

## ORIGINAL ARTICLE

## LIGATION AND DRAINAGE OF APPENDIX PREVENTS FUTURE APPENDICITIS IN RAT

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**Background** – The appendix is essentially a lymphoid organ which contributes to the production of B and T lymphocytes and is supplemental to the immune system. For many years, removal of normal appendix during other intraabdominal surgeries (incidental appendectomy) was a common practice. The present experimental study was designed to find a procedure in which, while preserving the appendix, the risk of future appendicitis is reduced.

**Methods** – Laparotomy was carried out on four groups of N-Mari rats: 1) obstruction group ( $n = 10$ )—the base of the appendix was ligated; 2) milking group ( $n = 31$ )—the contents of the appendix were milked into the cecum prior to ligation; 3) drainage group ( $n = 31$ )—the contents of the appendix were milked into the cecum prior to ligation and the tip of the appendix was cut, so that mucosal secretions could drain and be absorbed into the peritoneal cavity; and 4) control group ( $n = 31$ )—only exploration and manipulation of the appendix via celiotomy, but no surgical procedures, were performed. The blood supply to the appendix was preserved in all animals. All animals underwent a second laparotomy to remove the appendix and detect histopathologic evidence of appendicitis after 30 days. Chi-square and two-tailed Fisher's exact tests were used to analyze the data.

**Results** – All animals in the obstruction group developed acute appendicitis early in the 24 hours after ligation. Histopathologic evidence of inflammation was detected in 12 of 31 rats in the milking group and in three of 31 subjects in the control group after 30 days. No animal in the drainage group developed appendicitis, but two cases of mucocele were encountered. The combined ligation and drainage protocol did not lead to more inflammation than the control protocol ( $p = 0.7$ ).

**Conclusion** – These results suggest that combined appendiceal base ligation and appendiceal tip cutting (for draining mucosal secretions into the peritoneum) may be considered as an alternative to incidental appendectomy. Further validation of this technique is required before it can be recommended for application in the clinical setting.

**Keywords** • appendectomy • appendicitis • drainage • ligation

### Introduction

Until recently, the human appendix was considered “a vestigial organ with no definite function”.<sup>1</sup> This idea has been questioned, and some regard the appendix as a specialized part of the digestive tract.<sup>1,2</sup> Lymphoid tissue appears in the appendix wall soon after birth, and is accompanied by the appearance of gastrointestinal microflora. Between the ages of 12

and 20 years, there are about 200 lymph follicles in this organ.<sup>1</sup> The physiologic functions of the appendix are mostly related to the immune system and maturation of B lymphocytes.<sup>2, 3</sup> Recently, Dasso et al revealed that there are both B and T lymphocyte and immunoglobulin production in the appendix from childhood to old age.<sup>4</sup>

For many years, incidental appendectomy has been an accepted surgical procedure.<sup>5, 6</sup> The reason behind performing this unnecessary procedure on the healthy appendix was to eliminate the risk of future appendicitis.<sup>6, 7</sup> In 1964, McVay raised serious questions about this procedure, based on necropsy data indicating that appendectomy raises

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the risk of cancer.<sup>8</sup> Soon thereafter, several studies on cancer patients supported his claim,<sup>7, 9</sup> while others did not.<sup>10, 11</sup> Despite this controversy, excision of normal appendix is still widely performed during laparotomies. This experimental study was designed to find a procedure that would preserve the healthy appendix while reducing or eliminating the risk of future appendicitis.

**Materials and Methods**

A proposal was established and approved by the Research and Animal Ethical Committees of Kerman University of Medical Sciences, Kerman, in 1998. This study was carried out on 103 female N-Mari rats, 5 – 6 months old and weighing a mean ± SD of 230 ± 9.2 g. Anatomy and histology of the appendix in the rat is similar to the human child, i.e. 3 – 8 cm in length and with a wide base. The animals were housed in groups of three in each cage, under controlled conditions of temperature and with illumination from 7 am to 7 pm. They were fed with standard laboratory chow and tap water *ad libitum*, until 8 hours prior to surgery when they were deprived of food. The animals were anesthetized by an intraperitoneal injection of 10 mg/kg ketamin (Rotex, Trittau, Germany) and 10 mg/kg chlorpromazine (Tehran Chemie, Iran).<sup>11, 12</sup> After shaving and preparing the abdominal skin with povidon iodine (Toulidaru, Iran), and draping with a sterile towel, the abdominal cavity was opened by a 4-cm midline incision. All operations were performed by one surgeon. In the obstruction group (*n* = 10), the base of the appendix was ligated using a 3 – 0 silk surgical suture (SUPA, Iran). No additional procedure was carried out; but because of the morbid general condition of animals, they underwent a second laparotomy and appendectomy after 24 hours. In the milking group (*n* = 31), a similar ligation procedure was carried out and the contents of the appendix were milked back to the cecum. Animals in the drainage group (*n* = 31) were operated on similarly to the milking group, except that the tip of the appendix was cut so that mucosal secretions of the appendix could drain and be absorbed into the peritoneal cavity. In the first three groups, care was taken that the vascular supply to the appendix remained intact. In the control group (*n* = 31), only celiotomy for exploration and manipulation of appendix was performed.

In the milking and drainage group animals, a

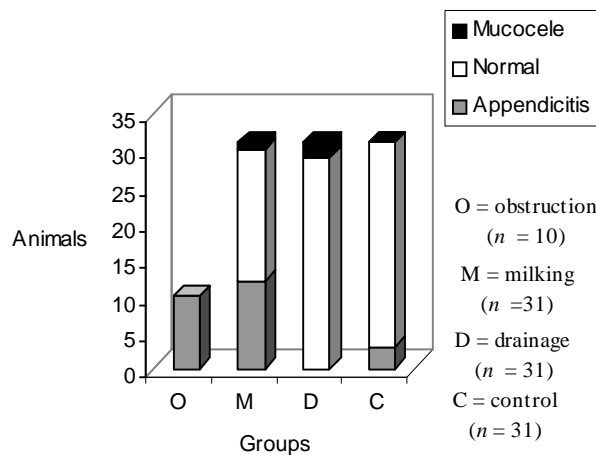
second operation to remove the appendix was performed after 30 days. The rats were sacrificed after an initial intraperitoneal injection of pentobarbital (Rotex, Germany). The appendix was removed and histopathologic examination for the presence or absence of inflammation was done by a blinded pathologist.

Data were analyzed using EPI-6 software (CDC, Atlanta, GA, USA). Chi-square and two-tailed Fisher’s exact tests were used.

**Results**

Because all rats in the obstruction group developed apathy, anorexia, and listlessness within 24 hours of the initial laparotomy, appendectomy and sacrifice was performed 24 hours later. Histopathologic examination of the appendices confirmed acute appendicitis in all animals. None of the rats in the other three groups developed clinical signs of acute illness, and appendectomy was performed after 30 days in all animals.

Results of pathologic examination of the appendices of all four groups are presented in the Table and the Figure. All rats in the obstruction group developed appendicitis. None of the rats who received the combination protocol of obstruction, milking and drainage (drainage group) developed appendicitis. However, mucocele was observed in two rats of the drainage group. In those two animals, the tip of the appendix was closed by a walling off process. There was a statistically significant difference in the development of appendicitis between animals of the milking (12 of



**Figure.** Effect of appendix ligation and drainage on prevention of appendicitis in the rat.

**Table.** Incidence of appendicitis or mucocele following appendix ligation and drainage in rat.

Group	Positive (n)	Negative (n)	Mucocele (n)
Obstruction	10	0	0
Obstruction + Milking	12*	18	1
Obstruction + Drainage	0	31	2
Control	3	28	0

\* $p = 0.0059$ , Chi-square = 7.56

31) and control (3 of 31) groups ( $p = 0.006$ ).

## Discussion

Removal of a normal appendix in abdominal and pelvic procedures (incidental appendectomy) is a common practice.<sup>3, 5</sup> The appendix is a probably useful organ in the immune system. There are many reports regarding the incidence and/or change in the course of some diseases such as colorectal cancer and ulcerative colitis following appendectomy.<sup>2, 7-9, 11</sup>

This experimental and novel study was designed to explore methods that could either prevent future risk of appendicitis or preservation of the normal appendix. It was expected that all the rats in the obstruction group would develop clinical signs of acute illness soon after the first operation, as the following three factors are well known to be involved in the initiation and perpetuation of acute appendicitis:

1. obstruction of appendiceal lumen by a fecolith or by hypertrophied lymph follicles;<sup>13</sup>
2. presence of bacteria in appendiceal content;<sup>14</sup> and
3. continued mucosal secretion increasing intraluminal pressure.<sup>15</sup>

Interestingly, subjects in the drainage group had no histopathologic evidence of appendicitis. One explanation for this result is that there may have been prevention of bacterial contamination of the appendiceal lumen and prevention of increasing luminal pressure by the basal ligation and mucosal drainage into the peritoneal cavity, respectively. No clinical evidence of acute illness in either the drainage or milking groups was found. For the milking group, it can be reasoned that, by emptying the appendiceal contents back into the cecum prior to luminal closure, the numbers of luminal bacteria were significantly reduced, and

those remaining were kept under control by immune defense mechanisms. In the drainage group, two cases of mucocele and one case of stitch inflammation (the inflammation was quite limited to the ligation stitch along the appendiceal lumen) were observed. Mucocele results from noninflammatory occlusion of an empty and sterile appendiceal lumen.<sup>1, 14, 16</sup> In these two cases of mucocele, the tip of the appendix was closed by omentum (walling off); hence, mucosal secretions of the appendix were retained in its lumen. The significant reduction in the incidence of appendicitis in the drainage group compared with this condition in obstruction group ( $p < 0.001$ ) and milking group ( $p < 0.05$ ) may be further attributed to continuous drainage of mucosal secretions into the peritoneal cavity, hampering any increase in intraluminal pressure. Interestingly, in the control group three animals developed appendicitis. Naturally, rats may develop appendicitis, but it may be argued that manipulating the appendix during laparotomy for other purposes can induce an inflammatory reaction in the appendix wall. This finding may be considered as an indication for incidental appendectomy. It seems that the presence of luminal microbial flora is more important than mere accumulation of mucus after appendix ligation for the promotion of an acute inflammatory process; the latter is thought to be the pathogenic mechanism of mucocele development in the appendix.<sup>1, 14, 16</sup>

Our findings suggest that the combined procedure of ligation of the appendiceal base, with preservation of its blood supply, and drainage of its lumen into the peritoneal cavity, could be an alternative to incidental appendectomy. The results of this animal study require further validation before this technique can be applied in the clinical setting.

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