REVIEW ARTICLE

Laparoscopic appendectomy vs open appendectomy during pregnancy: a systematic review

Rountis A[1,2], Dimitroulis D[2,3], Nikiteas N[2,3]

[1]1st Department of Obstetrics and Gynecology, "Alexandra" General Hospital
[2]3rd Hellenic Minimally Invasive and Robotic Surgery (MIRS) Study Group, National and Kapodistrian University
[3]2nd Department of Propaedeutic Surgery, «Laiko» General Hospital
Athens, Greece

Abstract

Background: Acute appendicitis and cholecystitis during pregnancy are the most common non-obstetrical surgical emergencies and can create severe clinical issues. Surgical treatment tends to be the method physicians recommend due to its tolerability and safety. During pregnancy, surgical intervention should minimize fetal risk without compromising the mother's health, although a favorable outcome for pregnant women is heavily dependent on accurate, early diagnosis and prompt intervention. Furthermore, the physicians should remain informed on the differences in current techniques to optimize the outcome of the operation.

Methods: This article performs a systematic review of the literature to examine whether laparoscopic treatment of acute appendicitis in pregnancy is a better option when compared to open surgery. We searched all major medical databases, identified the most relevant published studies on the subject, and performed a statistical analysis to answer that question.

Results: We identified 15 studies for inclusion, and their data were extracted. The resulting pool referred to 2,837 pregnant patients. Of those included patients, 1,103 underwent laparoscopic surgery and 1,656 had open surgery. All surgeries occurred in the second trimester. For laparoscopic surgery, the fetal demises rate was 2.44 % (27 deaths), and the preterm deliveries rate was 9.79 % (108 deliveries) as opposed to open surgery with a fetal demise rate of 2.64 % (48 deaths), and preterm deliveries rate at 10.7 % (178 deliveries).

Conclusions: Our meta-analysis and data suggest that laparoscopic appendectomy is a safer option for treatment. There is a reduced risk of fetal demise and preterm delivery for pregnant women. HIPPOKRATIA 2022, 26 (1):1-6.

Keywords: Open appendectomy, laparoscopic appendectomy, acute appendicitis, laparoscopic appendectomy vs open appendectomy, pregnancy appendectomy, pregnancy appendicitis surgery

Corresponding Author: Argirios Rountis, MD, "Alexandra" General Hospital, 4-2 Lourou str., 11528 Athens, Greece, tel: +306942518947, e-mail: rountis.argiris@gmail.com

Introduction

One in 500 women approximately will be subjected to abdominal non-obstetric surgery during pregnancy[1-4]. Acute appendicitis and cholecystitis are the most common non-obstetrical surgical emergencies that can create a significant clinical problem in pregnancy[1,3-5], with acute appendicitis having an incidence rate of around 0.12 % in pregnant women[5-9]. It is the most common reason for non-obstetric hospitalization for pregnant women during their pregnancy[10]. It is worth mentioning here that perforation of the appendix, a complication of acute appendicitis, is relatively higher in pregnancy, with reported rates of up to 43 % when compared to the general population with a reported rate of 19 %[11,12].

Non-obstetric abdominal surgery exposes to risks both maternal health and fetal viability. While a patient can undergo a non-surgical treatment, a surgical procedure is more likely to be recommended due to the tolerability and safety it provides[10]. During pregnancy, surgical interventions should minimize fetal risk without compromising the mother's health and safety. A favorable outcome for both the pregnant and the fetus depends on prompt intervention following an accurate, timely diagnosis. Thus, surgeons must be familiar with the most recent data concerning the differences in used techniques to optimize outcomes for pregnant women.

The purpose of this study was to perform a systematic review of the literature from 2010 until the present. The review summarizes the published data regarding the laparoscopic treatment of acute appendicitis in pregnancy compared to open surgery. We followed the international Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to perform this systematic review. We searched all major medical databases and gathered data from relevant published studies to perform an in-depth statistical analysis and attempt to answer the following questions: i) Is laparoscopy the golden standard when compared to open surgery? ii)

Does it have a more favorable outcome for pregnancy? iii) Does it cause more preterm deliveries and fetal demises than open surgery, or is a personalized approach regarding the pregnant patient and the center volume and experience the optimum approach?

Materials and Methods

Search strategy and study selection

We conducted an extensive search on three of the biggest electronic medical databases: PubMed, Embase, and the Cochrane central register of controlled trials to find relevant studies from 2010 onwards, using the following search terms: "pregnant women", "pregnancy", "appendicitis", "appendectomy", "preterm delivery", "pregnancy outcome", "fetal demise" and "fetal death". The query clause we utilized was (pregnancy OR (pregnant women)) AND (appendectomy OR appendicitis) AND (outcome OR (pregnancy outcome) OR (preterm delivery) OR (fetal demise) OR (fetal death)).

The result set was assessed following the PRISMA guidelines. Firstly, we read the titles and abstracts of the result set. All irrelevant studies were excluded. The remaining studies were retrieved and fully read to ensure adherence to our set exclusion and inclusion criteria. For any discrepancies, we discussed them appropriately between us and resolved them. The snowball procedure was also followed to identify other relevant articles that weren't returned by the initial query. The result set was narrowed down to the studies of interest, as can be seen in the process PRISMA flow diagram demonstrated in Figure 1.

Statistical analysis

Upon finalizing the result set of included studies followed by data extraction, we conducted a statistical meta-analysis using the Review Manager 5.4.1 software tool (The Nordic Cochrane Centre, The Cochrane Collaboration, September 2020). The data type used in the comparison and outcome wizard of Review Manager was dichotomous, and the statistical method selected was Mantel-Haenszel. We selected the Fixed Effect Analysis model. The effect measure was set to odds ratio (OR), and the confidence intervals (CI) were set to 95 %. Finally, the scale used for the graph(s) and forest plot(s) was set to 100.00. The heterogeneity in the methodological characteristics of the included data was significant, and therefore, the publication bias could not be tested appropriately. The authors expected that despite the heterogeneity in the data, the integrity of the results would not be affected. The statistical analysis significance marker (p-value) was set to $p < 0.05$.

Inclusion Criteria

For all relevant studies, only the ones from 2010 onwards were to be considered, so this review ensures that current modern practices, methodologies, and findings will be reported. The studies included should have been written as comparative studies investigating the outcomes of appendectomy, laparoscopic or openly performed in pregnant patients, and should report preterm delivery and fetal demise findings. The studies should have been written and published in the English language, irrelevant of their country of origin.

Exclusion Criteria

If any studies were review articles, case series, animal studies, letters, or were written in any other language except English, we considered them irrelevant. If not all

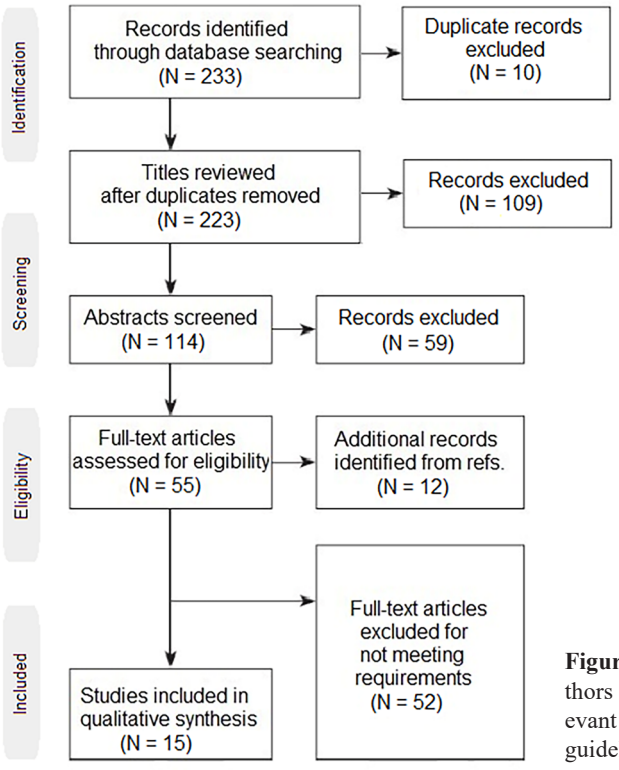

Figure 1: The process flow authors followed to identify all relevant studies according to PRISMA guidelines.

inclusion criteria were met, the study would be classified as non-interesting and would not be included. If the studies had overlapping populations and the findings were similar, only the most recent study was used.

Study outcomes and data extraction

The primary focus of this study was the pregnancy outcome of pregnant women after laparoscopic or open surgery, any preterm deliveries that occurred due to either surgery type, and the fetal demise the operation could have caused. A customized extraction form was used to gather all data of interest. The data we extracted consisted of general study data (authors, year of publication, journal), characteristics of the study (study design, sample size, outcome), baseline characteristics of the populations of the study (surgery type), and the pregnancy outcomes we focused on (preterm delivery, fetal demise).

Results

Study Characteristics

We identified 233 studies suitable for this review, as seen in the selection flow diagram in Figure 1. Two authors screened titles and abstracts, and 67 studies were chosen as candidates for inclusion. After full-text evaluation and assessment, 52 studies were excluded from our result set after applying the inclusion and exclusion criteria we predetermined. Since various reviews have been conducted on the subject before, only recent studies were included, meaning only studies from 2010 to 2022 were considered. The study should have been written in English and include patients who underwent laparoscopy or open surgery for an appendectomy. Moreover, the outcome of the operation was required to be at least mentioned in the study.

The 15 comparative cohort studies identified for inclusion referred to 2,837 female pregnant women, out of whom 1,103 underwent laparoscopic surgery while 1,656 had open surgery. All extracted study characteristics can be seen analytically in Table 1. The studies included were conducted all around the world: USA (n =3)[11,13,26], Israel (n =2)[17,21], Korea (n =2)[16,23], Turkey (n =2)[19,24], The Netherlands (n =1)[14], Saudi Arabia (n =1)[15], Taiwan (n =1)[18], Denmark (n =1)[20], Australia (n =1)[22], and China (n =1)[25]. In all studies, the surgery occurred during the second trimester. Preterm deliveries and fetal losses were reported in every study[11,13-26]. The rate of fetal demise after laparoscopic surgery was 2.44 % (27 deaths). The rate of fetal demise after open surgery was 2.89 % (48 deaths). A total of 75 fetal deaths (2.64 %) were reported in all studies independent of surgery type. One hundred eight preterm deliveries recorded in all studies after laparoscopic surgery translated to a rate of 9.79 %. Similarly, 178 preterm deliveries were recorded after open surgery, calculating a rate of 10.7 %. A total of 286 preterm deliveries (10.08 %) were reported in all studies, independent of whether it was laparoscopic or open surgery.

Labor outcomes

The selected studies diverge in findings. Data from some studies[13,16-20,24,25] suggest that open surgery procedures result in more preterm deliveries when compared to laparoscopic surgery. On the contrary, other studies[14,21,22,26] indicate that laparoscopic surgery results in more preterm deliveries when compared to open surgery. Statistical analysis showed that the risk of preterm delivery was higher for women who underwent open surgery when compared to those who underwent laparoscopic surgery. The finding was statistically significant, with the pooled OR being 0.59 (95 % CIs: 0.47, 0.76) in the fixed effects model (p =0.0001). The forest plot of the analysis can be seen in Figure 2.

Similarly, there is some controversy in the data regarding fetal demise. Some studies indicate no fetal losses after laparoscopic or open surgery[16,17,21], while others suggest more fetal demises in laparoscopic surgeries[11,14,15,18,23,26], and others support more fetal demises in the open surgeries[13,19,24,25]. Statistical analysis performed on the data gathered regarding fetal loss shows that the risk of fetal demise was higher for women who underwent open surgery than those who underwent laparoscopic surgery. The finding was statistically significant, with the pooled OR being 0.59 (95 % CIs: 0.38, 0.93) in the fixed effects model (p =0.02), as can be seen in Figure 3.

Discussion

The occurrence of appendicitis has been traditionally considered similar for the pregnant and non-pregnant populations. However, some studies suggest a lower incidence in pregnant women, especially in the 2nd and 3rd trimesters, with the 3rd trimester having the lowest incidence of all[27,28]. This systematic review found no statistically significant differences in the treatment of appendicitis between laparoscopic and open surgery regarding complication rate, clinical characteristics, gestational age at delivery, hospital stay, or birth weight[11,13-26]. The rates in the pregnancy population for both preterm deliveries and fetal loss were low in both groups (laparoscopy vs open surgery). For laparoscopic surgery, the preterm delivery rate was 9.79 % and 10.7 % for open surgery. In terms of fetal demise, it occurred at a rate of 2.44 % during laparoscopic surgery, while at a rate of 2.89 % during open surgery[11,13-26]. From these findings, we can recommend both methods as safe and preferable for treatment since the difference in rates between the two is not significant. Some of the studies we included in this review indicate that laparoscopic surgery is associated with a lower risk of wound infection, reduced pain, faster recovery time, improved diagnostic accuracy, and, therefore, a shorter length of stay, and agree with multiple other studies' findings[23,27-31]. This finding agrees with the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) guidelines[30].

Our data suggest that treatment of appendicitis via laparoscopic surgery is associated with a lower risk of preterm delivery and fetal loss. This finding heavily relies on the two biggest studies in our sample size, performed by Cheng et al and Tumati et al, respectively[19,26], and therefore cannot be taken for granted due to the small sample size (n =2,837 pregnancies). Interestingly, some studies suggest insignificant differences between surgery types concerning preterm delivery[17,23,29,32,33]. Others suggest a decreased risk of pre-

Table 1: Fifteen comparative cohort studies referring to 2,837 female pregnant women were included in the current systematic review that examined whether laparoscopic treatment of acute appendicitis in pregnancy is a better option when compared to open surgery.

Study	Year	Country	Study Design	Population	LS	OS	Other	FDL	FDO	PDL	PDO	Outcomes
Cai et al[11]	2020	China	Retrospective	48	12	36	0	3	0	1	1	Preterm delivery, fetal loss, operative time
Corneille et al[13]	2010	USA	Retrospective	49	9	40	0	0	3	1	5	Preterm delivery, fetal loss
Sadot et al[14]	2010	USA	Retrospective	57	41	16	0	1	0	12	3	Preterm delivery, fetal loss, birth weight, operative time, Apgar score
De Bakker et al[15]	2011	The Netherlands	Retrospective	15	12	3	0	1	0	1	1	Preterm delivery, fetal loss, operative time
Khan et al[16]	2012	Saudi Arabia	Retrospective	118	52	66	0	0	0	4	6	Preterm delivery, fetal loss, birth weight
Chung et al[17]	2013	Korea	Retrospective	61	22	39	0	0	0	2	4	Preterm delivery, fetal loss, birth weight, operative time, Apgar score
Peled et al[18]	2014	Israel	Retrospective	85	26	59	0	1	0	5	14	Preterm delivery, fetal loss, birth weight, Apgar score
Cheng et al[19]	2015	Taiwan	Retrospective	859	128	653	78	7	37	7	74	Preterm delivery, fetal loss
Karaman et al[20]	2016	Turkey	Retrospective	48	12	36	0	1	1	3	9	Preterm delivery, fetal loss, birth weight, operative time, Apgar score
Laustsen et al[21]	2016	Denmark	Retrospective	44	25	19	0	0	0	3	2	Preterm delivery, fetal loss, birth weight, operative time
Segev et al[22]	2016	Israel	Retrospective	92	50	42	0	2	2	5	3	Preterm delivery, fetal loss, birth weight, operative time
Winter et al23	2016	Australia	Retrospective	218	125	93	0	7	0	8	8	Preterm delivery, fetal loss, birth weight, operative time
Yoo et al[24]	2016	Korea	Retrospective	80	24	56	0	3	4	2	4	Preterm delivery, fetal loss, birth weight, operative time
Gök et al[25]	2018	Turkey	Retrospective	57	18	39	0	0	1	0	2	Preterm delivery, fetal loss, birth weight, operative time
Tumati et al[26]	2021	USA	Retrospective	1006	547	459	0	1	0	54	42	Preterm delivery, fetal loss

LS: Laparoscopic Surgery, OS: Open Surgery, FDL: Fetal Death Laparoscopic Surgery, FDO: Fetal Death Open Surgery, PDL: Preterm Delivery Laparoscopic Surgery, PDO: Preterm Delivery Open Surgery.

term delivery when laparoscopy is performed[34-36]. Others state that laparoscopy increases the risk of fetal demise[37-41] and in some cases preterm delivery[37,42]. Previous systematic reviews on the matter, namely the one performed by Lee et al in 2019, report that although their initial finding suggested that fetal demise and preterm delivery were higher in patients that underwent laparoscopic surgery, excluding one study and performing an additional meta-analysis on the data showed the opposite results[29]. Some studies do not report any fetal demises for none of the two compared surgical approaches. Based on all our findings and the literature[11,13-30], it is worth mentioning here that maternal outcomes are good in both laparoscopic and open surgery. We realize, though, that controversy exists regarding the association of fetal loss, preterm delivery, and the surgery method[36]. The unavailability of resources and the small sample size were also limitations when conducting this review.

We should also consider that we evaluate surgery protocols in this study. As mentioned earlier, shorter lengths of stay and postoperative complications are the factors to be considered for the safety of a surgical approach. Previous studies[11,13-26] and meta-analyses[29] suggest that the length of stay was quite shorter for pregnant women who underwent laparoscopic surgery, and wound infection was significantly lower for the laparoscopic appendectomy patients[11,24,25]. For many physicians, laparoscopic surgery is the preferred

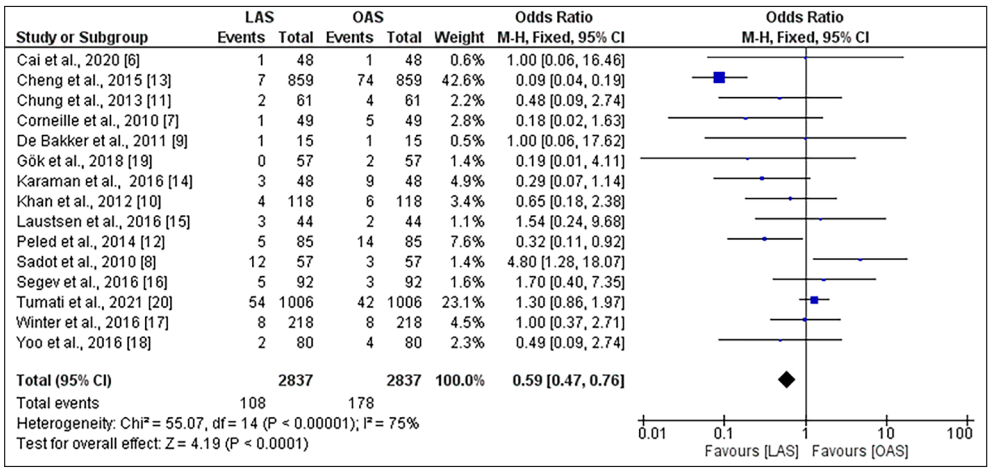

Figure 2: Forest plot after analysis performed on extracted data in Review Manager comparing the Preterm Delivery for Laparoscopic Surgery VS Open Surgery.

LAS: Laparoscopic Surgery, OAS: Open Surgery, CI: Confidence Intervals, M-H: Mantel-Haenszel.

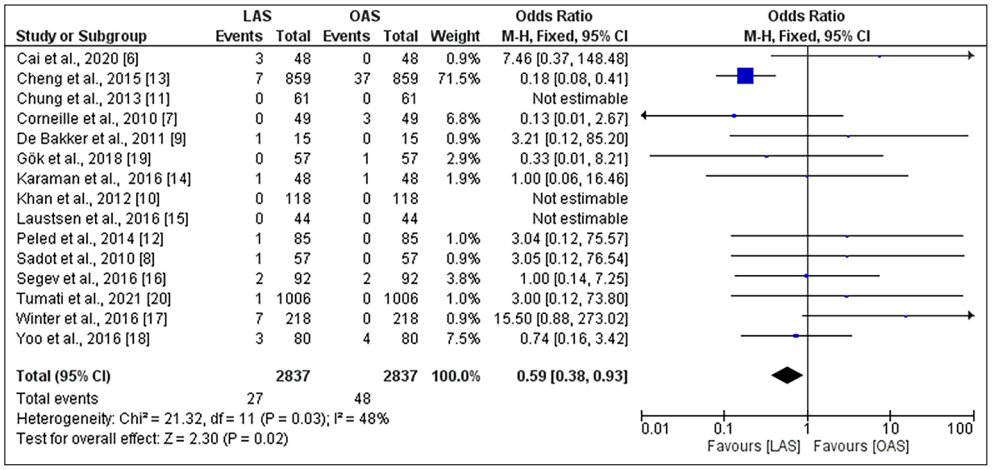

Figure 3: Forest plot after analysis performed on extracted data in Review Manager comparing the Fetal Loss for Laparoscopic Surgery VS Open Surgery.

LAS: Laparoscopic Surgery, OAS: Open Surgery, CI: Confidence Intervals, M-H: Mantel-Haenszel.

option due to its effectiveness in visualization, the reduction in surgical complications, and the ability to access the appendix directly. Finally, no publication bias was evident in our analysis, but we had high heterogeneity in the data. Our data suggested that preterm delivery and fetal loss are higher in pregnant women who underwent open surgery than patients who were laparoscopically treated. However, due to the small sample size the results between both methods are inadmissible. More research is needed to determine the causality and association.

Conclusion

Laparoscopic surgery is a well-established treatment modality for pregnant patients, showing promising results. More data and time are required to evaluate pregnancy outcomes in patients that underwent laparoscopic appendectomy compared to more traditional ways of treatment like open surgery. Our systematic review suggests that laparoscopic appendectomy and open surgery are very safe options for treatment. There is a reduced risk of fetal demise and preterm delivery for patients treated via either therapeutic protocol. The sensitivity analysis of this review does not suggest that there is a significant difference in pregnancy outcomes between laparoscopy and open surgery for treating appendicitis when looking at the percentage of the total studies' population that had a preterm delivery or a fetal loss. Taking our and other studies' findings, we can recommend laparoscopic appendectomy due to its lesser risk of surgical complications, smaller length of stay at a hospital, and lesser wound infection risk. We also suggest that only experienced laparoscopists should carry out laparoscopic appendectomy, and the surgery outcomes should always be monitored. There is a necessity for larger-scale trial studies to establish the current findings of our meta-analysis and define a new guideline in the treatment of pregnant women.

Conflict of interest

The authors declare there is no conflict of interest.

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