

Laparoscopic Appendicectomy in all Trimesters of Pregnancy

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ABSTRACT

Background: The laparoscopic approach for appendicectomy in pregnancy was not considered the preferred procedure until recently. The aim of this study was to examine our experience with laparoscopic appendicectomy in pregnancy and review the scientific evidence available in the medical literature.

Method: The clinical data of all patients who underwent laparoscopic appendicectomy during pregnancy at our hospital between 1999 and 2007 were collected and retrospectively analyzed. A Medline literature search restricted to English language articles on laparoscopic appendicectomy in pregnancy was carried out.

Result: Twenty patients underwent laparoscopic appendicectomy during pregnancy. Of these, 8 were in the first trimester, 9 in the second trimester, and 3 in the third trimester. Fifteen patients had histologically confirmed appendicitis. The mean operating time was 45 minutes, and the average postoperative stay in the hospital was 1.5 days. All patients except one had a full-term normal delivery. Literature search: An additional 637 patients from the English literature were reviewed and summarized.

Conclusion: Our results demonstrate that laparoscopic appendicectomy can be safely performed during all trimesters of pregnancy. The literature search suggests that although laparoscopic appendicectomy in pregnancy is associated with a low rate of intraoperative complications in all trimesters it may be associated with a significantly higher rate of fetal loss compared with open appendicectomy.

Key Words: Laparoscopic appendectomy, Pregnancy, Abortion.

INTRODUCTION

Appendicectomy is the most common nonobstetric operation during pregnancy.^{1,2} Pregnancy was a relative contraindication to laparoscopy until recently because of the belief that the procedure would decrease uterine and fetal blood flow and result in abortion or possibly influence fetal development. Several reports of successful laparoscopic procedures in pregnancy have indicated the safety of laparoscopy in pregnancy.³⁻³⁰ However, a recent review of laparoscopic appendicectomy in pregnancy reported a significantly higher fetal loss rate compared with open appendicectomy and has raised some concerns.³¹ Our experience is presented here, and the available literature is reviewed, regarding the present status of laparoscopic appendicectomy in pregnancy.

METHODS

The data for all patients undergoing laparoscopic appendicectomy during pregnancy in our hospital from January 1999 to January 2007 were analyzed. The data studied included presentation, estimated weeks of gestation at presentation, procedures, intraoperative findings, complications, and the outcome of laparoscopic appendicectomy. The birth records were also reviewed for outcome, including gestational age at delivery, birth weight, and Apgar score.

Operative Technique

The procedure was carried out with the patient under general anesthesia with end tidal carbon dioxide monitoring that was maintained within the physiological range (30 mm Hg to 40 mm Hg). A Foley catheter was inserted in all patients and removed at the end of the surgery. Patients were tilted to the left to displace the uterus from the IVC. In the initial 3 cases, pneumoperitoneum was carried out using a Veress needle. In all the later cases, pneumoperitoneum was carried out using an open (Hasson) technique. The pneumoperitoneum pressure was maintained between 10mm Hg to 12mm Hg. Fetal heart rate was recorded immediately before and after surgery.

The procedure was always performed using 3 ports, and their placement was modified in accordance with gesta-

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tional age. The first port (10 mm) was placed 2 cm cephalad to the gravid uterus in the upper midline between the umbilicus and xiphoid process. The second port (5 mm) was placed laterally in the right lower quadrant, and the third port (10 mm) was placed in the right upper quadrant in a more cranial location. The appendix was ligated with endoloops and extracted after the entire appendix was placed within the 10-mm port to reduce the possibility of contamination of the port site. Patients were administered antibiotics (cefuroxime and metronidazole), and the duration of antibiotic therapy was 24 hours for acute appendicitis and 2 days to 3 days for phlegmonous appendicitis. Oral intake was started on the first postoperative day, and tocolysis in the form of indomethacin 100 mg suppository was given to 4 patients because of uterine contractility on the advice of the obstetrician.

Literature Review

A review of the literature was carried out by searching the Medline database selecting only studies published in English that described well-documented cases of laparoscopic appendectomy in patients with intrauterine pregnancy and those in whom the surgical and obstetric outcome were clearly linked to the operative approach. Studies with incomplete or confusing data were rejected.

RESULTS

During the period under review, 16 803 deliveries were conducted by the obstetrical service. Twenty-six appendectomies were performed during pregnancy, an incidence of 0.15%. In 6 cases, an open procedure was chosen before surgery because of advanced gestational age or patient preference. The data of the remaining 20 patients who underwent laparoscopic appendectomy are summarized in **Table 1**.

Fourteen patients had acute pain located at McBurney's point. In 2 cases, the pain was located in the right flank, and 4 had central abdominal pain. The temperature ranged from 37°C to 38.5°C (mean temperature, 37.5°C), and WBC count ranged from $7.1 \times 10^9/L$ to $18 \times 10^9/L$ (mean, $15.7 \times 10^9/L$). Ultrasound of the abdomen was carried out in 10 patients in whom the diagnosis was uncertain. The findings included pericecal fluid collection in 5, thickened edematous appendix in 2, and hydronephrosis in one patient. Four patients were initially admitted under an obstetrician's care and then transferred to the surgical service once a diagnosis of acute appendicitis was entertained. The remaining patients were admitted primarily under the surgical service. Ten patients underwent sur-

gery within 12 hours of admission, 5 within 24 hours, 4 within 48 hours, and one after 72 hours. A preoperative obstetric assessment was carried out in all the patients. After an informed consent, laparoscopic appendectomy was performed.

The details of our patients including the operative findings and outcome are outlined in **Table 1**. The intraoperative findings included inflamed appendix in 12 patients, phlegmonous appendix in 2, appendicular mass in 1, and normal appendix in 5 patients. Fifteen patients had histologically proven appendicitis. Among the 5 patients with a normal appendix, the abnormal findings included omental adhesions to the right fallopian tube and cecum (2 patients) and an appendicular fecalith and torsion of the ovary in one patient each. The average duration of surgery was 45 minutes (range, 25 to 90). The hospital stay ranged from 3 days to 8 days (mean, 3.5). A delay in surgery of more than 24 hours after admission was noted in 5 patients. These included those who were primarily admitted under an obstetrician's care or had atypical presentation. The mean postoperative stay in the hospital was 1.5 days (range, 1 to 5). In 2 patients, the postoperative stay was longer than 3 days; these include the patient with appendicular mass and the one with hydronephrosis. The patient with hydronephrosis developed *Klebsiella pneumoniae* that was effectively treated with antibiotics and supportive treatment. This patient was discharged on the fifth postoperative day after the fever subsided. The other patient with appendicular mass had postoperative ileus for 2 days and was mildly febrile. These symptoms improved by the third postoperative day, and the patient was discharged a day later. None of these patients developed wound complications, including wound infection in the immediate postoperative period and port-site hernia following subsequent follow-up. No other postoperative complications were seen. All patients except one had a full-term normal delivery. The exception was a patient with a past history of recurrent abortion who aborted 3 weeks following appendectomy. No perinatal deaths occurred. The birth weights of the infants ranged from 3050 g to 3400 g (mean, 3200), and the mean Apgar score at 5 minutes was 9 (range, 8 to 10). Normal milestones were observed in all infants at 1-year follow-up.

The English literature search yielded 28 main reports with a total of 637 patients who underwent laparoscopic appendectomy during pregnancy³⁻³¹ and matched our inclusion criteria and are included in the review. The data are summarized in **Table 2**.

Table 1.
Operative Details and Outcome in Patients Undergoing Laparoscopic Appendectomy in This Series

Patient No.	Age (years)	Gestation (weeks)	Abdominal Entry (Veress Needle/ Hasson Technique)	Operative Finding	Operative Time (min)	Outcome of Pregnancy Delivery (weeks)	Hospital Stay (days)
1	26	20	V	Acute appendicitis	48	38	3
2	30	13	H	Appendicular mass	55	39	7
3	19	22	V	Fecalith normal appendix	30	39	4
4	26	16	V	Acute appendicitis	60	40	3
5	27	9	H	Acute appendicitis	50	Abortion	3
6	19	25	H	Normal appendix right hydronephrosis	35	38	8
7	23	26	H	Acute appendicitis	42	39	3
8	31	12	H	Omental adhesions to right salpinx normal appendix	40	38	3
9	38	10	H	Mucocele of appendix	35	39	3
10	22	13	H	Acute appendicitis	50	38	3
11	24	11	H	Acute appendicitis	40	39	3
12	20	15	H	Omental adhesions to caecum / right salpinx normal appendix	45	40	3
13	24	12	H	Acute appendicitis	40	38	3
14	21	24	H	Acute appendicitis	60	40	3
15	26	28	H	Acute appendicitis	55	39	3
16	19	13	H	Acute appendicitis	40	40	3
17	24	23	H	Torsion of right ovary normal appendix	55	39	4
18	28	10	H	Phlegmonous appendicitis	65	40	4
19	25	24	H	Acute appendicitis	55	40	4
20	19	14	H	Acute appendicitis	45	38	3

DISCUSSION

Acute appendicitis is the most common cause of nonobstetric acute abdomen during pregnancy, with a reported incidence of 0.05% to 0.1%.^{1,2,21} Even though the incidence of acute appendicitis in pregnancy has been considered identical to that in the nonpregnant population, a recent case control study suggested a lower incidence in pregnant women, with the third trimester being particularly protective.³² However, it has been noted that perforation of the appendix occurs twice as often in the third

trimester (69%) compared with the first and second trimester.³³ Twenty-five per cent of all pregnant women who have acute appendicitis will progress to perforation.³⁴ A 66% perforation incidence has been reported where surgery is delayed by more than 24 hours compared with 0% incidence when surgical management is initiated prior to 24 hours after presentation.³⁵

The difficulty in making a clinical diagnosis particularly close to term combined with the previously quoted high incidences of fetal and maternal mortality for appendiceal

Table 2.
Laparoscopic Appendectomy During Pregnancy Literature Review

Study	n	Trimester (1; 2; 3)	V / H*	MP* (mmHg)	MOT* (min)	Tocolysis	Introp Complications	Postop Complications	Preterm Delivery	Fetal Loss
Present study	20	8; 9; 3	3/17	10–12	45	4	—	—	—	1
Andreoli ¹²	5	0; 5; 0	NI	12	40	—	—	—	—	—
Affleck ³	19	6; 9; 4	NI	NI	54.5	4	—	NI	3	—
Amos ¹⁴	3	0; 3; 0	-/3	12	NI	—	—	NI	NI	1
Barnes ²⁰	2	0; 0; 2	-/2	12	60	1	—	NI	—	—
Buser ²²	1	0; 1; 0	NI	NI	NI	NI	—	—	—	—
Carver ⁹	17	5; 12; 0	NI	NI	NI	—	—	—	—	2
Curet ²¹	4	0; 4; 0	-/6	10–15	82	—	—	—	—	—
dePerrot ¹¹	6	2; 2; 2	1/5	12	51.6	3	—	—	1	2
Friedman ²³	1	0; 1; 0	1/-	NI	NI	—	1	1	1	1
Geisler ²⁴	2	0; 2; 0	2/-	15	NI	—	—	—	—	—
Gurbuz ¹³	5	2; 0; 3	-/5	12	64	—	—	—	—	—
Halkic ⁶	11	0; 11; 0	0/11	10–12	45	—	—	—	—	—
Hee ²⁵	7	NI	NI	NI	NI	NI	—	—	—	—
Lemaire ¹⁸	4	1; 3; 0	4/-	12	33.7	1	—	—	—	—
Lyass ¹⁰	11	5; 4; 2	0/1	12	46	11	—	—	—	—
McGory ³¹	454	NI; NI; NI	—	—	—	—	—	—	1	31
Moreno-Sanz ⁴	6	4; 2; —	0/6	12	46	0	—	—	1	—
Palanivelu ⁷	7	0; 7; 0	6/1	NI	NI	NI	0	0	0	0
Posta ¹⁶	1	0; 1; 0	-/1	12	70	—	—	—	—	—
Radwan ²⁶	1	1	NI	10–12	—	—	—	—	—	—
Rizzo ²⁷	4	0; 4; 0	-/4	10	25–90	—	—	—	2	—
Rollins ⁵	28	6; 13; 9	17/11	15	46.3	6	—	NI	6	—
Schreiber ¹⁹	6	2; 4; 0	6/-	NI	NI	1	—	—	NI	—
Schwartzberg ¹⁵	1	1; 0; 0	-/1	15	NI	—	—	—	—	—
Sirtos ²⁸	13	NI	—	—	—	—	—	—	1	—
Thomas ²⁹	2	2; 0; 0	-/2	NI	NI	NI	—	—	1	—
Tracey ³⁰	3	1; 2; —	—	—	—	—	—	—	—	—
Wu ⁸	11	4; 6; 1	0/11	NI	50.5	3	—	1	—	1

*V = Veress needle; H = Hasson technique; MP = mean pneumoperitoneum pressure; MOT = mean operative time; NI = not indicated.

perforation has led to a traditionally low threshold for surgical intervention. This has resulted in a higher negative appendectomy rate, ranging from 23% to 55% in pregnant women compared with 18% in nonpregnant women ($P < 0.05$).^{4,25,29,31,32,36} However, of concern was the finding in the systematic review by Walsh et al³⁶ who noted that fetal loss rates in the group with no evidence of appendicitis were as high as for those with simple appendicitis.

Use of laparoscopic procedures has rapidly gained acceptance in the treatment of patients with appendicitis. In a study of 3133 pregnant patients who underwent appendectomy,³¹ the laparoscopic approach was used in 14% of pregnant women compared with 23% of nonpregnant women. This change in approach stems from the fact that laparoscopic appendectomy, in addition to its general advantage of a smaller incision, less postoperative pain, and earlier return to normal activity, offers other potential

advantages for pregnant women.^{3-6,10} Laparoscopy can result in less manipulation of the uterus while obtaining optimum exposure of the surgical field and could reduce delays in diagnosis and treatment. It affords easier visualization and treatment of ectopically located appendix or helps in detecting other unexpected sources of pain as in 4 of our patients.^{10,11} Lower rates of dehiscence or herniation during labor are another potential benefit. Rapid return to full activity could reduce the frequency of maternal thrombosis and embolic events, which can be a major source of maternal mortality in some patients.^{4,11,21}

The major concerns, however, have been the potential effects of pneumoperitoneum on fetal physiology and the possibility of injury to the uterus during the operation. The effects of laparoscopic appendicectomy due to increased intraabdominal pressure and fetal acidosis during CO₂ pneumoperitoneum have been looked into in clinical or experimental studies, and no substantial adverse effects for the fetus have been found when the maximal pneumoperitoneum pressure was limited to 10mm Hg to 12mm Hg for a duration of <60 minutes.^{21,37} Although studies have demonstrated that laparoscopy can be performed safely during any trimester with good fetal and maternal outcomes, the long-term effects on the child after delivery have not been well studied. However, one recent study²⁷ evaluating 11 children from 1 year to 8 years whose mothers underwent surgery during pregnancy found no growth or developmental delay in these children.

Guidelines for laparoscopic procedures during pregnancy have previously been published by the Society of American Gastrointestinal and Endoscopic Surgeons³⁸ and modifications have been proposed by Moreno-Sanz et al.⁴ A pneumoperitoneum pressure of <12 mm Hg is recommended, because previous animal studies have demonstrated fetal hypercapnia and acidosis secondary to CO₂ pneumoperitoneum in pregnant ewes.³⁹ However, substantial adverse effects to the fetus with pneumoperitoneum limited to 10 mm Hg to 12 mm Hg have not been demonstrated.^{21,39}

Some controversy exists about the best approach to access the abdomen and to create the pneumoperitoneum. Complications have been described for all techniques, but accidental puncture of the uterus with a Veress needle is the most serious.^{21,23} Open access to the abdomen was the most common approach reported in the literature reviewed,^{6,8,9,11,13,15,17,20,27,29} but the Veress needle was only routinely used in 3 studies.^{18,19,24} The correct use of the Hasson technique is completely safe and reproducible and is recommended as the standard technique in preg-

nant patients in accordance with SAGES recommendations.³⁸ The remaining trocars can be positioned according to the preferences of the surgical team but always displaced cephalad to avoid the uterine fundus. It is recommended that the patient be placed on her left side after the second term of pregnancy to prevent uterine compression of the vena cava and to facilitate access to the appendix.^{4,37} This can be achieved by tilting the operating table to the left; it is unnecessary to place the patient in a strict lateral decubitus position.⁴ In a recent review,³⁶ the mode of laparoscopic entry was documented in 116 cases; the open (Hasson) technique was used in 68% of cases compared with the use of the Veress needle in 32% cases.

Tocolytic agents are used in patients either prophylactically or following the development of postoperative uterine contractions. However, a recent review revealed no statistical difference in the rate of preterm delivery among the prophylactic tocolysis group (0/15) and the nontocolysis group (3/79; P=0.59).³⁶ Hence, the use of prophylactic tocolytic agents is not indicated but can be appropriate if there are obstetric criteria as evidenced by uterine contractions and risk of premature birth.^{4,36,37} This has been the practice in our unit.

The need for continuous fetal monitoring by ultrasonography scans has been reported previously.^{17,38} Despite being SAGES recommendations, this measure has been abandoned because it is difficult to carry out and has a low efficacy.⁴ Most of the recent recommendations consider it essential to have uterine and fetal monitoring before and after operations rather than intraoperatively, and some would repeat this just before the discharge of their patients.^{3-5,11}

Operative times were reported in 110 cases (mean 51±13 min)(median, 46). The mean operative times were 45, 51, and 59 minutes for procedures in the first, second, and third trimesters, respectively.³⁶ This has been quicker than the recently reported median operating time for laparoscopic appendicectomy (LA) in a nonpregnant population (median 60 min) and may reflect the fact that the laparoscopic procedure in pregnancy is usually performed by experienced surgeons.^{36,40} This is supported by the low (1%) rate of conversion to laparotomy that is better than most published rates of nonpregnant patients.³⁶ The mean stay was 5±3.8 days. Information on the use of intraoperative antibiotics was sparse, with antibiotic administration routinely in 29/36 cases.³⁶

Advanced pregnancy was initially considered a relative contraindication by authors who suggested the gestational age limit for successful completion for laparoscopic sur-

gery during pregnancy should be 26 weeks to 28 weeks.^{14,17} However, there are several reports of successful laparoscopic appendectomy carried out in patients beyond the estimated gestational age of 26 weeks.^{3,5,20} Review of the literature reveals gestational age being recorded in 155 cases. Of these, 52, 77, and 26 women underwent LA in the first, second, and third trimesters of pregnancy, respectively. The mean (standard deviation) gestational age at the time of LA was 17.9 weeks (SD±5.7). Among the patients in the third trimester, 8 were in advanced pregnancy with the gestational age above 30 weeks.^{3,5,20} Even though successful LA has been carried out in advanced pregnancy, some feel that the size of the gravid uterus in the third trimester may interfere with adequate visualization and instrumentation,²⁰ and these procedures that are technically demanding should be carried out by experienced laparoscopic surgeons. However, there was no significant difference reported in the rates of intraoperative complications, fetal loss, or preterm delivery between the first and among the 26 patients in third trimesters.^{36,37}

The overall rate of preterm delivery following LA in pregnancy was 2.1% (13/624), which is significantly lower than that reported following open appendectomy (OA) (8.1%, 346/4193; $P < 0.0001$).³⁶ No fetal 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 appendectomy on subsequent birth weight.³⁶ An increased tendency toward obstetric complications following perforated appendicitis in pregnancy has been previously demonstrated. 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.³⁶ Complicated appendicitis was defined as appendicitis with evidence of perforation, appendiceal abscess, or generalized peritonitis. Fetal loss was statistically more likely following LA for complicated appendicitis compared with LA for simple appendicitis in pregnancy ($P = 0.0027$). There was no statistically significant difference in fetal loss in the simple appendicitis group compared with those who had a negative LA ($P = 0.0641$).³⁶

The overall rate of interrupted pregnancy (premature delivery and fetal loss) following LA in pregnancy has been reported to be 7.7%, which is significantly less than 11.3% following OA.³⁶ However McGory et al³¹ who examined appendectomy in 3133 pregnant women over an 8-year period in California noted an overall fetal loss rate of 5.6% (35/624) in the LA group, which was significantly higher than that reported following OA (3.1%, 128/4193; $P = 0.001$). The rate of fetal loss was significantly higher in those women

who underwent appendectomy via a laparoscopic approach despite a higher rate of nonappendicitis in this group.³¹ Hence, it appears that negative appendectomy is not entirely a benign intervention in a pregnant woman, and the risk of misdiagnosis needs to be carefully balanced against the risks of perforation from a delay in diagnosis.

CONCLUSION

Laparoscopic appendectomy is technically feasible in all trimesters of pregnancy and is associated with the same benefits of laparoscopic surgery experienced in nonpregnant patients, provided the specific recommendations for these types of patients are strictly followed. Although the laparoscopic approach to appendectomy in pregnancy is associated with a low rate of intraoperative complications in all trimesters, the rate of fetal loss following LA is almost 6%, which is significantly higher than that following open appendectomy. Rates of preterm delivery appear to be equal or slightly better in the LA group. The data available at present on LA in pregnancy are derived from case reports and retrospective case series rather than randomized controlled trials. 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, though desirable, seems less likely.

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