Review

Laparoscopic versus open appendicectomy in pregnancy: A systematic review

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\textbf{Abstract}

\textbf{Background:} Acute appendicitis is the most common non-obstetric indication for surgical intervention in pregnant women. The benefits of a laparoscopic over an open approach to appendicectomy are well established in the non-pregnant population. Data on the optimal surgical approach to acute appendicitis in pregnant women are conflicting.

\textbf{Methods:} A systematic review of reported cases of laparoscopic appendicectomy (LA) in pregnancy over the period 1990 to 2007. Twenty-eight articles documenting 637 cases of LA in pregnancy were included. Data on pregnancy outcome, patient characteristics, operative technique and peri-operative complications were analysed.

\textbf{Results:} The rate of fetal loss following LA in pregnancy approaches 6% and is significantly higher than that following open appendicectomy. Fetal loss was highest in cases of complicated appendicitis. Incidence of preterm delivery appears lower in the LA group although this complication is likely to be under-reported in a significant proportion of cases. Trimester at the time of LA does not appear to influence complication rates. The negative appendicectomy rate in this series was 27%, which is higher than in the non-pregnant population. Complication rates following LA with negative appendicitis are as high as with simple appendicitis. Rates of entry-related complications were 2.8% in the Veress needle group and 0% in the Hasson open entry group. The overall rate of conversion to laparotomy was 1%. No difference was found in the preterm delivery rate between women who received prophylactic tocolysis and those who were not tocolysed.

\textbf{Conclusions:} Laparoscopic appendicectomy in pregnancy is associated with a low rate of intra-operative complications in all trimesters. However, LA in pregnancy is associated with a significantly higher rate of fetal loss compared to open appendicectomy. Rates of preterm delivery appear similar or slightly better following a laparoscopic approach. Open appendicectomy would appear to be the safer option for pregnant women for whom surgical intervention is indicated.

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1. Introduction

Acute appendicitis represents the most common non-obstetric indication for surgical intervention in pregnant women, with a reported incidence of 1 in 1440 pregnancies. In the non-pregnant population, laparoscopic appendicectomy (LA) has previously been associated with fewer wound infections and less post-operative pain, facilitating earlier discharge from hospital and return to daily activities. Surgical intervention in pregnancy, both laparotomy and laparoscopy, has been shown to increase adverse pregnancy outcomes. Furthermore, it has been noted that pregnancy outcomes following surgery for appendicitis are worse than with surgery for other indications. Previous studies have found that, in general, laparoscopy does not endanger a pregnancy any more than laparotomy does. However, a recent review of appendicectomy in pregnancy found that fetal loss rates were significantly higher in women undergoing laparoscopic procedures compared to open appendicectomy. As such, data on the optimal surgical approach to acute appendicitis in pregnant women are conflicting.

Although laparoscopy for suspected ectopic pregnancy has been used for many years at early gestations, there remain concerns over the possible effects of laparoscopic intervention on the developing fetus. Most of the evidence regarding LA in pregnancy is limited to individual case reports and small case series, often with no comparative open appendicectomy (OA) group on which to draw meaningful conclusions. Here we present a systematic review of 637 previously reported cases of laparoscopic appendicectomy in pregnancy. The clinical features of acute appendicitis in pregnancy, and the potential diagnostic difficulties in the pregnant patient, have been extensively studied and are not addressed.

2. Methods

This review is based on a search of PubMed, restricted to English-language articles published between 1974 and 2007. The following terms were used in the literature search: “appendicectomy (appendectomy) in pregnancy”, “laparoscopic appendicectomy (appendectomy) and pregnancy” and “appendicitis in pregnancy”. Individual case reports, retrospective and prospective cohort studies and review articles were included, with further references obtained from articles identified in the initial search. All papers on appendicectomy in pregnancy were considered.

We identified 68 articles documenting appendicectomy in pregnancy. Articles were reviewed and those that did not include laparoscopic appendicectomy were excluded. From the remaining articles, only those in which surgical and obstetric outcomes were clearly linked to the operative approach were included. Twenty-eight articles matched our inclusion criteria and are included in the review (Table 1). Primary outcomes were rates of fetal loss and preterm delivery. In addition, data were collected where available on patient characteristics, operative time, entry technique, use of tocolysis, operative complications and hospital stay. Comparative rates of complications following open appendicectomy in pregnancy were derived from the two largest reports to date. In a review of non-obstetric surgical intervention in pregnancy, Cohen-Kerem et al reviewed 22 reports of OA in pregnancy from 1974 to 2001, totalling 1514 patients. These were added to a further 2679 pregnant patients undergoing OA, which were reported recently by McGory et al.

Statistical analysis was performed using Statsdirect statistical package 2.5.7 (Statsdirect Ltd., UK). Categorical data were examined using Fisher’s exact test or Chi-square test as appropriate. Two-tailed p values were used throughout and the 5% level was considered significant.

3. Results

We identified 637 published cases of laparoscopic appendicectomy in pregnant women (Table 1). This includes 454 cases recently published by McGory et al, who examined appendicectomy in 3133 pregnant women over an 8-year period in California. The overall fetal loss rate in this group was 5.6% (35/624), which is significantly higher than that reported following OA (3.1%, 128/4193; p = 0.001). It should be noted that Amos et al reported 4 fetal losses among 7 laparoscopic procedures in pregnancy, including 3 laparoscopic appendicectomies. However, data are insufficient to determine which, if any, of these losses followed LA. The overall rate of preterm delivery following LA in pregnancy was 2.1% (13/624) which is significantly lower than that reported following OA (8.1%, 346/4193; p < 0.0001). No neonatal deaths were recorded among the cases of preterm delivery following LA although other neonatal outcomes are not reported. Data are insufficient to examine the effect of appendicectomy on subsequent birth weight.

An increased tendency towards obstetric complications following perforated appendicitis in pregnancy has previously been demonstrated. Pathological findings were available in 565 cases (84%). Of these, acute appendicitis was confirmed histologically in 415 cases. There were 324 cases (57%) of simple appendicitis and 91 (16%) cases of complicated appendicitis. The negative laparoscopic appendicectomy rate in this series was 27% (150/565). This is significantly higher than a recently reported negative appendicectomy rate of 18% in almost 92,000 non-pregnant women (p < 0.0001). Rates of fetal loss were 3.4% (11/324), 12.1% (11/91) and 7.3% (11/150) in simple, complicated and negative appendicitis respectively. Complicated appendicitis was defined as acute appendicitis with evidence of perforation, appendiceal abscess or generalised peritonitis. Fetal loss was statistically more likely following LA for complicated appendicitis compared to LA for simple appendicitis in pregnancy (p = 0.0027). There was no difference in rate of fetal loss in the simple appendicitis group compared to those who had a negative laparoscopic appendicectomy (p = 0.0641). Histological data were unavailable in the remaining 2 cases of fetal loss following LA in pregnancy. There were 13 reported cases of preterm delivery following LA in pregnancy. However, corresponding histopathological data were only available in 5 of these cases. As such, insufficient data exist to stratify the risk of preterm delivery according to pathological findings.
3.1 Obstetric complications by gestational age

The avoidance of laparoscopic procedures in the third trimester of pregnancy because of potential damage to the enlarged uterus resulting in preterm delivery or fetal loss has been suggested. Gestational age at the time of surgery was recorded in 155 cases. Of these, 52, 77 and 26 women underwent LA in the 1st, 2nd and 3rd trimesters of pregnancy respectively (Table 2). The mean (standard deviation) gestational age at the time of LA was 17.9 (5.7) weeks. No significant differences were found in the rates of either fetal loss or preterm delivery between the first and third trimesters. No fetal losses were reported among 26 procedures carried out in the 3rd trimester.

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3.2 Operative characteristics

The mode of laparoscopic entry was documented in 116 cases. An open (Hasson) technique was used to create the pneumoperitoneum in 79 (68%) and a blind entry using the Veress needle in 37 (32%) cases. Information on the use of intra-operative antibiotic prophylaxis was sparse, with antibiotics administered routinely in 29/36 cases. In total, 25 women received peri-operative tocolysis at the time of LA, either prophylactically (n = 15) or following post-operative contractions (n = 10). Ninety-one women did not receive tocolysis and no data were available in the remaining 521 cases. We found no statistical difference in the rate of preterm delivery among the prophylactic tocolysis group (0/15) and the non-tocolysis group (3/79; p = 0.59).

Operative times were reported in 110 cases (mean 51 ± 13 min). Complete data on operative times by gestational age were available for 36 women. The mean operative times were 45, 51 and 59 min for procedures in the 1st (n = 10), 2nd (n = 20) and 3rd (n = 6) trimesters, respectively. Length of post-operative stay was documented in only 28 patients. The mean stay was 5 (±3.8) days; however, we note that one of the earliest reports of LA in pregnancy by Schreiber et al10 documents a number of post-operative stays substantially longer than the mean. The median (inter-quartile range) post-operative stay was 3.0 (2–9) days. In addition, total hospital stay was reported in a further 49 cases [median 2.6 (2.5–3.0) days].
3.3 Intra-operative complications

The rate of entry-related complications was 0.5% (1/183) in this series. A pneumoamniion following a blind laparoscopic entry using the Veress needle in a woman at 21 weeks was described by Friedman et al.9. Spontaneous rupture of membranes and preterm delivery of a stillborn infant followed. No entry-related complications were reported among the 79 cases which used an open technique. Previous studies have suggested a tendency towards preterm delivery with the Hasson entry technique.10 Insufficient data exist to analyse the effect of entry technique at LA on preterm delivery rates. The overall rate of conversion to laparotomy was 1% (3/183). Two conversions were reported by the same authors and were indicated for poor surgical exposure in third trimester appendicectomies.11 The indication for the third conversion is not reported.12 There was only one report of wound infection following LA in pregnancy (0.5%, 1/183) and this was a minor infection managed conservatively with dressing changes.13 No cases of maternal mortality following LA in pregnancy were reported.

4 Discussion

The reported incidence of acute appendicitis in pregnancy varies widely; however, the largest study to date reports an incidence of 1 in 1440 pregnancies.1 Traditionally, the incidence of appendicitis in pregnancy has been considered identical to the non-pregnant population, although a recent case-control study suggested a lower incidence in pregnant women, with the 3rd trimester being particularly protective.14 Cohen-Kerem et al15 reviewed 54 papers documenting 12,452 cases of non-obstetric surgical intervention in pregnancy. Twenty-four of these papers reported cases of appendicectomy in pregnancy. We excluded 2 papers16,17 which included cases of LA, which left data on 1514 women undergoing OA in pregnancy. These were added to the 2679 cases of OA in pregnancy reported by McGory et al17 (n = 4193) to serve as a comparator group to the current review (Table 3).

The overall rate of interrupted pregnancies following LA in pregnancy is 7.7%, which is significantly less than the 11.3% following OA. However, the most serious adverse pregnancy outcome — fetal loss — was significantly higher in those women who underwent appendicectomy via the laparoscopic route, despite a higher rate of non-appendicitis in this group. This is of concern, given a number of previous papers which have drawn reassuring conclusions regarding the relative safety of laparoscopy in pregnant women.

We found that incidence of preterm delivery (<37 completed weeks) was significantly higher in the OA group (8%) compared to the LA group (2%). Although this would appear to favour a laparoscopic approach based on this complication alone, a number of factors limit the impact of this result. Firstly, precise data on gestational age at delivery are unavailable, so we do not know how the surgical approaches compare with regard to the more clinically important outcome of early preterm delivery (<34 weeks). The second and associated limitation is the striking lack of data on neonatal outcomes in both groups. Finally, a significant proportion of both LA cases and the OA comparator cases, are taken from the recent paper by McGory et al17 which was based on procedure-specific coding and included only preterm deliveries which occurred during the same admission for appendicectomy. As such, the incidence of preterm delivery is almost certainly underestimated in this paper. If we examine rates of preterm delivery excluding the McGory data, we find no difference in rates of preterm delivery between the LA cohort (7.4%; 12/162) and the OA group (8.6%; 130/1514; p = 0.6085).

Guidelines for laparoscopic procedures during pregnancy have previously been published the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES)18 and modifications proposed by Moreno et al.19 A pneumoperitoneum pressure ≤12 mmHg is recommended as previous animal studies have demonstrated fetal hypercapnia and acidosis secondary to CO2 pneumoperitoneum in pregnant ewes.20,21 However, substantial adverse effects to the fetus with a pneumoperitoneum limited to 10-12 mmHg have not been demonstrated.12,19 An open Hasson technique is recommended for laparoscopic entry in pregnancy. Complications have been reported following all surgical approaches to appendicectomy in pregnancy.4,10,22 In the cases reviewed here, the rate of entry-related complications was 0% (0/79) in the Hasson open entry group and 2.8% (1/36) in the Veress needle group. Although this difference is not statistically significant (p = 0.32), we would endorse the SAGES recommendation that an open laparoscopic approach be used in pregnant women.18 Port site locations should be adapted to the gestational age, with a midline entry point between the umbilicus and xiphisternum favoured by most authors, to avoid the enlarging uterus, particularly in the second half of pregnancy. In addition, the routine use of pneumatic compression devices and the avoidance of routine prophylactic tocolysis are recommended. Maternal end tidal CO2 monitoring is suggested, given the concerns regarding fetal acidosis from CO2 absorption. Finally, peri-operative obstetric consultation and fetal monitoring is suggested.

LA in pregnancy is associated with a mean operating time of 51 (±13) minutes (median 46 min). This is quicker than the recently reported median operating time for LA in the non-pregnant population (median 60 min)3 and may reflect the fact that laparoscopic procedures in pregnancy are usually performed by experienced surgeons. This is supported by the low (1%) rate of conversion to laparotomy, which is better than most rates published on non-pregnant patients. Examining the role of prophylactic tocolysis following LA in pregnancy, we found no significant difference in the rate of preterm delivery among the women receiving prophylactic tocolysis (0%) and those who received no tocolysis (3.8%,

| Table 3 – Outcomes following laparoscopic (LA) versus open appendicectomy (OA) in pregnancy |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Outcome         | LA group (n = 624) | OA group (n = 4193) | p Value |
| Fetal loss      | 5.6% [35/624]    | 3.1% [128/4193]   | < 0.001 |
| Preterm delivery| 2.1% [13/624]    | 8.1% [346/4193]   | < 0.0001 |
| Total interrupted| 7.7% [48/624]    | 11.3% [474/4193]  | < 0.0006 |
p = 0.59). As such, the routine use of prophylactic tocolysis at the time of LA in pregnancy cannot be recommended. The rate of wound infection among the cases of LA reviewed here was 0.5% (1/183) which is significantly lower than the rate among 94 open appendicectomies reported by Ueberrueck et al\(^{23}\) (6.4%, 6/94; \(p = 0.69\)).

It has been suggested that the physiological and anatomical changes of pregnancy make the diagnosis of acute appendicitis more difficult in pregnant patients.\(^{24,25}\) In a recent review of almost 92,000 non-pregnant women undergoing appendicectomy, the incidence of negative appendicitis was 18%.\(^7\) The negative laparoscopic appendicectomy rate in the present review is 27% in pregnant women, which is significantly higher. The difficulty in making a clinical diagnosis, combined with the previously quoted high incidences of fetal and maternal mortality for appendiceal perforation, have meant that traditionally, a low threshold for surgical intervention with a resultant higher negative appendicectomy rate has been accepted in pregnancy-associated appendicitis. It is notable that in the present review, fetal loss rates in the group with no appendicitis were as high as those with simple appendicitis. However, appendicitis complicated by perforation or abscess does increase the risk to the fetus. As such, we would agree with McCory et al\(^7\) who concluded that negative appendicectomy is not an entirely benign intervention in a pregnant woman, and the risks of misdiagnosis need to be carefully balanced against the risks of perforation from a delay in diagnosis.

5. Conclusions

Acute appendicitis is the most common non-obstetric indication for surgical intervention in pregnancy. Although the laparoscopic approach to appendicectomy in pregnancy is associated with a low rate of intra-operative complications in all trimesters, the rate of fetal loss following LA is almost 6% which is significantly higher than that following open appendicectomy. Rates of preterm delivery would appear to be equal or slightly better in the LA group. It would appear, therefore, that pregnant women requiring appendicectomy should undergo an open procedure in the interests of fetal wellbeing.

It is regrettable that much of the available data on LA in pregnancy derives from case reports and retrospective case series. However, given the surgical expertise needed to confidently perform laparoscopic procedures in pregnant women, a large randomized trial to address the optimal surgical approach to appendicitis in pregnancy seems unlikely.

Conflicts of interest
None.

REFERENCES