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Laparotomy versus Laparoscopy in canine abdominal exploratory surgery

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Abstract
Abdominal exploratory surgery; the process by which a surgeon examines the internal organs of the abdomen in order to find and treat abnormalities; is a common procedure performed on canines by veterinarians. The surgery is typically done via one of two methods: laparotomy or laparoscopy. Laparotomy, the more common technique, involves making a large incision across the abdomen, providing surgeons with both visibility of the internal structures as well as the ability to physically palpate the organs. Laparoscopy allows a surgeon to examine the inside of the abdominal cavity using a small incision and a laparoscope; a fiber optic instrument with a video camera. As laparoscopies become more common in veterinary practice, research regarding the comparison between the two procedures is needed. A PubMed search was used to identify and review six studies on the topic of laparotomy versus laparoscopy in order to present basic guidelines as to which operation may be preferred in certain situations. The guidelines advise decision-making on the basis of diagnostic imaging (types of foreign bodies and location of gastrointestinal obstruction); presence of comorbidities, such as the location of lesions in the gastrointestinal tract and the presence of free peritoneal fluid; and the pain threshold. Further research is needed to refine the current guidelines and improve the outcomes for canine abdominal exploratory surgeries.

Keywords
Canine abdominal surgery, Canine Laparoscopy, Canine Laparotomy, Foreign body retrieval, Diagnostic imaging, Gastrointestinal obstruction, Peritoneal fluid, Abdominal radiography, Abdominal cavity adhesions, Veterinary medicine

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1. Introduction

In canines, abdominal exploratory surgery is utilized for several reasons, such as tumor removal, gastric or intestinal foreign body removal, and biopsy collection. The principal methods of abdominal exploratory surgery in canines are laparotomy and laparoscopy (1).

Laparotomy, long considered to be the gold standard for exploratory surgery, consists of making a lengthwise incision along the abdomen to view the internal organs. If no evidence of abnormality is seen, the surgeon may lift the organs out of the body cavity for closer inspection. The surgeon may also cut into certain organs for an internal view. A laparotomy allows for a comprehensive analysis of the abdominal cavity and the organs, and is a major operation to undergo. Prior to surgery, the canine is placed under general anesthesia and its underside is shaved. Analgesics and an Elizabethan collar are required during recovery. A follow-up visit is typically necessary two weeks after the operation. The average cost of a laparotomy in the United States is between $3,000 and $10,000 (2).

The less invasive option for exploratory surgery is laparoscopy, a surgical technique for viewing the internal abdominal cavity by passing a laparoscope through a keyhole incision. Laparoscopy is widely used in both veterinary and human medicine, and allows for precise and accurate localization of various internal organs. Prior to exploratory laparoscopy, the canine is placed under general anesthesia. During the surgery, small incisions are made along the abdominal wall, surgical instruments and a camera are inserted through these ports, and the internal organs are examined. Similar to laparotomy, an Elizabethan collar is generally required during recovery. The average cost of a laparoscopy in the United States is also between $3,000 and $10,000 (3).

1.1 Scope of review

There is a paucity of research on a direct comparison between laparotomy- and laparoscopy-assisted exploratory surgery in canines. This systematic review aims to examine current research on canine exploratory surgery and reach a formulated conclusion on the comparison of laparotomy and laparoscopy. For the purposes of this review, the variables compared and/or discussed are success rate, conversion rate, ease of recovery, severity of complications, and operating time. Success rate is defined as the frequency at which a correct diagnosis is reached and, if applicable, a foreign body is removed or other abnormality is successfully addressed during surgery. Conversion rate is defined as the frequency at which laparoscopy is initially performed but must be converted to laparotomy in order to complete the surgery and/or reach a diagnosis.

Thus, this review focuses on the benefits and limitations of laparotomy versus laparoscopy for canine exploratory surgery with regard to success rate, conversion rate, ease of recovery, severity of complications, and operating time.

2. Materials and Methods

A comprehensive search was performed using the PubMed advanced search engine and the Cochrane Database. In order for an article to be chosen for the systematic review, the following criteria needed to be met: the article must have been related to canine abdominal surgery, been written within the past ten years, and discussed rate of success. For both databases, key phrases searched were 'canine laparoscopy', 'canine laparotomy', 'canine exploratory surgery', and 'canine laparoscopy versus laparotomy'. Key words such as spay, neuter, ovariectomy, conversion, and recovery were not included because they fell outside of the scope of this review, which focused specifically on comparing laparotomy and laparoscopy for abdominal exploratory surgery in canines. Thus, literature discussing other surgical applications of these techniques was excluded– except for one article on adrenalectomies that had relevant implications for laparoscopic-assisted surgeries. Additionally, words such as 'conversion' and 'recovery' were not searched because the studies comparing laparotomy and laparoscopy tended to already take these factors into account. Using the PubMed search engine, 394 articles were found, and two were found using the Cochrane Database. Overall, 396 articles were found, out of which 390 were excluded due to not meeting the predetermined criteria (Figure 1). A total of six studies were thus analyzed.

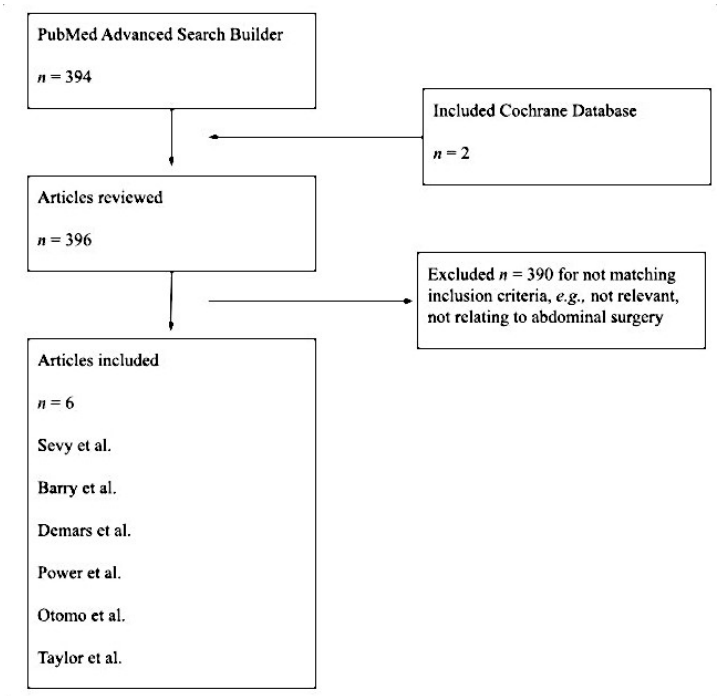

Figure 1. Manuscripts chosen for the review

3. Results

3.1 Success rates of Laparoscopy and Laparotomy

A successful exploratory surgery is one that reaches a diagnosis and, if possible, treats that abnormality apparent in the patient. Both laparotomy and laparoscopy-assisted exploratory surgeries have been shown to be reliable for diagnosis. Sevy et al. compared the results of abdominal computed tomography (CT) scans and exploratory laparotomy in dogs. The study used a logistic regression model to analyze 100 cases of dogs that underwent a CT scan followed by an exploratory laparotomy from 2009 to 2023. In 97 cases, the CT scan and the exploratory laparotomy found the same diagnosis. In the three cases that had disparate results, the exploratory laparotomy found an abnormality that the CT scan missed (4). Thus, it can be concluded that exploratory laparotomy is a reliable method for diagnosing abdominal conditions in canines.

Laparoscopy has been shown to be an equally effective diagnostic tool. Barry et al. performed an experiment in which 16 dogs underwent single-incision laparoscopy performed by a board-certified veterinary surgeon, immediately followed by exploratory laparotomy performed by a separate board-certified veterinary surgeon. The second surgeon was blinded to the results of the findings of the first. In this study, the primary diagnoses were the same with both techniques for all 16 dogs. Therefore, laparoscopy could be concluded to be as reliable in reaching a correct diagnosis as laparotomy (5).

Although both techniques performed similarly in establishing a primary diagnosis, the Barry et al. study found a significant difference in treatment outcomes between the two. This could have been due to the lack of accessibility of the gastrointestinal tract provided to the surgeon during laparoscopy (Table 1).

Table 1. Comparison of accessibility of various organs between laparoscopy and laparotomy, n=16.

Organ	Number of dogs in which organ was accessed during Laparotomy	Number of dogs in which organ was accessed during Laparoscopy
Liver	16	16
Pancreas	16	16
Stomach	16	16
Duodenum	16	16
Jejunum	16	14
Ileum	16	14
Cecum	15	13
Colon	15	15

This difference is especially notable in the case of foreign bodies (5). The presence of foreign bodies is a common diagnosis in canines– thus, the ability to successfully remove them is an important consideration when comparing surgical techniques for exploratory surgery. Laparotomy is traditionally the preferred procedure for foreign body removal, due to its established success rate of > 94% (6).

However, other less invasive techniques have been utilized to remove foreign objects. Demars et al. examined a possible approach for removal of foreign bodies from the intestines. In this study, 58 cases were reviewed. In each, a laparotomy was initially performed on the canine to maneuver the foreign body from the lower intestines into the stomach. An upper endoscopy was then performed to remove the foreign body from the stomach. Following the laparotomy with endoscopy ensured that the foreign body could be removed without intestinal incisions. The technique was designed to be less invasive, yet just as successful as a complete laparotomy. 25 of 58 cases resulted in foreign body removal, a success rate of ~ 43% (7). A different study, conducted by Power et al., studied five dogs who underwent laparotomy-assisted transoral foreign body retrieval. The retrieval utilized laparotomy to manipulate gastrointestinal foreign bodies into the jaws of an endoscopic instrument. Four of the objects retrieved were linear foreign bodies, one was non-linear. Of the five objects, two were located from the pylorus to the jejunum, one was located from the pylorus to the duodenum, one was located in the duodenum, and one was located in the stomach. The success rate was 100%, significantly higher than the 43% reported by Demars et al. for the same method, indicating that further research regarding the combination of elements of laparotomy and the less invasive endoscopy is necessary to estimate a success rate that accurately reflects the general canine population (8).

Another technique for intestinal foreign body removal is single-incision laparoscopy, for which a 77% success rate was reported by Otomo et al. In this retrospective study, 13 laparoscopy cases and 15 laparotomy cases for simple small intestinal foreign body removal were reviewed. Of the 13 laparoscopies, 10 were successful. The type of foreign object retrieved was not recorded for this study, but all 13 canines were noted to have jejunal foreign bodies (9).

A two-proportion z-test was performed to determine if the success rate of single-incision laparoscopy was significantly different than that of endoscopy-assisted laparotomy. The success rate was not found to be significantly different than that of the endoscopy-assisted laparotomy investigated by Power et al. (p = 0.10). However, it was found to be significantly different than the success rate of the endoscopy-assisted laparotomy investigated by Demars et al. (p = 0.03).

To augment this review, a proportions meta-analysis was performed using data from Otomo et al. and Barry et al. The remaining studies were excluded due to significant clinical heterogeneity. The analysis found a 100%

pooled diagnostic success rate for laparotomy and a 79.5% pooled diagnostic success rate for laparoscopy for the two studies.

3.2 Conversion to Laparotomy

The need for conversion to laparotomy arises when laparoscopy either fails to reach a diagnosis or reaches a diagnosis that is treatable only by laparotomy. The rate of this conversion is an important factor in comparing laparotomy and laparoscopy because a high rate of conversion may indicate that laparotomy is useful in a greater variety of situations than laparoscopy, or that the diagnostic methodology is not accurate enough. Of the six studies reviewed, four reported scenarios that resulted in conversion to laparotomy. Barry et al. followed 16 dogs with suspected gastrointestinal blockage. All 16 dogs underwent a laparoscopy followed by a laparotomy. Primary diagnoses were consistent between the two surgeries, but three laparoscopies were unable to be completed due to adhesions preventing access to the abdomen and required conversion to laparotomy to reach a final diagnosis. Furthermore, four abnormalities required treatment via laparotomy. In total, seven of 16 cases would have required conversion to open surgery (Table 2), an approximately 44% rate of potential conversion (5).

Table 2. Barry et al. findings regarding conversion rate

Conversion	Number	Percent
Did not require conversion	9	56.3
Required conversion for diagnosis	3	18.8
Required conversion for treatment	4	25
Total	16	100

Otomo et al. found that three of 13 dogs that underwent laparoscopy required conversion to laparotomy, an approximate 23% rate of potential conversion (9). The proportion meta-analysis found a 20.5% pooled conversion rate from laparoscopy to laparotomy for the Otomo et al. and Barry et al. studies.

The reasons for conversion in the study by Otomo et al. included gastrointestinal adhesions and the presence of abdominal free fluid upon laparoscopic abdominal explorations. The study mentioned that abnormalities on the ultrasound or CT scan that should deter the surgeon from performing laparoscopy also included the presence of linear foreign material or multiple foreign bodies (9).

Barry et al. reported that the reasons for potential conversion included the presence of gastrointestinal adhesions, lesions of the duodenum or colon, and linear foreign bodies. Adhesions in the abdominal cavity can result in an inability to access the internal organs via laparoscopy. Additionally, abnormalities along the duodenum are more difficult to treat via laparoscopy than an abnormality along the

jejunum or ileum, which is easier to access due to their long mesenteric roots (5). Linear foreign objects such as string or pantyhose are particularly difficult to remove via laparoscopy, as they can get caught in multiple places along the gastrointestinal tract and cause intestinal perforation, whereas this is less likely to occur in the case of discrete foreign bodies such as balls or plastic toys. For this reason, dogs affected by linear foreign objects tend to show more severe clinical signs than dogs affected by discrete foreign objects, and the removal of a discrete foreign body is typically easier and less costly than the removal of a linear foreign body (10).

Overall, different abnormalities have different likelihoods of requiring conversion from laparoscopy to laparotomy, and more research is needed to accurately estimate this conversion rate. For now, however, analyzing ultrasound or radiograph scans prior to surgery may be helpful in determining which route to take, as the presence of linear foreign bodies, abdominal fluid, or gastrointestinal adhesions bodes poorly for laparoscopic success.

3.3 Recovery and complications

Laparotomy and laparoscopy seem to have similar postoperative complications. In the study by Barry et al., researchers found that neither procedure caused major complications (such as death or hemorrhage requiring transfusion), and the rate of minor complications (such as puncture wounds or hypotension) was similar between canine patients. Of the 16 dogs in the study, three had minor complications during laparoscopy and one had a minor complication during laparotomy. This was not a significant difference ($p = 0.59$) (5). Otomo et al. reported no postoperative complications for either group (9).

Hospitalization time is also a consideration for measuring the ease of recovery, since a longer stay is usually an indicator of a more difficult recovery. Taylor et al. compared outcomes for 40 dogs with abdominal adrenal tumors treated by adrenalectomy with laparoscopy or laparotomy. In this retrospective inquiry, 14 dogs were treated with laparoscopy and 26 dogs were treated with laparotomy. The study reported that the hospitalization times for laparotomy and laparoscopy were 46.3 ± 25.1 hours and 39.3 ± 14.9 hours ($p = 0.15$) respectively (11). Additionally, Otomo et al. found no significant difference in duration of hospitalization for laparotomy and laparoscopy, with the median hospitalization time for laparotomy being 43 hours and the median hospitalization time for laparoscopy being 41.5 hours ($p = 0.34$) (9).

One significant difference between laparotomy and laparoscopy is the pain experienced by canine patients during recovery. In their study of laparotomy-assisted transoral foreign body retrieval, Power et al. reported that, along with displaying lower pain scores, dogs tend to have increased postoperative activity and decreased stress when undergoing laparoscopy compared to laparotomy (8). ‘Ease of recovery’ takes into account the severity of postoperative complications, hospitalization time, and general pain.

Overall, the postoperative complications and hospitalization time between laparotomy and laparoscopy are not significantly different, but the recovery from laparotomy is more painful than that of laparoscopy. The weight of this statistic on the overall choice of procedure will vary on a case-to-case basis, as some abnormalities may be significantly easier to treat via laparotomy, outweighing the benefit of an easier recovery with laparoscopy.

3.4 Operating time

Complications usually increase with an increase in surgical and anesthetic time. The length of surgery, as well as how long the patient will be under general anesthesia, must be a consideration when deciding between laparotomy and laparoscopy.

Taylor et al. found that the surgical time for dogs that underwent a laparotomy-assisted adrenalectomy was 108.6 ± 42 minutes, while the surgical time for the laparoscopy-assisted adrenalectomy was 69.8 ± 21.8 minutes ($p = .0003$). This indicates that laparoscopy may involve less surgical time for canine adrenalectomy (11).

However, these numbers may not be extrapolable to abdominal exploratory surgery. Otomo et al. observed no significant difference between the surgical time for open laparotomy and single-incision laparoscopy. For this study, median surgical times of 75 minutes for the 10 dogs that successfully underwent laparoscopy and 60 minutes for the 15 dogs that underwent laparotomy were reported (9). However, Barry et al. found that it is significantly faster to perform an exploratory surgery via laparotomy than laparoscopy. In this investigation, dogs with suspected gastrointestinal blockage underwent both surgeries in succession. The mean procedure time for laparotomy was 12.8 minutes, while the mean procedure time for laparoscopy was 36.8 minutes ($p < .001$). It is worth noting that the laparoscopic procedure is much less common, and therefore the veterinary surgeon performing that surgery may have been less experienced. Interestingly, a significant negative association ($r^2 = 0.53$) was identified between the chronological order of patients and duration of laparoscopy (for the same surgical team), indicating that increased surgeon experience may lead to reduced procedure times (5).

Regardless, the palpation of the abdominal organs is certainly a useful diagnostic measure accessible to the surgeon during laparotomy. This physical technique is able to be replicated using surgical instruments during laparoscopy, but may require more time. Further research involving a larger sample size of veterinary surgeons is needed to determine whether or not a statistical difference exists in procedure times between laparoscopy and laparotomy. Study results by Barry et al. suggest that, strictly for abdominal exploratory surgery, laparoscopy may be significantly slower than laparotomy. This increased operating time may be a factor in deciding between the two surgical techniques.

4. Discussion

Ultimately, the decision to perform a laparoscopy in place of an exploratory

laparotomy is up to the discretion of the veterinarian and the client, and is dependent on the specific situation. A basic recommendation is to take into account the following considerations as shown in Table 3.

Table 3. Considerations for performing laparotomy versus laparoscopy

Consideration	Better fit for Laprotomy	Better fit for Laproscopy
Diagnostic imaging results	Presence of free peritoneal fluid Linear foreign body Gastrointestinal adhesions Lesions of the duodenum or colon	Discrete foreign body Lesion of the Jejunum of Ileum Abnormality not known to increase the likelihood of conversion
Pain threshold	Greater Taller and heavier canines	Lesser Shorter and lighter canines

Initially, diagnostic imaging procedures should be performed. With the help of radiographs, CT scans, and ultrasound, a general diagnosis may be formed (e.g., discrete foreign object obstructing the ileum). Once a diagnosis is made, the likelihood of conversion to laparotomy can be determined. Conversion appears to be more likely in the presence of free peritoneal fluid (9), or in cases of linear foreign bodies (5, 9, 10), gastrointestinal adhesions (5, 9), and lesions of the duodenum or colon (6). Thus, the first consideration should be whether the general diagnosis meets any of these criteria. If so, the canine patient may not be well-suited for laparoscopy, and laparotomy is advised.

The second consideration is the canine's pain sensitivity. Research has indicated that lighter and shorter dogs tend to be more sensitive to pain than their heavier and taller counterparts (12). For patients who are more susceptible to discomfort and do not present with any preoperative diagnoses that would make them better candidates for laparotomy, laparoscopy may be the better option, since it is associated with a less painful recovery (8).

Laparoscopies are becoming increasingly common in veterinary practice. However, this seems more of a trend to prefer minimally invasive surgery, rather than support from any data from a robust mechanism and outcome based research comparing laparotomy and laparoscopy. The basic guidelines formed in this study by analyzing current information are intended to be a starting point. Further research is needed to better understand and improve outcomes for canine patients with suspected abdominal abnormalities by selecting the procedure that best fits the patients' needs.

5. Perspectives

Research should be conducted on a large enough canine sample size to accurately assess the benefits and limitations of choosing laparoscopy over laparotomy for canine abdominal exploratory surgery. Variables such

as diagnostic tool accuracy - types of foreign bodies and location of gastrointestinal obstruction, surgeon experience, hospital type, dog breed, anesthetic risk, and comorbidities – such as the location of lesions in the gastrointestinal tract and the presence of free peritoneal fluid - should be taken into account and standardized where possible. Additionally, cases should be randomly assigned to laparotomy or laparoscopy; leaving the procedure up to the discretion of the surgeon may introduce bias, as dogs that are perceived to be more ill may be assigned to laparotomy and vice versa. Future studies investigating the role of preoperative ultrasound or CT evaluation could also provide valuable information in determining appropriate case selection criteria.

It should also be noted that abdominal radiography is the most common and convenient method of imaging for general veterinary practices. However, its sensitivity and specificity for detecting obstruction (approximately 80 percent and 70 percent, respectively) are lower than that of CT scans (approximately 95 and 80 percent) (13). Thus, further research into the feasibility of using artificial intelligence and machine learning models to improve the sensitivity and specificity of abdominal radiography is warranted. Such technologies, if developed, might be utilized with existing imaging techniques to improve accuracy, better guide preoperative decision making, and improve overall outcomes.

In addition, the equipment required to perform a laparoscopy may not be widely available in all veterinary practices. Accordingly, further studies should focus on increasing awareness and availability of laparoscopic options to enhance the surgical range of veterinary practices. Additionally, prioritizing ongoing research and training will aid in knowledgeable decision-making when choosing the best surgical approach for each case.

6. Conclusion

Across studies, diagnostic success rates were similar for both laparotomy and laparoscopy, but reported treatment success rates varied, with some studies estimating significantly higher success rates than others. These discrepancies may be attributable to inaccurate diagnostic tools, differences in surgical experience, not controlling for case complexity, or deviations in overall experimental design.

Additionally, some cases required conversion to laparotomy. Factors such as linear foreign bodies, presence of peritoneal fluid, abdominal adhesions, and lesions in the duodenum or colon increased this likelihood. Reported conversion rates varied from 23 to 44%. A larger sample size is needed for a more accurate estimate of the general population.

Complication rates for both operative techniques were similar, though the recovery for laparotomy was consistently reported to be more painful than that for laparoscopy. Furthermore, while reported surgical times varied for laparotomy and laparoscopy,

surgical experience may decrease laparoscopic operative time.

Laparoscopy is a viable alternative to laparotomy for abdominal exploratory surgery in some cases, but additional research is warranted to refine the selection criteria developed in this paper. Furthering the understanding of the potential advantages and disadvantages of laparotomy and laparoscopy will improve outcomes in canine abdominal exploratory surgery.

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