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Is laparoscopic appendectomy safe in pregnant women?

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Abstract
Background: Because of limited laboratory and clinical data, no accepted guidelines concerning the safety of laparoscopic appendectomy (LA) in pregnancy have been established yet. In this prospective study, we evaluated the safety and outcome of LA in pregnant women as compared with the same control group of pregnant women who underwent open appendectomy (OA) during the same period.
Methods: During the years 1996 to 1999, 11 consecutive pregnant women (mean age, 27 years; range 21–39 years; gestation age range, 7–34 weeks) who underwent LA were prospectively evaluated and compared with a matched group of 11 women (mean age, 30 years; range 18–42 years; gestation age range, 11–37 weeks) who underwent OA. The following parameters were analyzed: obstetric and gynecologic risk factors, length of procedure, perioperative complications, length of stay, and outcome of pregnancy. Both groups were well matched in age and risk factors for pregnancy loss.
Results: There was no significant difference in the length of procedure (60 vs. 46 min) and the complications rate (one in each group) between the LA and OA groups, respectively. There was no conversion in the LA group. The length of postoperative stay was shorter in the LA group (3.6 vs 5.2 days; $p = 0.05$). There was no fetal loss or other adverse outcome of pregnancy in either group, and all the women in both groups had normal full-term delivery. The infants' development was normal in both groups for a mean follow-up period of 30 months.
Conclusions: According to this relatively small-scale study laparoscopic appendectomy in pregnant women may be as safe as open appendectomy. This procedure is technically feasible in all trimesters of pregnancy and associated with the same known benefits of laparoscopic surgery that nonpregnant patients experience.

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Despite the potential advantages of laparoscopic surgery in pregnant women such as decreased narcotic consumption and fewer wound complications, the increased intra-abdominal pressure and the use of carbon dioxide (CO_2) for pneumoperitoneum have raised significant concern about the pregnancy outcome. Because of limited experience as well as limited laboratory and clinical data, no accepted guidelines concerning this issue have been established yet. In this prospective study, we evaluated the safety and outcome of laparoscopic appendectomy (LA) in pregnant women as compared with the same in control group of pregnant women who underwent open appendectomy (OA) during the same period.

Materials and methods

During the years 1995 to 1999, all consecutive pregnant women with acute appendicitis treated by two surgeons (S.L. and P.R.) underwent LA while other surgeons in the same department performed OA on similar patients. All the women were given the same preoperative treatment, which included intravenous (IV) fluids and antibiotics (gentamycin and clindamycin) and the same perioperative monitoring and management. All the patients in both groups with a gestation age less than 24 weeks were given intramuscular progesterone supplement before procedure and 48 to 72 h after surgery for uterine contraction prophylaxis. The patients with a gestation age more than 24 weeks received steroids (dexamethazone 12 mg) before surgery and 12 h after the procedure to induce fetal lung maturation. Fetal monitoring was used routinely before induction of anesthesia, while the patient was on the operating table, and immediately after the procedure in the recovery room, and repeated as needed. General anesthesia with rapid-sequence endotracheal intubation was performed in all patients. The length of antibiotic therapy was 24 h for acute appendicitis and 2 to 3 days for phlegmonous appendicitis. Oral intake was started on postoperative day 1 in all the women.

All the women were followed by both surgeon and obstetrician until after delivery. Gestation and general data were recorded and evaluated prospectively including length of procedure, perioperative complications, length of stay, and outcome of pregnancy. The data about development of the infants was obtained by a telephone questionnaire. The statistical analy-

Table 1. Comparison of laparoscopic vs open appendectomy

	Laparoscopic appendectomy	Open appendectomy	*p*
Number of patients	11	11	
Age, mean (range)	27 (21–39)	30 (18–42)	0.4
Gestation age, weeks (range)	16 (7–34)	24 (11–37)	0.03
Pathology:			
Normal appendix	1	6	
Acute/phlegmonous appendicitis	10	5	
Length of surgery, min (range)	60 (25–100)	46 (20–75)	NS
Conversion	None		
Intraoperative complications	None	None	
Postoperative complications	1	1	NS
Length of stay, days (range)	3.6 (2–5)	5.2 (3–11)	0.05
Fetal loss	None	None	
Full-term normal delivery	All	All	
Normal infant development	All	All	

NS, not significant

sis was performed using Wilcoxon and *t*-tests, with a p value less than 0.05 considered significant.

Technique of laparoscopic appendectomy in pregnant women

The patient was placed on the table in the supine position. After intubation, the urinary bladder was decompressed with the indwelling urinary catheter. Creation of pneumoperitoneum was always by the open Hasson technique to avoid inadvertent injury of the uterus or other organs. The location of the first port was moved from the umbilical to a more cephalad location according to the size of the uterus. The working pneumoperitoneum pressure was set to 10 to 12 mmHg. Two additional ports in the left lower (5 mm) and right upper (12 mm) quadrants were used for grasping, dissection, and use of the laparoscopic linear stapler to divide the mesentery and appendiceal base. This rather expensive instrument was used to reduce the length of the procedure. The appendix was removed in a bag through the right upper quadrant port. At 10- and 12-mm port sites, the fascia was sutured separately. The ordinary technique of open appendectomy was used with inversion of the appendiceal stump into the cecum by a silk purse-string suture.

Results (Table 1)

In this study, 11 women underwent LA and were compared with 11 women who underwent OA during the same period. The mean age of the two groups did not differ significantly. The gestation age at the time of appendectomy was younger in the LA group (16 vs 24 weeks; $p = 0.03$). In the OA group, two patients were in the first trimester, four patients in the second trimester, and five patients in the third trimester of pregnancy. In the LA group, five patients underwent appendectomy in the first trimester, four patients in the second trimester, and only two patients in the third trimester of pregnancy.

Both groups were well matched in terms of risk factors for pregnancy loss: in the OA group there were no patients with obstetric risk factors, and in the LA group there was only one patient with increased risk for pregnancy loss. This was a 39-year-old woman with a history of four spontaneous abortions secondary to cervical incompetence. She underwent suturing of the cervix at the gestation age of 12 weeks. This patient underwent LA at the 34th week of pregnancy for phlegmonous appendicitis and had an uneventful recovery. She subsequently had a full-term normal delivery.

The mean length of surgery was not significantly different between the two groups (60 min for LA vs 46 min for OA). There were no intraoperative complications in either group. Postoperatively, one patient in each group suffered from uterine contractions, which were successfully treated with tocolytic agents. The mean length of hospital stay was shorter in the LA group (3.6 vs 5.2 days; $p = 0.05$).

Interestingly, the most of the patients in the LA group (10 of 11) had an inflamed appendix, whereas in the OA group only 5 of 11 patients had acute appendicitis at surgery, which also was confirmed by the pathologic examination. There were no cases of perforated or gangrenous appendicitis in this series.

All the patients in the OA group had an uncomplicated delivery at full term. In the LA group, all the women had a full-term delivery, although one patient had prolonged bleeding after vaginal delivery, which was treated conservatively. The infants' development was normal in both groups for a mean follow-up period of 30 months.

Discussion

Some known advantages of laparoscopic surgery may be even more crucial in pregnant women who undergo emergency surgery, including better intraoperative visualization and exposure, confirmation of diagnosis, decreased surgical trauma, reduced postoperative pain, and easier recovery. Decreased gravid uterine manipulation is an additional important advantage in the pregnant patient [3].

However, a significant concern was raised about the safety of laparoscopy in pregnant women because of the increased intra-abdominal pressure during pneumoperitoneum, which may cause decreased venous return with a concomitant decrease in cardiac output. [5, 11, 15, 20]. Such a decrease in cardiac output may place the placental and fetal blood flow at risk. However, it was demonstrated that the effect of increased intra-abdominal pressure on venous return is volume dependent [14]. In relatively hypovolemic subjects, increased intra-abdominal pressure decreases venous return. This effect is a result of elevated venous resistance that is greater than the concomitant increase in mean systemic pressure. Conversely, in relatively hypervolemic subjects, increased intra-abdominal pressure causes only minimal compression of the inferior vena cava, and increased mean systemic pressure "pumps" the blood into the inferior vena cava. This effect causes increased venous return and increased cardiac output resulting from the Starling mechanisms [14]. Therefore, because pregnancy is associated with a marked increase in circulating blood volume [19], pregnant women usually are hypervolemic, and the pneumoperitoneum should not lead to lower cardiac output or decreased fetal flow. Moreover, moderately increased intra-abdominal pressure to the level usually used at laparoscopy (12–15 mmHg) was shown to increase preload at the beginning of pneumoperitoneum as a result of "milking" pooled blood from the splanchnic veins to the systemic circulation and forcing blood to the intravascular compartment from the compressed liver and spleen [7, 9, 12, 13].

Another issue of concern is fetal acidosis resulting from

systemic absorption of CO_2. Unfortunately, there are only a few studies (all in animals) of fetal response to CO_2 pneumoperitoneum. It was shown, however, in one study that CO_2 pneumoperitoneum may cause fetal respiratory acidosis and minimal fetal tachycardia with hypertension [10]. This was not confirmed in another animal study [4]. One other animal study showed that despite the marked decrease in maternal placental blood flow, the fetal placental perfusion pressure and blood flow, pH, and blood gas tensions were unaffected by CO_2 insufflation of 60 min duration [2]. The authors of this study concluded that the fetus has sufficient placental flow reserves or compensatory responses to maintain adequate gas exchange during a 1-h, 20-mmHg maternal pneumoperitoneum. No long-term fetal effects were noticed by investigators who followed gravid ewes after CO_2 pneumoperitoneum [6].

Despite some concern, several clinical reports of laparoscopic surgery during pregnancy have shown favorable results, although most were reports of small-scale studies [5, 8, 17, 18]. One of the first reports describing laparoscopic nonobstetric surgery in pregnant women was by Schreiber [16] in 1987, who reported his experience with three LAs [17]. In 3 years, he extended his experience to six procedures in women representing all stages of pregnancy with no complications. Five cases of LA with no immediate or late complications were reported by Gurbuz and Peetz [8]. A serious concern regarding the possibility of laparoscopic surgery in pregnant women was raised by Amos et al. [1]. These researchers reported four fetal losses in a series of four laparoscopic cholecystectomies for gallstone pancreatitis and cholecystitis and three LAs for perforated and acute appendicitis. However, it is not clear from this report whether these complications occurred after cholecystectomy or after appendectomy, and at what gestation age. Moreover, no fetal monitoring was used in this series before surgery. Therefore, it is difficult to determine whether the fetal distress was attributed to the surgical intervention itself or to the severity of disease.

The safety of laparoscopic procedures was demonstrated even during the "higher risk" associated with the first trimester of pregnancy [5, 8, 18]. In the current study, the number of women in the first trimester of pregnancy was higher in the laparoscopic group (5 vs 2), and no abnormal fetal organogenesis was observed. In this study, we also demonstrated the technical feasibility of LA at an advanced gestation age (two patients underwent operation during the 28th and 34th weeks of pregnancy). Such an advanced gestation age was previously regarded as a contraindication for LA because of expected technical difficulties [5]. Because the disease severity in the OA group was less than in the LA group (only 5 of 11 had acute appendicitis) and there were no cases of perforated appendicitis, which usually requires more prolonged antibiotic therapy in both groups, the shorter hospital stay in the LA group reflected faster recovery.

Another advantage of laparoscopy in pregnant women with suspected acute appendicitis is its diagnostic value. Because the differential diagnosis of right lower quadrant pain varies widely in these patients, laparoscopy may help in confirming the right diagnosis, thus preventing unnecessary surgery.

In summary, according to this relatively small-scale study laparoscopic appendectomy in pregnant women may be as safe as open appendectomy. The LA procedure is technically feasible in all trimesters of pregnancy and associated with the same known benefits of laparoscopic surgery experienced by nonpregnant patients. However, before final conclusions concerning the safety of LA may be reached, further large-scale clinical and animal studies are needed.

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