Review Article
Is Laparoscopy Safe During Pregnancy

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Introduction

In the United States, approximately 2% of pregnant women undergo non-obstetric surgery every year most commonly appendectomy, cholecystectomy and adnexal surgery (Mazze and Kallen, 1989). Due to a general perception that surgery during pregnancy may be associated with increased fetal morbidity and mortality and due to the diagnostic difficulties of abdominal pathology secondary to anatomical displacement of organs by the gravid uterus, the management of surgical abdominal pathology in pregnant patients can be very challenging.

Treatment of pregnant patients require consideration of the well-being of both the mother and the fetus. The underlying abdominal and pelvic pathologies that require surgical intervention or the procedure itself can pose risks to the mother and the fetus. The specific risks associated with surgery during pregnancy include fetal asphyxia, pregnancy demise, premature labor, premature rupture of membranes, and thromboembolic events. Perinatal mortality had been reported in 7.3% of pregnant patients who underwent surgery (Mazza and Kallen 1989; Cohen et al 1971; Duncan et al 1986). The gravid patients can benefit from the minimally invasive nature of operative laparoscopy if the approach proves to be safe for both the mother and fetus.

Operative laparoscopy was revolutionized with the incorporation of a camera and video equipment in the mid 1980's. The magnification of the pelvic and abdominal anatomy afforded by the camera and video allow the surgeon to thoroughly examine and treat pathology with greater precision (Nezhat et al 1995). The technique has now been applied beyond gynecological indications including appendectomy, cholecystectomy, herniorrhaphy, and bowel resection. Several randomized studies demonstrated superior outcome and decreased morbidity and convalescence period with the laparoscopic approach compared to equivalent procedures by laparotomy when performed by skilled surgeon (Nezhat et al 1995). As favorable experience accumulates with operative laparoscopy, the candidates for laparoscopic approach has widened beyond the healthy adult population to include the pregnant patients.

Since 1990, there are scattered case reports of successful diagnostic and advanced operative laparoscopy during pregnancy for adnexal surgery, appendectomy, and cholecystectomy (Nezhat 1997). One retrospective case-control study compared the outcome of laparoscopic appendectomy and cholecystectomy with that of laparotomy during the first two trimesters. Laparoscopic management significantly decreased the length of hospitalization and the need for narcotics for pain relief. Postoperatively, no differences were noted in the gestational age at delivery, 1- and 5- minute Apgar scores, birth weights, or other complications (Curet 1996). Although case reports and one retrospective case control study are insufficient basis to conclude the safety of operative laparoscopy during pregnancy, they suggest the potential application of laparoscopy for this patient population.

Physiological Changes and Risks Unique to Gravid Patients

During pregnancy, significant maternal and physiologic changes occur that require particular

attention during laparoscopic surgery. For instance, after the first trimester, the gravid patient's respiratory function is significantly altered because of reduction in functional residual capacity and residual volume, increased minute ventilation and oxygen consumption, physiologic hyperventilation, and a lowered oxygen reserve (Rosen 1999). Mechanical ventilation of a gravid patient during laparoscopic surgery can be difficult because of the upwardly displaced diaphragm prior to abdominal insufflation. The decreased respiratory reserve of pregnant patients limits the degree of the trendelenburg position. Furthermorre, from mid-gestation aortocaval compression by the gravid uterus increase the risk of decreased cardiac output and uteroplacental blood flow, particularly in the supine position. Anesthetic agents that interfere with sympathetic tone can compromise physiologic compensation for the reduced cardiac output, making pregnant women prone to profound hypotension during surgery. These physiologic alterations put the fetus to be at particular risk of hypoxia during surgery and dictate that the anesthesiologists and surgeons pay particular attention to proper positioning of the mother. The hip should be tilted by at least 15 degrees, and the hemodynamic and respiratory variables should be carefully monitored to decrease the risk of hypoxia (Barron 1985).

Risk of Premature Labor

Limited reports and anecdotal experience suggest that surgery during pregnancy is associated with a greater likelihood of premature labor. The gravid patient with a surgical abdomen is exposed to the pathologic condition, anesthesia, surgical manipulation, and other stresses. How these affect prostaglandins, oxytocin, hormonal changes, or direct myometrial activity alone or in combination that result in premature labor is unknown. Levine and Diamond (1961) found that intra-abdominal procedures are associated with a greater tendency for premature labor than were extra-abdominal procedures. Smith (1963) additionally reported that surgery requiring cervical manipulation increased the risk for premature labor as much as did intra-abdominal manipulation. Laparoscopic approach may reduce the need for uterine or cervical manipulation by enabling the surgeon to operate in a limited field with smaller instruments.

The increase in premature labor may also be caused by the underlying pathologic condition. This is most aptly demonstrated in the case of appendicitis, where perforation of the appendix is associated with risk of preterm labor at least four times higher than non-perforated appendicitis (BabaKhia et al 1977; Sharp 1994). Ahlgren (1959) demonstrated that elevated temperature independently increased the motility of human myometrium in vitro. Kullander (1977) noted premature labor in 50% of rabbits with induced fever. Pyrogen can alter the neurohypophyseal axis, which may result in the release of oxytocin from the posterior pituitary gland (Dinarello 1978). Thus, the fever and infectious processes that mandate surgical intervention rather than the operative technique, can cause uterine contractions and lead to increased risk of preterm deliveries and pregnancy losses. Early diagnosis and prompt intervention to treat the underlying pathologic condition is essential when an intra-abdominal inflammatory process is present.

The increased risk of preterm labor with surgical procedures during a pregnancy also depend on the gestational age and the acuteness of the problem. In reports of the operative management of adnexal tumor by laparotomy, preterm contractions and labor were more likely in the third trimester. Emergency procedures had a greater risk of causing a spontaneous abortion and premature labor than those performed electively. Although no controlled studies for elective procedures done at different gestations exist, Hess reported that operations required emergently due to torsion and rupture of adnexal mass after 31 weeks gestation in two patients resulted in preterm delivery within 72 hours. In contrast, the 39 cases that underwent elective removal of the adnexal masses did not have preterm labor (Hess et al 1988). Such observation advocate that while concerns remain regarding the safety of surgery during a pregnancy, prompt and elective operations are preferable to emergency procedures.

Reports of Advanced Operative Laparoscopy during Pregnancy

For many years, gynecologists performed diagnostic laparoscopies in pregnant women in the first trimester to rule out an ectopic pregnancy. Some of these resulted in normal intrauterine pregnancies, and exposure to laparoscopy per se did not have adverse effects on the pregnancy (Samuelson and Sjovall 1972).

Appendectomy

Appendicitis is the most common indication for non-obstetric abdominal surgery during pregnancy occurring at a rate of 1:1000 – 1:2000, and can pose significant diagnostic and management challenges due to the displacement of the appendix by the gravid uterus (Nezhat et al 1997). Currently available non-invasive diagnostic tests such as ultrasound and C.T. scans are associated with a 30% false positive rate. (Sharp 1994;

Sarason Bauman 1963). The fear of surgical intervention in a pregnant woman, compounded by the diagnostic challenge frequently lead to delay in appendectomy. However, when a perforation of the appendix occurs, fetal mortality is dramatically increased up to 20% (Fallon et al. 1995) and hence as originally stated in 1908, the mortality of appendicitis complicating pregnancy is the mortality of delay. (Bobler, 1908). While some might argue that the laparoscopic approach does not offer added benefit of dramatically smaller incisions compared to the open approach, laparoscopy does expand the ability to explore the abdomen with less uterine manipulation. Laparoscopic appendectomy have been reported in 38 patients from 20 case reports with gestational ages ranging between 8 to 29 weeks (Nezhat et al 1997; Affleck et al 1999). All but one study reported favorable outcomes with no immediate complications. Preterm delivery was reported in one retrospective case-control series by Affleck et al (1999) comparing laparoscopic and open appendectomy during pregnancy. In the laparoscopic appendectomy group of 22 women, preterm delivery occurred on the average 21.6 weeks after the laproscopic surgery and one week earlier than term but there were no differences when compared to women undergoing open appendectomy.

Cholecystectomy

Cholecystitis occurs in 1:600 to 1:10,000 pregnancies and is the second most common indication for non-obstetric surgical intervention during pregnancy (Nezhat et al 1997). When cholecystectomies are performed for uncomplicated gallstones, there is no increased maternal mortality compared to non-obstetric patients but a fetal loss rate of 5% has been reported. If surgery was undertaken for complicated gallstone disease, maternal mortality has been as a much as 15% and fetal loss rate up to 60% (Holthausen et al 1999). A retrospective study by Dixon et al (1987) compared maternal morbidity, fetal outcome and cost in 44 patients with biliary colic. Twenty-six were managed conservatively, and eighteen underwent cholecystectomy by laparotomy. Of those treated conservatively, 58% had recurrent symptoms, a fraction required parenteral nutrition for extended periods, and one patient developed pancreatitis. Spontaneous abortion was observed in 3 (12%) of the patients managed conservatively, while none occurred in the cholecystectomy group. Of the eighteen who had cholecystectomy, all the women delivered at term except one patient. She delivered prematurely because of pre-eclampsia during the eighth month of gestation, many weeks after the surgical procedure.

A review of 33 reports of 159 cases of laparoscopic cholecystectomy occurring in pregnancie with gestational ages ranging from 3 to 32 was previously reported (Nezhat et al 1997; Dixon et al 1987 Cozensa et al 1996). Obstetric complications were noted in several instances. Four spontaneous abortion occurred within one week after the procedure in early second trimester, another occurred two months after the operation, and one maternal-fetal mortality occurred 15 days later from an intra-abdominal hemorrhage (Amo et al 1996, Barone et al 1999). While laparoscopic cholecystectomy has been successful in the third trimester in over 20 women, the risk of uterine damage is increased In 1992, the Office of medical applications of research and the national institute of diabetes and digestive and kidney diseases of the national institute of health (NIH 1993) held a consensus conference to evaluate the available data on laparoscopic cholecystectomy and issued the following guidelines specific to pregnancy "Patients with acute cholecystitis, acute gallstone pancreatitis that has subsided, prior surgery in the upper abdomen, and symptomatic gallstones in the second trimester of pregnancy may be candidates for laparoscopic cholecystectomy, providing the operating surgeon is experienced in treating patients with complex laparoscopic cholecystectomy problems. The use of laparoscopic cholecystectomy in patients in the first trimester of pregnancy is controversial because of the unknown effects of carbon dioxide pneumoperitoneum on the developing fetus…patients in the third trimester of pregnancy should not usually undergo laparoscopic cholecystectomy because of risk of damage to the uterus during the procedure."

Adnexal Surgery

For the obstetricians, another common indication for surgical intervention during pregnancy is persistent adnexal mass. In both non-pregnant and pregnant state, adnexal mass greater than 5-6cm is considered significant. With the routine use of early prenatal ultrasounds, the detection of incidental adnexal tumors have increased to 1:80 to 1:170 pregnant women (Hogston 1986; Nelson et al 1986). The majority of these have benign ultrasound features and regress by the second trimester. Retrospective reviews of the outcome of pregnancies with adnexal masses found that 13-42% of cases resulted in complications such as torsion, rupture, hemorrhage and obstruction of labor in the second half of gestation often necessitating urgent surgical intervention (Nezhat et al 1997). The complications were more likely if the mass were greater than 5-6 cm. These acute presentations were associated with increased fetal morbidity and mortality primarily due to premature delivery.

In addition to potential complications during pregnancy, persistent adnexal mass may represent potential cases of ovarian cancer. Although only 2-8% of ovarian tumors occurring during pregnancy are found to be malignant (Nezhat et al 1997), delaying treatment of ovarian cancer until the end of 40 weeks gestation may be deleterious since the success of ovarian cancer treatment largely depends on the stage at diagnosis. In non pregnant women, the anechoic, simple cysts carry the least risk of being malignant. In pregnancy, these anechoic simple cysts, because of their size, pulsatility index, resistive index values, are frequently in the range associated with malignancy in the non-pregnant state because of pregnancy related ovarian changes (Salim et al 1994; Dillon et al 1993). Thorton and Wells (1987) reported a series of 69 adnexal cysts greater than 5 cm detected in pregnancy by ultrasound. They noted that out of the simple cysts that did not regress, 6 of them greater than 10 cm in size contained borderline malignant features by histologic analysis. Some have advocated management of simple ovarian cysts by needle aspiration as a therapeutic and diagnostic maneuver. However the accuracy of cytologic diagnosis of cyst fluid remains controversial. There are two reports of the development of diffuse intra-abdominal dissemination of Stage I ovarian cancer after cyst aspiration. (Trimbos and Hacker 1993; De Crespigny 1995). Thus, if the mass is greater than 5-6 cm and persist beyond 15-16 weeks, the increased risk of malignancy alone warrants surgical diagnosis and removal of the adnexal tumor. By waiting until after 15-16 weeks gestation, the majority of the cysts will spontaneously regress, while allowing major organogenesis to be completed in the developing fetus.

Adnexal surgeries approached laparoscopically appears to be safe during pregnancy in the first trimester in an acute setting. There are eleven instances of laparoscopic removal of heterotopic pregnancies between 6 and 10 weeks of gestation, involving either salpingectomy or cornual resection of an interstitial pregnancy. All the associated in utero pregnancies progressed normally into the third trimester. For adnexal mass, there have been 8 series of 38 cases of laparoscopic cyst aspirations and detorsion done in the first trimester, and 9 series of 75 cases of laparoscopic cystectomies during the first and second trimesters. Among these, there were five first trimester pregnancy losses, two congenital anomalies resulting in second trimester termination of pregnancy, one premature delivery of twin gestation at 31 weeks resulting in one neonatal death. (Nezhat et al 1997).

These successful case reports of operative laparoscopy during pregnancy do suggest its feasibility and potential safety. However, case reports are biased in the sense that successes are more likely to be reported. A recent questionnaire surveying the experience of laparoscopic surgeons confirm the low complication rate. Among 189 respondents to the questionnaire, 40 laparoscopic procedures involving pregnant women were reported; 197 (48%) cholecystectomies, 66 (16%) appendectomies and 115 (28%) adnexal surgery. 133 (32.5%) were reported to occur in the first trimester, 222 (54.1%) were in the second trimester and 54 (13.4%) in the third. Out of a total 14 complications (3.4%), there were 5 intraoperative complications including one intrauterine Veress needle insertion, and 9 post operative complications including 5 first trimester spontaneous abortions, and 1 preterm labor (Reedy 1997). However such surveys are limited due to selection bias as not all participants choose to complete the questionnaires and are retrospective in nature.

Possible Risks of Laparoscopy during Pregnancy

What are the possible risks with laparoscopy during pregnancy? First, with the enlarged uterine size, inadvertent uterine injuries from trocar placement may occur. There are reports of Veress needle insufflating intrauterine cavity resulting in CO_2 embolism. (Reedy 1997, Barnett and Liu 1974). Numerous investigator reported preferring the open laparoscopic approach using the Hasson cannula to avoid such complication (Nezhat et al 1997). Our experience has been to modify the primary and secondary trocar insertion site to either supra-umbilical or sub-xiphoid midline, or left upper quadrant. We also believe that direct trocar placement rather than insufflation with Veress needle is safer to avoid inadvertent uterine insufflation. The primary insertion site is best determined after palpating the uterine tundus, and the ancillary trocars can be placed safely under direct visualization.

Another potential risk is the influence of pneumoperitoneum when using CO_2 on the maternal hemodynamics and possible acid-base imbalance form CO_2 absorption and hypercarbia. Both may compromise the fetus. Peritoneal space is a closed body cavity which normally contains a little serous fluid. Increased intra abdominal pressure alone can decrease cardiac output by several mechanisms, including direct alteration of venous resistance in the inferior vena cava, total peripheral resistance, and mean systemic pressure. Impaired venous return via compression of the inferior vena cava is of particular concern in the second half of pregnancy since the enlarged uterus can also limit venous return. The uterine compression of vena cava can be minimized by tilting the left hip up by about 15 degrees (Barron 1985).

In operative laparoscopy, CO_2 is the gas of choice because of its rapid rate of absorption, high

solubility, rapid clearance from the body through the lung and non-explosive nature when electrosurgery is utilized. CO_2 pneumoperitoneum, however, can result in physiologically significant hypercarbia and respiratory acidosis (Callery and Soper 1993). The physiologic changes in the pulmonary function make pregnant women particularly prone to hypoxia and hypercapnia and hyperventilation. The risk of hypercarbia and acidosis is best minimized by maintaining the intra-abdominal pressure to less than 15-20 mmHg and short operative time. (Kashtan et al 1981). Hypercarbia and respiratory acidosis can be monitored to some extent by capnography which measures end-tidal CO_2 concentration in the endotracheal tubes. One prospective study by Bhavani-Shankar et al (2000) reported that respiratory acidosis did not occur when end-tidal CO_2 was maintained at 32 mm Hg during laparoscopic surgery in eight pregnant women with 17-30 weeks gestation. Concerns remain, however, as several studies of pneumoperitoneum in pregnant sheep have demonstrated increased fetal arterial blood pressure, tachycardia and respiratory acidosis which were only partially corrected with alternation in ventilator settings based on maternal capnography results (Barnard et al 1995; Hunter et al 1995; Hutwin et al 1994). Several reports addressed this issue and used the laparolift technique rather than insufflation with CO_2. (Nezhat et al, 1997). In one study with pregnant ewe, the fetal respiratory acidosis was not demonstrated when pneumoperitoneum was established with N_2O (Hunter et al, 1995). As an anesthetic agent nitrous oxide has been administered to pregnant women during the first two trimesters of pregnancy for many decades without any reported ill effects on the fetus. However, nitrous oxide can irreversibly inactivate vitamin B_{12} and has been shown to compromise hematopoiesis (Baden et al 1983).

Another potential danger specific to laparoscopic surgery is the exposure to intra-abdominal smoke generated by electrosurgery and lasers, with resultant production of increased levels of noxious gases, most importantly carbon monoxide (Beebe et al 1993). Measurement of serum carboxyhemoglobin in women undergoing prolonged operative laparoscopy procedures in one study, however, did not reveal an increase in the levels, which was attributed to rapid evacuation of intra-abdominal smoke generated during surgery (Nezhat et al 1996).

Conclusion

Abdominal and pelvic pathology that necessitates surgical intervention represents a clinical challenge to the obstetrician/gynecologist. Operative laparoscopy is increasingly being utilized for pregnant women due to its known advantages and benefits. The experiences reported thus far in the literature suggest that operative laparoscopy can be safely performed in experienced hands and that pregnant women may benefit from minimally invasive surgery. Concerns remain, however, and prospective, randomized controlled trials are needed to assess the effect of CO_2 pneumoperitoneum on the maternal and fetal hemodynamics, acid-base balance, and the safety, efficacy, and advantages of operative laparoscopy over exploratory laparotomy.

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