Original Article

Peritoneal Lavage during Laparoscopic Appendectomy for Complex Appendicitis is Associated with Increased Post-Operative Morbidity

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Abstract

Aim: Appendicitis is one of the most common paediatric surgical pathologies seen by paediatric surgeons worldwide. Laparoscopic appendectomy is undertaken for all cases of appendicitis in our institute. Intraperitoneal lavage following appendectomy is the conventional way of managing complicated appendicitis; however, some surgeons debate the efficacy of this practice. The aim of this study was to compare outcomes of intraperitoneal lavage versus suction only in children with complicated appendicitis. **Methods:** Data were collected retrospectively between January 2018 and January 2019. All patients undergoing laparoscopic appendectomy for complex appendicitis were included and divided into two groups, patients who had suction only and those who had lavage and suction. Outcome parameters studied were the length of stay (LOS), number of temperature spikes > 37.7 (TS), operative times (OT) and readmission for intra-abdominal collections. Comparison between the two groups was performed using two sample *t*-test with unequal variance, significance was set at $P < 0.05$. **Results:** A total of 115 patients were included (lavage $n = 52$, Suction $n = 63$). The LOS ($P = 0.0054$), TS (0.0109), OT ($P < 0.0001$) were significantly higher in the lavage group compared to the suction-only group. Overall rates of readmission were similar between groups, however, readmission for the confirmed intra-abdominal collection was more common in the lavage group. **Conclusion:** Based on our study, it appears that there is no advantage in performing an intraperitoneal lavage for complex appendicitis. It resulted in a prolonged stay, more post-operative TS and longer operative duration. The likelihood of being readmitted with an intra-abdominal collection following a lavage was higher compared to suction only.

Keywords: Complex appendicitis, intra-abdominal collection, laparoscopic appendicectomy, length of stay, peritoneal lavage, temperature spikes

Introduction

Acute appendicitis is the most common abdominal surgical emergency within the paediatric population. It can be classified as simple (inflammation confined to the appendix and not involving the peritoneum) or complex (localised or diffuse peritonitis).[1,2] The standard therapeutic approach for acute appendicitis is to perform a laparoscopic appendicectomy.[3]

The use of peritoneal lavage during paediatric laparoscopic appendicectomy was first descried in 1906.[4] Two schools of thought continue to exist on this subject. The first argues that the application of peritoneal lavage allows for dilution of the bacterial load associated with perforated appendicitis and thus reduces the likelihood of complications developing namely intra-abdominal abscess (IAA) formation. In contrast, others argue that lavage only washes the bacterial load off mesothelial surfaces, resulting in only a temporary reduction in bacterial load. An additional argument against the use of lavage is that there is the potential for bacterial contamination to be distributed across a wider area of the abdominal cavity. This could result in said contamination being spread into areas of the abdomen which cannot be reached laparoscopically, resulting in some contamination remaining after the operation is complete.[5]

Whilst there is a consensus that laparoscopic appendicectomy is the optimal surgical approach, debate continues with regards to performing peritoneal lavage during the procedure. Some

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argue for the use of peritoneal lavage, whilst others feeling that it is detrimental to patient outcomes. Many studies and reviews have been conducted to address this issue, with no clear consensus being reached. Common parameters, used as proxy measures to assess outcomes for each method, include rates of IAA, wound infections, length of hospital stay and need for further surgical intervention. A multitude of confounding factors adds to the difficulty in conducting such studies. Differences in antibiotic regimes, pre-operative morbidity and intra-operative techniques, such as the volumes of lavage used, all have the potential to skew results and therefore add to the difficulties in drawing meaningful and correct conclusions.

Despite a plethora of studies into the topic, ambiguity remains. Published literature shows contrasting results, with some finding lavage to be detrimental to patient outcomes, whilet others show clear benefits. Many papers demonstrate no statistical significance in the differences found and suggest that this indicates that there is no benefit obtained for the patient by performing lavage. This led to the undertaking of a retrospective analysis of patient outcomes within our centre to guide our own clinical practice.

Methods

115 cases of complex appendicitis, treated at our centre between 2018 and 2019, were retrospectively analysed. Operative notes recorded on ORMIS 10 were reviewed to categorise patients into 'lavage' and 'suction only' groups. Inpatient notes were then reviewed for each individual case to determine outcome parameters. Patient observations, recorded on Nervecentre, were reviewed to determine the frequency of post-operative temperature spikes (TS) for each case. A temperature spike was classified as any temperature >37.8°C recorded on patient's routine observations. Length of hospital stay was also determined, measured from point of admission via the emergency department to the point of discharge. Further analysis of operation notes was conducted to determine the duration of surgery, measured as the time between 'knife to skin' and 'dressings on', according to timings recorded on ORMIS.

All cases underwent laparoscopic appendicectomy using a standard three-port approach. Lavage was performed at the discretion of the operating surgeon and was carried out with 0.9%NaCl. The volume of fluid used was not consistently recorded during the study period, and in those recorded varied from case to case, therefore this was not included in the analysis.

All patients with complex appendicitis were treated with a triple antibiotic therapy protocol of cefuroxime, metronidazole and gentamicin for at least 5 days.

Sample sizes were not equal and therefore statistical significance was determined using two-sample T-tests with unequal variance, with statistical significance being set at $P < 0.05$.

For all three outcome parameters, values did not show the normal distribution and therefore, interquartile ranges are provided.

Descriptive statistics were applied to outcomes relating to readmission rates as there were only small numbers of these and these would not have reached statistical significance.

Results

A total of 115 patients were included in the study, 52 patients in the lavage and 63 in the suction-only group. The average age in the lavage group was 10.12 years with a range of 3 years to 15 years. The suction-only group had an average age of 9.74 years with a range of 2 years to 15 years. There were a total of 59 boys and 56 girls, of which the lavage group had 20 boys and 32 girls. The suction-only group had 39 boys and 24 girls. Demographics are displayed in Table 1.

Of the parameters assessed, the mean length of stay (LOS) in the lavage group was 7.67 days (standard deviation [SD] = 5.526) and in the suction group, it was 5.41 days (SD = 3.18). The mean number of TS was 7.9 (SD = 8.04) in the lavage group and 4.71 (SD = 6.5) in the suction group.

A two-sample *t*-test with unequal variance was used for statistical analysis. Differences in both lengths of hospital stay and number of post-operative TS were found to be statistically significant, with $P = 0.0054$ and 0.01, respectively.

The mean operating times were 84.4 min (SD = 31.28 min) in the lavage group and 57.11 min (SD = 15.88 min) in the suction-only group. Again, this difference was found to be statistically significant with $P < 0.0001$. Observed rates of readmissions for all indications were similar, with a rate of 11.5% seen in the lavage group, compared with 12.7% seen in the suction-only group. However, of those readmitted in the lavage group, 66.7% were due to a confirmed intra-abdominal collection, whereas only 12.5% readmitted in the suction-only group were due to a confirmed collection. Results are displayed in Table 2.

Discussion

In concordance with some other published literature on this topic, our results suggest the use of peritoneal lavage has a detrimental effect on patient outcomes.[5] A statistically significant increase in three key parameters; operative duration, frequency of post-operative spikes of temperature and overall duration of hospital stay, was demonstrated in patients who underwent intraoperative peritoneal lavage. Although rates of readmission were found to be similar between the two groups, readmission due to confirmed collection was more commonly seen in the lavage group. These results can be used, alongside findings from other authors, to argue for the avoidance of peritoneal lavage.

Spikes of temperature are a common finding which both would contribute to and indicate post-operative morbidity. Similarly, a longer hospital stay can be extrapolated to indicate increased patient morbidity. Our results demonstrate a clear difference in these two outcome measures, indicating that the use of peritoneal lavage resulted in increased post-operative morbidity.

Table 1: Cohort Demographics

Demographics	Lavage group	Suction only group
Total number	52	63
Boys	20	39
Girls	32	24
Average age (range)	10.12 (3-15)	9.74 (2-15)

Table 2: Results

	Lavage group	Suction group	*P*
Number (male/female)	52 (20/32)	63 (39/24)	
Average age (range)	10.12 (3-15)	9.74 (2-15)	
Mean length of stay (SD)	7.67 (5.53) IQ range=2	5.41 (3.18) IQ range=2	*P*=0.0054 (0.54-3.98) DF=77
Mean number of temperatures (SD)	7.90 (8.04) IQ range=6	4.71 (6.51) IQ range=5	*P*=0.0109 (0.44-5.97) DF=97
Mean operative times (SD)	84.46 (31.39) IQ range=23	57.12 (15.88) IQ range=17	*P*<0.0001 (17.78-36.89) DF=72
30-day readmissions (%)	6 (11.5)	8 (12.7)	
30-day readmissions for confirmed intra-abdominal collection	4	1	

IQ: Interquartile range, DF: Degrees of freedom, SD: Standard deviation

Furthermore, the results imply an increased treatment burden for the patient and increased healthcare costs associated with peritoneal lavage. The ever-increasing pressure on hospital resources makes this an important finding to consider.

Although not statistically analysed due to the low volumes involved, our results demonstrate an apparent trend for those treated with peritoneal lavage to be admitted as a result of a confirmed intra-abdominal collection. A larger data set would be required to further analyse this trend and determine if the differences observed within this data set are continued to a level which reaches statistical significance.

All patients included in our study were treated with three-port laparoscopic appendicectomy and commenced on 5-day course of triple antibiotics (cefuroxime, metronidazole and gentamicin), which was extended if clinically indicated. This standardisation could be argued to add strength to the arguments presented, by removing the confounding effect of variations in perioperative management sometimes seen in study protocols and reviews.

Furthermore, these findings could be used in combination with those studies that have found no clinical benefit in the performance of lavage to argue that its use should be avoided. We have demonstrated that performing intra-operative lavage significantly increases both the operative duration and length of hospital stay. This can be considered to contribute to the ever-increasing service pressures placed on health-care systems. When considered in conjunction with evidence showing that lavage provides no benefit to the patient, one could suggest that lavage should be avoided on this basis.

Unlike some other study protocols, the decision on whether lavage should be used was based on surgeon discretion at the time of surgery. This opens the possibility of confounding of results from this aspect, as it is possible that more severe cases, with more extensive peritoneal contamination, were subjected to lavage as a result. However, studies using a randomised protocol which therefore remove this potential bias have also found similar results associated with lavage.[6,7] In addition, the retrospective nature of this study is another limitation of the findings presented.

Our design does not allow for comparisons based on the volume of lavage used to be made. As suggested by some available literature this may be a factor which has an influence on patient outcomes.[3,8]

It is important to remain vigilant of the disparity seen in the results published on this topic. Variation in surgical technique is one factor which may explain this discord in outcomes seen between trials.

Although many studies have found differences in their outcome measures, often these differences do not reach a level of statistical significance. A large systematic review by Bi *et al*. found no difference in the incidence of IAA formation or wound infection.[2] Individual trials have found similar results, with the addition of findings of no increase in overall length of hospital stay.[7,9]

A separate review by Di Saverio *et al*. of adult and paediatric papers concluded that peritoneal lavage, as a method of removing peritoneal contamination, had no advantage compared with suction alone. The same study also stated that if lavage is to be used, employing repeated cycles of small volume lavage and suction is preferential as this avoids spreading contamination throughout the peritoneal cavity.[10] This is a theory which is contradicted by evidence from other trials. For example, a study of adult patients by Sun *et al*. and a similar study of paediatric patients by LaPlant *et al*. both argue for the use of large volumes of irrigation fluid.[3,8]

Studies assessing specific volumes of lavage have shown contrasting outcomes. LaPlant *et al*. retrospectively analysed the volume of lavage used in cases where a post-operative IAA occurred and compared it to the volume used in patients who did not develop an IAA, within a paediatric population. There was no difference in the volume of irrigation used between each group, suggesting that increasing the volume of lavage did not decrease the risk of developing IAA.[8]

In contrast, Sun *et al*. demonstrated that increasing the volume of lavage fluid used per case results in a reduced rate of IAA, leading to authors being able to conclude that lavage should be employed if such operative techniques are utilised. This protocol

mandated the use of at least 2 l of lavage fluid, with the average volume being used totalling 3 l. Although conducted on an adult population, this study suggests that when larger volumes are employed, lavage is successful at reducing the rate of IAA.[3]

Those who have published results specific to paediatric patients, demonstrating no benefit, or harm, associated with the use of peritoneal lavage have often employed smaller overall volumes of lavage[7] This is discord in lavage techniques and protocol may contribute to the ambiguity which surrounds this topic. Further work is needed to assess whether similar results are seen with standardisation of the lavage technique.

Less commonly, results have been published which favour the use of peritoneal lavage. Escolino *et al*. recently demonstrated improved outcomes with the use of intraperitoneal lavage, when compared with suction alone, within a paediatric population. This well-powered study included data from six international paediatric surgery centres. The authors highlight that their practice employed low-pressure lavage systems and the placement of intra-abdominal drains in the recovery period. This could be argued to confound the results presented. Alternatively, it could be argued that this study demonstrates best practice when it comes to performing peritoneal lavage, an argument which would need further high-powered studies to be carried out to potentially corroborate these findings.[11]

Recent studies have also looked at the use of novel lavage fluids, as opposed to normal saline, within the paediatric population. Two such studies have used povidone-iodine and 'strong acid electrolysed water' respectively, to assess the impact of such practices on patient outcomes.[11,12]

Statistical analysis by Anderson *et al*. demonstrated an 89% probability that using povidone-iodine reduced the risk of IAA formation when compared to employing a no lavage approach.[12]

Kubota *et al*. investigated the efficacy of 'strong acid electrolysed water' as an alternative lavage fluid, comparing the outcomes to patients who underwent lavage with saline. Although no difference in the rate of IAA formation was found, the rate of wound infection was reduced to a statistically significant level. No difference was found in other parameters, such as post-operative pyrexia, c-reactive protein levels and duration of hospital stay, demonstrating no harm associated with the use of strong acid electrolysed water as a lavage fluid in addition to the arguably beneficial finding of reduced rates of wound infections.[13] This is an exciting new avenue and has the potential to lead to improved patient outcomes if these findings can be replicated in further studies.

Conclusion

Our study has demonstrated that lavage led to a prolonged post-operative course, with associated increased morbidity. In combination with other published results, this study adds weight to the argument for the avoidance of peritoneal lavage in the treatment of paediatric perforated appendicitis. Further, well-powered randomised prospective work is required to determine whether the results seen here are maintained under these conditions. If so, this would allow for stronger recommendations to be made with the hope of a clear consensus on the issue being reached.

Additional randomised work analysing the impact of both the volume and type of lavage fluid employed is suggested. Preliminary studies in these areas have published exciting results and could lead to further clarification on the disparities found to date within the literature.

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Conflicts of interest

There are no conflicts of interest.

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