the small intestine, it may produce a small but sufficient  
125 opening into which the intestine can migrate. (Fig. 8-A, 8-B) In his article, Edwards considered  
126 this type of presentation peculiar of non-strangulating pedunculated lipomas (Fig. 9A) but short  
127 stalked lipomas can cause strangulation, and this can be only explained by assuming the intestine  
128 moves around the stalk. Large lipomas with a short stalk (Fig 9B) can also produce mild, recurrent  
129 colic by stretching the mesentery, as also reported by others.<sup>5,6</sup> The above hypothesis can also  
130 explain why small lipomas can entrap the intestine. In such cases the weight of the lipoma may  
131 not be sufficient to tense the stalk , but the length of the stalk can predispose to the entrapment (Fig  
132 8-C). In the same way , this hypothesis could also explain why some lipomas tend to lie dormant  
133 and some lead to severe intestinal damage. Either (in some cases both) the weight of the lipoma  
134 and length of the stalk are responsible for the tension on the stalk itself. Small lipomas with a long  
135 stalk and heavy lipomas with a relatively shorter stalk are those most likely to cause strangulation  
136 (Fig 8-C and 8-D). Relatively small lipomas with a relatively short stalk are less likely to produce  
137 enough tension on the stalk to allow the movement of the intestine. In such cases the lipoma and  
138 its stalk are likely pushed aside from the intestinal movement. (Fig 8-E) unless clinched by another  
139 viscus (Fig. 8-F). Our model can also explain the incarceration of intestine without strangulation.<sup>7</sup>  
140 These case are rare, and can be explained by insufficient time or the optimal conditions (length  
141 of the stalk, weight of the lipoma, intestinal content, weight of the entrapped loop) to reach  
142 completion. The model we hypothesized can also explain strangulation caused by omental  
143 lipomas, in which case the omentum acts as a stalk. Despite being found in large numbers, lipoma  
144 of the small colon mesentery reportedly cause strangulation in only few cases<sup>2</sup>. Anatomy, content,  
145 weight, mobility and peristalsis of the small colon are very different from those of the small  
146 intestine, and may not allow the movement of the loop of intestine necessary to cause  
147 strangulation as described in our model. Alternatively, this model cannot explain why in some

148 cases only the mesentery is involved in the strangulation, as described by Bauck et al.,<sup>8</sup> and a  
149 complete different mechanism can be responsible.

150 **Clinical importance:** improved understanding of the manner in which intestine becomes  
151 entrapped by a lipoma could provide a method of resolving the strangulation. Strangulations by  
152 lipoma can be freed by transecting the stalk, sometimes blindly and deep in the abdomen, which  
153 could risk injury to major mesenteric vessels and mesentery.<sup>9</sup> Reversing the direction followed by  
154 the lipoma during strangulation, based on our hypothesis (Fig. ...), might be an easier and less  
155 risky alternative in some cases, especially if the tightness of strangulation was not exacerbated by  
156 tissue swelling.

157 .Further studies and particularly in clinical cases are needed to develop this technique. If the  
158 proposed mechanism is valid, administration of motility-inhibiting drugs (such as hyoscine, alfa-  
159 2 agonists or even opiates) in the early phases of the process, i.e. in the first visit by referring  
160 veterinarians, could reduce the amount of intestine entrapped and prevent involvement of the  
161 ileum. This may also apply to inguinal hernias and epiploic foramen entrapments, which undergo  
162 a similar process after entrapment according to Kopf.<sup>4</sup> The proposed mechanism could also  
163 underscore the importance of early referral, which could prevent the recruitment of a long segment  
164 into the entrapment and the tightness of the strangulation.

**Conclusions:** The proposed hypothesis is intended to provide an alternative mechanism to explain  
strangulation by a pedunculated lipoma. The goal is to develop a better understanding  
of the process and thereby improving methods of correction.

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## **Figure legends**

FIGURE 1: lipoma suspended across the mesentery.

FIGURE 2: the intestine moves across the stalk.

FIGURE 3: because of the peristalsis or lack of space in the abdominal cavity, the intestine enter

the split-like opening

FIGURE 4: because of the effects of distension and peristalsis, more intestine is drawn into the opening

Fig. 5: the weight of the intestine cause the loop to “fall”

Fig. 6: an half-hitch knot is formed and strangulation start

FIGURE 7: with the increase in volume of the strangulated loop the knot became irreversible

FIGURE 8: diagrams of the different hypothesis for “dormant” and pathologic lipomas. A) Large lipoma with stalk originating close to the mesentery-intestine junction; B) small lipoma

with stalk originating close to mesentery-intestine junction: its weight is not sufficient to keep the stalk under tension, but this is obtained by the fact that the lipoma is clinched between the intestine and the abdominal wall or other viscera; C) small lipoma with stalk

originating in the proximal mesentery: the stalk is of sufficient length to originate the same condition as in “B”; D) Large lipoma with stalk originating in the proximal mesentery: the weight and size of the lipoma are sufficient to put the stalk under tension; E) Small lipoma with stalk originating in the proximal mesentery: the weight of the lipoma is not sufficient to put the stalk under tension; F) Small lipoma with stalk originating in the proximal mesentery clinched by surrounding viscera: as in “E” the weight of the lipoma is not sufficient to put the stalk under tension but this may be action of surrounding viscera.

FIGURE 9: Short stalked lipomas: A) Mechanism for strangulation of the intestine by short stalked lipomas as hypothesized by Edwards and Proudman (**needs permission for re-printing**); B) A large, short-stalked lipoma causing recurrent colics.