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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Laparoscopy for appendicitis and cholelithiasis during pregnancy

A new standard of care

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Abstract
Background: Subsequent to a report from the authors' institution, the laparoscopic management of symptomatic cholelithiasis and appendicitis during pregnancy has become the standard of care at LDS Hospital using institutional guidelines. For comparison with previous outcomes described by the authors, 59 additional laparoscopic cases are reported.
Methods: Medical records of all pregnant patients at LDS Hospital who underwent open or laparoscopic cholecystectomy or appendectomy between 1998 and 2002 were reviewed. The outcomes were compared with the authors' previous data.
Results: The laparoscopic management of symptomatic cholelithiasis and appendicitis during pregnancy increased from 54% to 97%. No significant differences in preterm delivery rates, birth weights, or 5-min Apgar scores were found between the two periods. No birth defects or uterine injuries occurred.
Conclusions: With the use of the authors' guidelines, laparoscopy has become the standard of care for managing symptomatic cholelithiasis and appendicitis during pregnancy at LDS Hospital without significant increase in morbidity or mortality.

Key words: Pregnancy — Laparoscopy — Cholecystectomy — Appendectomy

The acute abdomen in the gravid patient presents a dilemma in which the surgeon must weigh the risks and benefits of potential diagnostic methods and therapy not only to the mother but also to the fetus. Approximately 1 in 500 to 1 in 635 women require nonobstetrical abdominal surgery during pregnancy [13, 14]. Acute appendicitis, intestinal obstruction, and cholecystitis are the three most common nonobstetrical emergencies requiring surgery during pregnancy [13].

Laparoscopy has improved dramatically since its advent, resulting in changes to the operative management of appendicitis and symptomatic cholelithiasis. Although pregnancy was once considered an absolute contraindication to laparoscopic surgery, such surgery now is being performed in all trimesters with increasing frequency: The largest series of laparoscopic cholecystectomy (45 cases) and laparoscopic appendectomy (22 cases) in the gravid patient to date was previously reported at our institution [1]. Although our laparoscopic management pattern during pregnancy varied from the published Society of American Gastrointestinal Endoscopic Surgeons (SAGES) guidelines [19] on four points (Table 1), no fetal losses, birth defects, or uterine injuries were reported. Furthermore, the preterm delivery rates of the laparoscopic groups, as compared with that of patients undergoing open procedures, were not significantly different [1].

Controversies remain regarding laparoscopy during pregnancy including the timing of surgery, the safest method of abdominal cannulation, and appropriate maternal and fetal monitoring. To evaluate the safety of our institutional management strategies and the recommendations of our original study, we analyzed maternal and fetal variables from the 59 laparoscopic cases performed in gravid patients at LDS Hospital in the 4 years after our previous study.

Materials and methods

The medical records of all deliveries at LDS Hospital from June 1998 to August 2002 (period 2) were selected using a central database. The patients undergoing open or laparoscopic cholecystectomy or appendectomy then were selected for review. Available birth records were reviewed for fetal outcomes including gestational age, birth weights, birth defects, and Apgar scores. The birth records of 16 patients were obtained from the state department of vital statistics, and we were unable to obtain the birth record of one patient.

Preterm delivery (PTD) was defined as any delivery before 37 weeks gestation, and early preterm delivery (EPTD) was defined as any

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Table 1. Comparison of guidelines for laparoscopy during pregnancy

LDS hospital	SAGES	LDS hospital and SAGES
Pre- and postsurgery monitoring of fetus/uterus	Intraoperative fetal and uterine monitoring	Pneumatic compression devices
Appropriate criteria for all trimesters	Second-trimester deferment	Lead shield with selective fluoroscopy
Pneumoperitoneum 10–15 mmHg	Pneumoperitoneum 9–12 mmHg	Dependent positioning
$ETCO_2$ 30–40 mmHg	Serial arterial blood gas analysis/$ETCO_2$ monitoring	Obstetrics consultation
Open (Hasson) or Veress technique	Open (Hasson) technique	
Tocolytics—uterine irritability (not prophylactically)		

SAGES, Society of American Gastrointestinal Endoscopic Surgeons; $ETCO_2$, end-tidal carbon dioxide

delivery before 35 weeks gestation. Comparisons were made of both maternal and fetal perioperative and intraoperative variables as well as fetal outcomes among the 1998–2002 study population. These same variables then were compared with those of our previous study population from 1990 to 1998 (period 1). Mann–Whitney *U* tests (applied to continuous variables) and Fisher's exact tests (applied to categorical variables) were performed to test whether the factors were different between the periods. Exact two-sided *p* values were reported. The null hypothesis was tested at the 5% two-sided significance level, and the null hypothesis was rejected if the *p* value was less than 0.05.

Results

General

From June 1998 to August 2002 (period 2) there were 18,590 deliveries altogether at LDS Hospital. These deliveries included 1,636 preterm deliveries. Thus, the overall incidence of PTD was 8.8% (Fig. 1), which was significantly increased from the 6.4% incidence during period 1 ($p < 0.001$, odds ratio 1.41; 95% confidence interval [CI], 1.32–1.51).

During period 2, 31 laparoscopic cholecystectomies (LC), no open cholecystectomies, 28 laparoscopic appendectomies (LA), and two open appendectomies were performed for pregnant patients. One patient with chorioamnionitis and early delivery (33.4 weeks) was included in the analysis of the laparoscopic appendectomy group. An additional patient with documented cholelithiasis who underwent both LA and LC at an estimated gestational age (EGA) of 18 weeks for chronic cholecystitis and acute appendicitis subsequently delivered a healthy term infant, but was excluded from the analysis to allow a presentation of conservative results. Therefore the incidence of cholecystectomy was 1 in 600 and that of appendectomy was 1 in 620. Patients delivering before 37 weeks were compared between the two periods according to EGA at the time of surgery (Fig. 2). There were no significant differences in the PTD or EPTD rates for either the LC or LA groups between studies. Furthermore, there were no spontaneous abortions in either period.

Laparoscopic cholecystectomy

From June 1998 to August 2002, 31 laparoscopic cholecystectomies were performed in pregnant patients. Three LCs were performed during the first trimester, 19 during the second trimester, and 9 during the third trimester. The average EGA at the time of the procedure was 20.8 weeks, and patients delivered an average of 16.9 weeks after surgery. The rate of PTD during period 2 (Fig. 1) was 20.0%, as compared with 11.9% during period 1 ($p > 0.5$, Fisher's exact test; odds ratio, 1.85), and the rate of EPTD was 6.7% versus 4.8% ($p = 1.0$). In the PTD group, the average EGA at the time of surgery was 20.9 weeks, which was not significantly different from the EGA of those who delivered at term. The PTD group delivered an average of 3.2 weeks early and 12.9 weeks after the procedure. Laparoscopic transcystic common bile duct exploration was performed in two patients, both of whom delivered term infants. Intraoperative cholangiography (IOC) was performed in 52% of pregnant patients, whereas 84% of nonpregnant women undergoing LC during the same period had IOC.

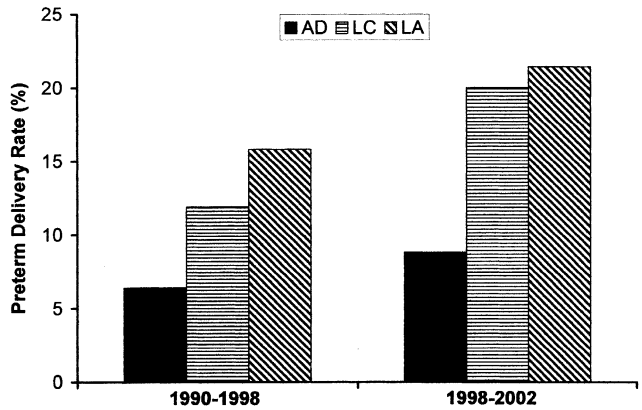

Fig. 1. Preterm delivery (PTD) rates in period 1 (1990–1998) and period 2 (1998–2002). The PTD rate for all the deliveries (AD) at LDS Hospital during period 2 was significantly higher than during period 1 ($p < 0.001$). The increased PTD rate during period 2 in the LC group ($p = 0.5$) and the LA group ($p = 0.7$) was not significant. LC, laparoscopic cholecystectomy; LA, laparoscopic appendectomy.

Fetal heart rate (FHR) monitoring was performed immediately before and after the procedure (respective means, 143 and 142 bpm; normal range, 120–160 bpm). The average maternal end-tidal carbon dioxide ($EtCO_2$) was within the normal physiologic range (33–39 mmHg). The average pneumoperitoneum used was 13.1 ± 1.7 mmHg. Pneumoperitoneum pressure, maternal $EtCO_2$, maternal and fetal hemodynamics, EGA, pathology, and Apgar scores at 1 and 5 min were not significantly different between the two periods. Operative times ranged from 31 to 130 min (mean, 61.2 min) in

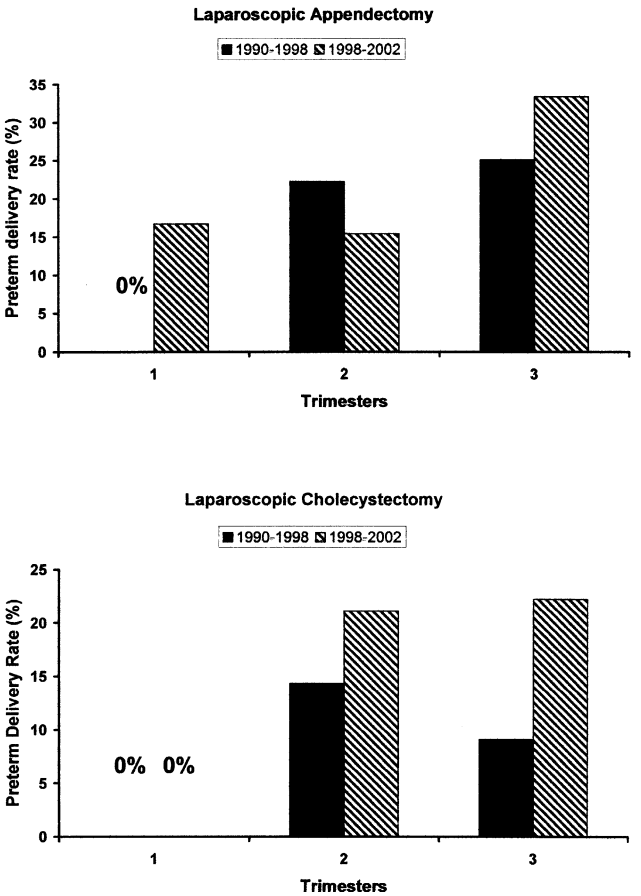

Fig. 2. Period comparison of preterm delivery rates according to the gestational age at the time of surgery. There were no significant differences in any trimester for either the laparoscopic cholecystectomy group or for the laparoscopic appendectomy group.

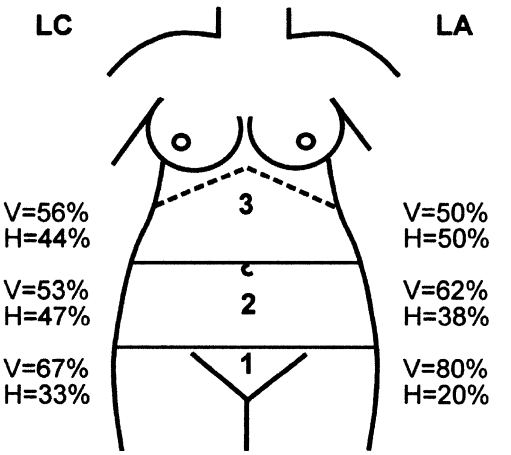

Fig. 3. The percentage of laparoscopic cholecystectomies (LC) and laparoscopic appendectomies (LA) in which either the Hasson technique (H) or Veress needle (V) was used for initial abdominal access according to gestational age at the time of surgery. 1, first trimester; 2, second trimester; 3, third trimester.

the current study, which was significantly shorter than for period 1 (mean, 79.7 min; $p = 0.04$).

The method of initial abdominal cannulation to accomplish pneumoperitoneum did not vary significantly among trimesters (Fig. 3). However, the location of initial abdominal cannulation varied with the EGA. In the first trimester, all patients underwent initial abdominal cannulation in the lower abdomen (infraumbilical cannulation), whereas in the third trimester the upper abdomen (supraumbilical, epigastric, or right upper quadrant cannulation) was used for all patients. There was a tendency toward PTD with the use of the Hasson technique, as compared with the Veress needle, although it was not statistically significant (PTD Hasson, 37.5% vs Veress, 6.3%; $p = 0.07$).

Tocolytics were administered for perceived or documented contractions. No patients were given tocolytics preoperatively. Nine patients received tocolytics postoperatively: two patients in the second trimester and seven patients in the third trimester. Two of the seven patients receiving tocolytics in the third trimester delivered preterm an average of 8 weeks after the procedure. The two who received tocolytics during the second trimester delivered at term.

No association was found between PTD and maternal age, in contrast to the finding in our prior study, in which younger patient age correlated with PTD. Similar to our previous findings, PTD was not associated with operative time, pneumoperitoneum pressure, maternal $EtCO_2$, maternal and fetal hemodynamics, EGA, pathology, or Apgar scores at 1 and 5 min.

No uterine injuries were experienced. One fetal death occurred in the LC group. The patient had undergone LC as an outpatient at an EGA of 14 weeks for symptomatic cholelithiasis. She delivered a 16-week fetus by pathologic examination 9.4 weeks after the procedure. Perioperative care and monitoring were performed similarly to those for the group, and there were no unusual perioperative circumstances or complications. We were unable to obtain the hospital records for review of the circumstances surrounding the 23.4-week delivery of the nonviable fetus.

Laparoscopic appendectomy

During period 2, 28 laparoscopic appendectomies were performed. Six LAs were performed during the first trimester, 13 during the second trimester, and 9 during the third trimester. The average EGA at the time of the procedure was 20.7 weeks, and patients delivered an average of 17.7 weeks after surgery. The rate of PTD during period 2 (Fig. 2) was 21.4%, as compared with 15.8% during period 1 ($p > 0.7$; odds ratio, 1.45), and the EPTD rates were 10.7%, as compared with 5.3% ($p > 0.6$). In the PTD group, the average EGA at the time of surgery was 21.7 weeks, which was not significantly different from the EGA of those delivering at term. The PTD group delivered an average 1.7 weeks early and 13.6 weeks after the procedure.

Perioperative maternal and fetal monitoring was performed as for the LC group. Fetal heart rate monitoring was performed immediately before and after the procedure (respective means, 152 and 144 bpm). Maternal $EtCO_2$ was maintained within the normal physiologic range (30–40 mmHg). The average pneumoperitoneum used was 12.6 $\pm$ 1.6 mmHg. The operative times ranged

from 21 to 114 min (mean, 46.3 min). The operative time was less during the second period (mean, 46.3 vs 51 min) although this difference was not statistically significant. Maternal age, method of initial abdominal cannulation, pneumoperitoneum pressure, maternal maximum $EtCO_2$, EGA, pathology, and tocolytic use were not significantly different between the two periods.

Significant differences were discovered between the term and PTD groups regarding maternal and fetal monitoring as well as fetal outcome. First, maternal minimal intraoperative systolic blood pressure was lower in the PTD group (mean, 87 mmHg PTD vs 96 mmHg term; $p = 0.04$). Second, postoperative FHR was higher in the PTD group (mean, 153 bpm PTD vs 142 bpm term; $p = 0.04$). Finally, the maternal maximal $EtCO_2$ approached significantly lower values in the PTD group (mean, 34 mmHg PTD vs 39 mmHg term; $p = 0.052$). No statistically significant difference was detected in 1-min Apgar scores between PTD and term groups, although they tended to be lower in the PTD group. The 1-min Apgar scores were significantly lower among all LA patients in the second period than in the first ($p = 0.003$). There was no significant difference in 5-min Apgar scores between the two periods.

The Veress needle was used for insufflation more frequently than the Hasson technique 61.5% (vs 38.5%) in the LA group (Fig. 3). There was a tendency toward use of the Veress needle in the first trimester, whereas the Hasson technique was used for half of the cases performed in the third trimester. The lower abdomen was chosen for initial trocar placement in all the patients during the first trimester, whereas the upper abdomen was chosen for initial placement in 87.5% of the patients during the third trimester.

Tocolytics were administered for perceived or documented contractions as in the LC group. One patient was given tocolytics preoperatively in the second trimester and one in the third trimester. Both patients were found to have normal appendicies and subsequently delivered healthy term infants. Four patients, all in the third trimester, were given tocolytics postoperatively. Two patients delivered preterm including one patient who delivered at 33.6 weeks, which was 6.6 weeks after the procedure, and one who experienced chorioamnionitis and delivered at 33.4 weeks. As in our prior study, PTD was not associated with maternal age, operative time, method of initial abdominal cannulation, pneumoperitoneum pressure, maternal maximum $EtCO_2$, EGA, pathology, or tocolytic use. There were no uterine injuries or fetal deaths.

Pathologic examination of both laparoscopic and open appendectomies showed 12 (41%) normal specimens, 14 (52%) with acute inflammation, and two (7%) perforations. One pathology report was not obtainable. One perforation occurred within the LA group in a 39-year-old patient during her 30th week of pregnancy. She subsequently delivered a healthy infant at 41.3 weeks. The other perforation presented with a pelvic abscess in a 31-year-old patient during her 25th week of pregnancy. She also gave birth to a healthy term infant at 40 weeks. In one PTD patient, chorioamnionitis developed after LA at 32.14 weeks gestation as a result of a nonperforated, acutely inflamed appendix. This patient delivered at 33.43 weeks. The 1- and 5-min Apgar scores were 4 and 5, respectively, and the birth weight was 2203 g.

Discussion

Laparoscopy has become the standard of care at our institution for the management of appendicitis and symptomatic cholelithiasis during pregnancy. This change in our institutional practices resulted from our previous findings demonstrating the efficacy and safety of laparoscopy in all trimesters. All cholecystectomies and 93% of appendectomies required during pregnancy have been performed laparoscopically over the past 4 years without any spontaneous abortions or uterine injuries.

The PTD rates after laparoscopy in our current study have increased, as compared with those in our previous study [1]. However, this increase was not statistically significant and was lower than rates reported elsewhere [7]. The increase in the PTD rates for all deliveries during period 2 was significant, as compared with the rates during period 1, and the odds ratio of 1.41 implies that the odds of any delivery before 37 weeks gestation is 41% greater in period 2. Thus, the increase in PTD rates after laparoscopy in the current study may reflect the increase in PTD rates for all pregnancies at our institution as well as the increase in PTD rates reported nationally [20]. Furthermore, the increased incidence of PTD after laparoscopy, as compared with those for pregnant patients not undergoing surgery may be attributable to patient disease or simply a small patient population. Finally, PTD occurred an average of 3 months after the procedure, which was similar to the results in our previous study. Therefore, it is difficult to attribute PTD solely to the procedure and not to other postsurgical patient variables.

Abdominal pain requiring nonobstetric general surgery during pregnancy is similar at our institution to the 0.2% reported in the literature [5]. Appendicitis is the most common acute general surgical condition during pregnancy [14]. When uncomplicated, appendicitis results in a 1.5% rate of fetal loss. Perforation, which occurs in 10% of cases, increases the fetal loss rate to 35% [13], and may lead to preterm labor and premature delivery in as many as 40% of patients [5]. However, the two patients in this study treated for a perforated appendix subsequently delivered at term.

The rate of appendicitis during pregnancy at our institution is consistent with that reported in the literature [6]. The negative appendectomy rate during period 2 (43%) was similar to that for period 1 (42%) and within the 22% to 55% range reported by others [11, 15]. The higher incidence of negative appendectomy among gravid patients likely results from both anatomic and physiologic changes that occur during pregnancy as well as attempts to prevent perforation because perforation results in high maternal and fetal morbidity and mortality. We rely heavily on clinical judgment for the diagnosis of acute appendicitis in the gravid patient. However, some studies suggest that helical computed tomography [3] and ultrasonography [16] are highly accurate for diagnosing

acute appendicitis during pregnancy and may help reduce the negative appendectomy rate.

Significant increases in postoperative FHR were seen in the current study among women who delivered fewer than 37 weeks after LA, although the mean FHR was within the normal range. Also, a lower intraoperative maternal systolic blood pressure was seen in this group. One might speculate that the lower intraoperative maternal systolic blood pressure could have led to a decrease in uterine blood flow, resulting in fetal stress, an elevated postoperative FHR, and eventual PTD. However, this explanation for PTD seems unlikely given the length of time from procedure to delivery.

Laparoscopic cholecystectomy continues to be the most common laparoscopic general surgical procedure performed during pregnancy [2]. Some recommend that the initial management of symptomatic cholelithiasis should be nonoperative during pregnancy [12]. However, this management strategy has been associated with a high recurrence of symptoms leading to hospitalization [9]. In addition, nonoperative management of symptomatic cholelithiasis increases the risk of gallstone pancreatitis up to 13% [4], which causes fetal loss in 10% to 20% of cases [18]. Nonoperative management also has been associated with higher incidences of spontaneous abortions, preterm labor, and preterm delivery than among those undergoing cholecystectomy [5]. Earlier surgical intervention in symptomatic patients may therefore be warranted to reduce the risk of these complications. No PTDs occurred after first-trimester laparoscopic cholecystectomies in either study. These results, and the findings of others [10, 17] support our previous conclusion that laparoscopy can be performed safely in the first trimester without an increase in maternal or fetal complications, and that there is no need to defer surgery until the second trimester [19].

Cholangiography did not correlate with PTD or adverse fetal outcomes. We agree that fluoroscopy during pregnancy should be used selectively with lead shielding. Although our IOC rate is higher during pregnancy than the 26% reported in one review of the literature [10], IOC is used less often in pregnant than in nonpregnant women.

With the use of our guidelines, both mother and fetus continue to be managed safely by monitoring of maternal $EtCO_2$ intraoperatively and FHR before and after surgery. The monitoring of maternal acid–base status using $EtCO_2$ measurements [8] and the perioperative monitoring of the FHR [5, 10] also have been supported by others. Intraoperative fetal monitoring and analysis of serial maternal arterial blood gases as recommended by SAGES [19] seem unnecessary given our results.

Methods of abdominal cannulation during pregnancy remain an area of debate among all surgeons, including those at our institution. By altering the location of initial abdominal access according to fundal height and using maneuvers to elevate the abdominal wall during insertion, we use both the Hasson technique and the Veress needle. The use of the Veress needle during pregnancy has been supported by others [15], contrary to the recommendation by SAGES [19] for use of only the Hasson technique. According to surgeon preference at our institution, the Veress needle is used with equal or increased frequency in all trimesters without an increase in either maternal or fetal morbidity.

Finally, some have suggested that the gestational age limit for successful completion of laparoscopic surgery during pregnancy is 26 to 28 weeks [8]. In this study, we successfully managed 18 cases involving patients with an EGA greater than 26 weeks. There were five PTDs, which occurred an average of 1.6 weeks early.

The laparoscopic management of appendicitis and symptomatic cholelithiasis has become the standard of care at our institution. We continue to perform laparoscopy safely in all trimesters by following our previous recommendations without significant increases in either maternal or fetal morbidity or mortality.

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