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Laparoscopy During Pregnancy: A Literature Review

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ABSTRACT

Objective: To review the literature regarding the role of laparoscopy during pregnancy, particularly adnexal mass and non-obstetric surgery, incorporating the results of a series of 9 cases of laparoscopy during pregnancy at our centers.

Materials and Methods: A Medline search was performed to review the literature, and the reference lists provided by those articles were further explored for citations regarding laparoscopic adnexal surgery, appendectomy, and cholecystectomy. Our series of 9 patients consisted of pregnant patients with adnexal mass or acute abdomen who would otherwise have undergone exploratory laparotomy. Follow-up data for these 9 cases were collected by office visits, inquiry to the primary referring physicians, and telephone calls to the patient.

Results: The literature search yielded 42 additional cases of operative pelvic laparoscopy and 51 cases of abdominal operative laparoscopy (cholecystectomy and appendectomy). The publications, particularly regarding cholecystectomy, were supportive of the laparoscopic approach during pregnancy. All of the patients in our series had favorable outcomes.

Conclusions: Advanced operative laparoscopy has been successfully performed for certain indications during pregnancy.

Key Words: Laparoscopy, Pregnancy, Adnexal mass.

INTRODUCTION

Non-obstetric surgery is performed in 1.6-2.2% of pregnant women, but operative laparoscopy during pregnancy has been limited to sporadic case reports, largely for cholecystectomy, appendectomy, or removal of adnexal mass.[1,2,3] The objective of this report is to review the literature regarding the role of laparoscopy during pregnancy, particularly for adnexal mass, and non-obstetric surgery. We also describe our experience of 9 cases of pelvic laparoscopy performed during pregnancy between 12 and 22 weeks gestation with good outcome.

MATERIALS AND METHODS

To review the literature, a Medline search was performed to identify reports on laparoscopic surgery during pregnancy. Reference lists provided by the articles were further explored for citations regarding advanced operative laparoscopic adnexal surgery, appendectomy, and cholecystectomy. The results of our series were also taken into account, which included nine women with an average age of 30 (range 23-40 years) whose gestational ages at the time of surgery ranged from 12-22 weeks (median 14 weeks). Seven women underwent ovarian cystectomy for persistent adnexal mass (3 dermoid cysts, 1 endometrioma, 1 hemorrhagic cyst with deciduosis, 1 simple ovarian cyst, and 1 corpus luteal cyst) and two women required emergent surgery for acute abdominal pain, including one for abdominal hemorrhage and one for torsion of paratubal cyst.

RESULTS

Laparoscopic adnexal surgeries reported in the literature are summarized in **Table 1**.[1-24] Most cases were performed in the first trimester, which is the most common time for presentation, secondary to adnexal torsion or heterotopic pregnancy. **Table 2** summarizes the literature on laparoscopic appendectomy.[25-30] For cholecystectomy, the literature was even more abundant and supportive of the laparoscopic approach **(Table 3)**. **Table 3** summarizes 18 reports of 31 cases of laparoscopic cholecystectomy.[31-54] Gestational age ranged from 3 weeks to 31 weeks with no pregnancy complications attributed to the surgery. All 9 of the patients in our series had favorable surgery outcomes

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Table 1.
Literature Review of Published Data in Laparoscopic Adnexal Surgery

Author	EGA	Diagnosis	Procedure	Complications
Mage (1989)	6 weeks	Adnexal torsion	Cyst aspiration	None
Hanf (1990)	7 weeks	Bilateral heterotopic	Bilateral salpingectomy	None
Shalev (1990)	8 weeks	Adnexal torsion	Cyst aspiration	None
Nezhat (1991)	16 weeks	Endometrioma	Cystectomy	None
Ozcan (1992)	8 weeks	Adnexal torsion	Detorsion only	None
Grauer (1993)	8 weeks	Ruptured right heterotopic	Right salpingectomy	Vaginal bleeding at 29 weeks, full term delivery
Nagase (1993)	6 weeks	Adnexal torsion	Cyst drainage	None
Shalev (1993)	Unknown 10 cases	Adnexal torsion	Cyst aspiration and detorsion	None
Bowditch (1994)	9 weeks	Bleeding right heterotopic	Right salpingectomy	None
Gazarelli (1994)	8, 5 weeks	Adnexal torsion	Cyst aspiration	None
Lucas (1994)	7, 13 weeks 8, 20 weeks 16 weeks	Pelvic pain Torsion Persistent mass Dermoid cyst	Cyst aspiration Cyst aspiration and cystectomy Cyst aspiration and cystectomy	
Howard (1994)	13 weeks 21 weeks	Dermoid cyst Torsed paratubal cyst	Cystectomy Cystectomy	None None
Parker (1995)	6 weeks	Left heterotopic	Left partial salpingectomy	None
Remorgida (1995)	10 weeks	Left heterotopic	Left salpingectomy	None
Sherer (1995)	8 weeks	Ruptured right interstitial heterotopic with triplets	Cornua resection	None
Parker (1996)	9-17 weeks	Dermoid cyst	Cystectomy	2 elective TOP for congenital anomalies
Nezhat (1996)	12-22 weeks	Persistent adnexal mass (7 cases)	Cystectomy	None
		Acute abdomen	Paratubal cyst removal	None
		Acute abdomen	Evacuation pelvic hematoma	None

and 8 of them went on to deliver at term infants of appropriate size for gestational age. One patient had premature rupture of membrane at 31 weeks and delivered a viable male with appropriate gestational age via emergent cesarean.

DISCUSSION

Operative laparoscopy is becoming increasingly popular due to the low postoperative morbidity and minimally invasive nature.[55] In our series of 9 cases of operative laparoscopic pelvic surgery performed during pregnancy, the outcomes were good. Currently, there remains controversy in three areas: 1) management of adnexal mass in pregnancy; 2) safety of surgical intervention in pregnancy; and 3) laparoscopic surgery during pregnancy.[56] In the following discussion, we review the literature regarding: 1) the natural history of adnexal tumors in pregnancy, with incidence of malignancy and complications from expectant management; 2) risk of non-obstetric surgical intervention during pregnancy; and 3) the composite reports on operative

Table 2.
Literature Review of Published Data in Laparoscopic Appendectomy During Pregnancy

Author	EGA	Complications
Schreiber (1990)	8	None
	13	None
	21	Contractions before surgery, responded to tocolytics
	25	Difficulty to place veress needle
Cristalli (1992)	14	None
Lucas (1994)	18.5	None

laparoscopy during pregnancy and the documented and theoretical maternal and fetal risks.

Adnexal Tumors in Pregnancy - Incidence and Risk of Malignancy:

Adnexal tumors greater than 5-6 cm are considered significant in both the non-pregnant and pregnant state. In pregnancy, prior to regular ultrasound use, the reported prevalence of such tumors was between 1:328 and 1:1399.[56-67] With the routine use of prenatal ultrasound, asymptomatic incidental adnexal tumors have been detected in 1:80 to 1:170.[67,68] Traditional management has been to follow conservatively until 15-16 weeks of gestation and then remove any adnexal mass greater than 6 cm, in order to rule out malignancy and prevent complications. Although only 2-8% of ovarian tumors occurring during pregnancy are found to be malignant, success of the treatment largely depends on the stage at diagnosis.[58-67] Thus, delay in surgical intervention could be deleterious. Waiting until 15-16 weeks allows for a majority of the cysts to regress spontaneously (50-87%), for the fetus to complete organogenesis, and for most of spontaneous miscarriages to have taken place.[56-67] Furthermore, surgical intervention prior to the third trimester is least associated with premature delivery.[67,68]

Whether all adnexal tumors greater than 6 cm need to be removed remains controversial.[58] There are several reports that suggest that ultrasound may significantly improve the ability to distinguish benign from malignant adnexal tumors.[69-74] Numerous studies have shown that in non-pregnant women, the anechoic, simple cysts carry the least risk of being malignant. In pregnancy, the most common adnexal tumor is an anechoic, simple cyst, which carries the least risk of being malignant.[69,70] Several investigators have reported on the management of these simple cysts by ultrasound guided transcutaneous or transvaginal aspiration. With the advent of high resolution ultrasound and color Doppler flow, diagnostic capabilities have become further refined.[73-76] Lerner reported a weighted score system of ultrasound characteristics of the adnexal mass, which had a high sensitivity of 96.8%, a specificity of 77%, and a negative predictive value of 99.6%.[73] However, these studies were based on tumors in a non-pregnant state and have not been adequately repeated in pregnant women. Several factors such as size of the tumor and ovarian resistive index on Doppler flow may be altered in pregnancy into the range associated with malignancy in a non-pregnant state.[74,75] The efficacy of ultrasound to distinguish benign and malignant adnexal tumors in pregnancy therefore remains in question.

Thornton and Wells reported a series of 69 adnexal cysts greater than 5 cm detected in pregnancy by ultrasound. They aptly raised concern by demonstrating that, out of the 20 persistent simple cysts, 6 were more than 10 cm and had borderline malignant features histologically.[66] Management of ovarian cysts by aspiration and the accuracy of cytologic diagnosis also remains controversial. Several reports in the literature demonstrate diffuse intra-abdominal dissemination of ovarian cancer after cyst aspiration.[77,78] More studies are needed to investigate the efficacy of ultrasound in ruling out malignancy in pregnancy and the safety of cyst aspiration. There is currently a general consensus that masses greater than 6 cm that do not spontaneously regress by 15 weeks require tissue diagnosis.[79,80]

Complications of Adnexal Mass in Pregnancy:

Even if the tumor pathology is benign, enlarged adnexa can cause several complications. Surgical intervention in asymptomatic patients may be justified if the incidence of potential complications without surgery is high and may adversely affect the pregnancy. The older literature provides several reports that allow appreciation of the rationale for surgical intervention. Patton reported in 1906 that the maternal mortality from adnexal mass followed conservatively was 26% while that of surgical removal was 4.5%. Mortality of women managed expectantly was secondary to suppuration of adnexa torsion, hemorrhage or peritonitis from ruptured cysts and obstruction of labor. The mortality in the operative group was due to sepsis in 80% of the cases in the pre-antibiotic era.[78] With the advent of antibiotics, blood banking, and safer anesthetics and surgical approaches, maternal mortality secondary to adnexal tumor is rare, except in cases of malignancy.

In 1954, Grimes published a retrospective review of 185 cases of adnexal masses of all sizes and found that 87% regressed spontaneously.[57] Of those, 94% were less than 5-6 cm. However, of the cysts greater than 6 cm at mid-second trimester, 75% persisted into the postpartum period. Of all cases, 26% experienced torsion, rupture, hemorrhage

Table 3.
Literature Review of Published Data in Laparoscopic Cholecystectomy During Pregnancy

Author	EGA	Procedure	Complications
Arvidsson (1991)	22 weeks	Cholecystectomy and common bile duct stone removal	None
Milenin (1991)	27 weeks	Cholecystectomy, transhepatic transcutaneous drainage	None
Pucci (1991)	31 weeks	Cholecystectomy	None
Weber (1991)	13.5 weeks	Cholecystectomy	None
Morrell (1991)	13,14,17, 18,23 weeks	Cholecystectomy and intra-operative cholangiogram	None
Soper (1992)			
Adamsen (1993)	2nd trimester	Cholecystectomy	None
Bennett (1993)	19 weeks	Cholecystectomy	None
Elerding (1993)	3, 14 18, 25, 28 weeks	Cholecystectomy	None
Fabiani (1993)	14 weeks	Cholecystectomy	None
Hart (1993)	12, 23 weeks 23 weeks	Cholecystectomy Cholecystectomy and intra-operative cholangiogram	None None
Jackson (1993)	17 weeks	Cholecystectomy	Not reported
Rusher (1993)	17 weeks	Cholecystectomy	Not reported
Schorr (1993)	16, 21 weeks	Cholecystectomy	Not reported
Chandra (1994)	13 weeks	Cholecystectomy	None
Comitalo (1994)	14-19 weeks (4 cases)	Cholecystectomy	One deliverred at 37 weeks with RDS
Constantino (1994)	14, 22 weeks	Cholecystectomy	None
Csaba (1994)	25 weeks	Cholecystectomy	Not reported
DePaula (1994)	21 weeks	Common bile duct exploration, transcystic choledoscopy, intra-operative cholangiography	Not reported
Edelman (1994)	15 weeks	Cholecystectomy	None
Shaked (1994)	10 weeks	Cholecystectomy of empyema	None
Iafrati (1995)	14 weeks	Cholecystectomy, laprolift	None
Williams (1995)	18 weeks	Cholecystectomy	None

RDS: Respiratory Distress Syndrome

or obstruction of labor requiring surgery. Of those, 80% were greater than 6 cm.[57] In 1963, Booth reported 50 cases with adnexal masses greater than 6 cm detected during pregnancy.[58] Of the 50 cases, 76% were diagnosed at the first prenatal visit and 10% subsequently presented with torsion prior to 15 weeks. Out of the 50 adnexal masses, 21 (42%) required operation due to various symptoms between 13-26 weeks. Only 6 cysts spontaneously regressed. In Tawa's 1964 retrospective review of 62 pregnancies with adnexal tumors greater than 6 cm, 50% were diagnosed at the first prenatal attendance in first trimester, 35% developed symptoms, and 13% had complications such as torsion, rupture, dystocia and infection.[59] In 1984, Struyk retrospectively reviewed 90 cases with adnexal tumors greater than 5 cm in size.[62] Of the 90 cases, 15 (16.6%) were removed electively after reaching a diagnosis. Of the 75 not removed electively, 13 (17%) required emergent surgery prior to 16 weeks gestation. Out of the remaining 62, two (3.2%) had torsion with one resulting in preterm labor and neonatal death at 24 weeks, 13 (17%) had obstruction at parturition and 6 (9.5%) cysts ruptured during labor with ensuing peritonitis and postpartum sepsis. Thus, in these series simple conservative observation of benign pathology was associated with complications in

13-42% of the time at later gestation. Prevention of such potential complications may be a sufficient indication for surgical intervention in the asymptomatic patient.

Risk of Non-Obstetric Surgical Intervention in Pregnancy:

There is general concern that surgery during pregnancy may be associated with increased fetal morbidity and mortality. If the risk can be minimized, perhaps diagnosis and treatment of pregnant women with non-obstetric pathology can be made earlier, leading to improved outcome. Advanced operative laparoscopy, if proven to be safe during pregnancy, may be such a minimally invasive tool.

What is the actual risk of surgery during pregnancy? Every year, about 50,000 (1.5%-2.2%) pregnant women undergo non-obstetric surgery in the United States.[1-3] Limited reports suggest that surgery during pregnancy may be associated with a greater risk of pregnancy demise or premature labor. Levine found that intraabdominal procedures were associated with a greater tendency for premature labor than were extra-abdominal procedures.[81] Smith reported similar findings and added that surgery requiring cervical manipulation increased the risk for premature labor as much as intra-abdominal manipulation.[82] However, it is not clear whether the increase in premature labor is secondary to the underlying pathologic condition or due to the surgical technique itself. This is most aptly demonstrated in the case of appendicitis, where perforation of the appendix is associated with at least four times higher risk of preterm labor than non-perforated appendicitis.[83-87] Fever and pyrogen may induce uterine contractions. Ahlgren demonstrated that elevated temperature increased the motility of human uterine muscle *in vitro*.[88] Thus, it is possible that the inflammation and infectious processes that require surgical intervention cause premature contractions and raise the risk of preterm deliveries and pregnancy losses, rather than surgery itself.

In the reports of surgical management of adnexal tumor via laparotomy, preterm contractions and labor were more likely to occur when the surgery took place in the third trimester. Furthermore, Hess noted that surgery undertaken emergently had more risk of spontaneous miscarriage and premature labor than those performed electively.[67] Spontaneous miscarriage occurred in 3 out of 6 emergent cases in the first trimester, and 1 out of 8 cases operated between 12-30 weeks. Two emergent cases due to torsion and rupture after 31 weeks gestation both resulted in preterm delivery within 72 hours of surgery. In contrast, the 39 cases that underwent elective removal of the adnexal mass had no loss or preterm labor.[67] Thus, surgical intervention itself may not pose a risk to the pregnancy if performed in a non-emergent setting, and particularly if uterine and cervical manipulation can be avoided.

Laparoscopy During Pregnancy:

In recent years operative laparoscopy has become increasingly popular due to the presumed minimally invasive nature. Aside from the minimally invasive feature, laparoscopy is claimed to provide superior exposure due to the panoramic view and the ability to examine closely the organ of interest. Hence, laparoscopy has been postulated to allow the surgeon to diagnose pathology more accurately in a less invasive manner than laparotomy. With increasing reports of success with advanced operative laparoscopy, numerous procedures are now regularly performed laparoscopically. Laparoscopy has several notable advantages: 1) rapid return of postoperative bowel function; 2) decreased postoperative incisional pain; 3) reduced requirement for pain medications; and 4) lower morbidity from atelectasis and thromboembolic events. Prompt treatment of surgical conditions may diminish the delay in diagnosis and treatment, subsequently reducing late complications secondary to delay in treatment. In the absence of clinical trials to examine this issue, we reviewed all case reports of operative laparoscopy during pregnancy.

Scattered reports with favorable outcome of advanced operative laparoscopy for adnexal surgery, appendectomy, and cholecystectomy during pregnancy began to appear in 1990. Our current report on 9 cases of laparoscopic adnexal surgery adds further to the literature to support the hypothesis that operative laparoscopy may be a safe alternative during pregnancy. The obstetric outcomes were not seemingly adversely affected. None of the patients required tocolytics and they delivered babies with birth weight appropriate for gestational age.

Laparoscopic Adnexal Surgery During Pregnancy:

In 1989, Mage et al. published a series on laparoscopically managed adnexal torsion, which included 2 patients who were 6 weeks pregnant. One had a gangrenous adnexal torsion with an ectopic pregnancy, and the other had torsion of a corpus luteal cyst which was aspirated laparoscopically and detorsed. Pregnancy for the latter progressed normally.[4] Subsequently, others have reported 21 cases of laparoscopic cyst aspiration and detorsion of the adnexa, 2 of which used a harmonic scalpel. Gestational age was unknown in 10, less than 13 weeks in 9 cases, 9 to 17 weeks in a report on 12 cases and one each at 16 and 20 weeks gestation.[5-17]

Our group was the first to report in 1991, advanced pelvic laparoscopy, for an ovarian cystectomy of bilateral endometrioma at 16 weeks gestation. Since then, we are

aware of three other series of laparoscopic cystectomy, 16 cases altogether. Gestational age ranged from 13 to 21 weeks with a mean of 14 weeks.[11,16,17] Our current series of nine cases brings the total number reported in the literature to 28 cases.

Other than ovarian cyst aspiration and cystectomies, there are also six cases of laparoscopic removal of heterotopic pregnancies at gestational age between 6 and 10 weeks.[18-24] One case was converted to a laparotomy after diagnosis was made.[18] Five cases involved laparoscopic salpingectomy and one had laparoscopic cornual resection for an interstitial ectopic pregnancy with viable triplets in utero.[19-24] All of the in utero pregnancies progressed normally. The triplets were delivered by cesarean section at 33 weeks, after premature rupture of the membranes occurred. At that time, the cornua was noted to be intact. While the total number of cases is small, the lack of complications from these reports is encouraging regarding the feasibility of laparoscopic adnexal surgery during pregnancy.

Laparoscopic Appendectomy:

Appendicitis, in particular, can be very difficult to diagnose during pregnancy due to the uterine displacement of the appendix. A false positive preoperative diagnosis one-third of the time is generally accepted.[87-89] Fetal mortality dramatically increases when perforation occurs. Thus, if laparoscopy can be performed safely, it may greatly decrease the risk by diminishing the hesitancy in surgical intervention.[87] There have been a total of 11 cases of laparoscopic appendectomy, with gestational ages ranging from 8 to 25 weeks.[26-30] None were associated with obstetric complications.

Laparoscopic Cholecystectomy:

Cholecystitis in pregnancy was also traditionally managed conservatively.[87] Surgical intervention was avoided as much as possible except when medical treatment failed or when perforation, sepsis, or peritonitis were suspected. In a retrospective study, Dixon aptly made an argument for more aggressive surgical intervention, particularly in the second trimester.[90] He compared maternal morbidity, fetal outcome and cost in 44 patients with biliary colic. Twenty-six were managed conservatively, of which 58% had recurrent episodes of colic. A fraction required parenteral nutrition for extended periods and one patient developed pancreatitis. Spontaneous abortion occurred in three (12%) of the patients managed conservatively. Eighteen underwent cholecystectomy by laparotomy. There were no spontaneous abortions, and of those available for follow-up and who electively continued on with pregnancy, all delivered healthy infants at full term gestation except one. One delivered prematurely due to preeclampsia at the eighth month of pregnancy.

Due to the location of the gallbladder in the right upper quadrant, laparoscopic cholecystectomy appears to be feasible even in the third trimester. The main concern would be to avoid uterine injury during the trocar placement.

Potential Complications of Operative Laparoscopy During Pregnancy:

These successful case reports of laparoscopic surgery during pregnancy do suggest that laparoscopic surgery is safe during pregnancy. 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 also confirmed the low complication rate.[91] Out of 189 respondents to the questionnaire, 410 laparoscopic cases in pregnancy were reported, including 197 (48%) cholecystectomies, 66 (16.1%) appendectomies, and 115 (28%) adnexal surgeries. Of the 410 surgeries, 133 (32.5%) were in the first trimester, 222 (54.1%) were in the second trimester, and 54 (13.1%) in the third. A total of 14 (3.4%) complications occurred, consisting of 5 intraoperative complications (including one intrauterine Veress needle insertion) and 9 postoperative complications (including 5 first trimester spontaneous abortions and one preterm labor).[91] However, such surveys are limited due to selection bias, as not all participants choose to complete the questionnaires and are retrospective in nature.

What are the possible risks with laparoscopy during pregnancy? First, with an enlarged uterine size, inadvertent uterine injuries from trocar placement may occur. There are two reports of Veress needle insufflating intrauterine cavity resulting in CO_2 embolism.[91,92] Numerous investigators reported preferring the open laparoscopic approach using the Hasson cannula to avoid such complications.[13,33,35,39,41,42,44,46,51,54] 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 technique is safer to avoid inadvertent uterine insufflation. The primary insertion site is best determined after palpating the uterine fundus, and the ancillary trocars can be placed safely under direct visualization.

The second concern has been the influence of pneumoperitoneum using CO_2 on the maternal hemodynamics and possible acid-base imbalance from CO_2 absorption and hypercarbia. Both may compromise the fetus. Peritoneal space is a closed body cavity which normally contains a small amount of serous fluid. Introduction of gas into such

a cavity has two immediate effects: 1) increase in intra-abdominal pressure and 2) gaseous exchange leading to an equilibrium with gases in the blood. Increased intra-abdominal pressure 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.[93] 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 slight lateral positioning of the mother.[94]

In terms of gaseous exchange, CO_2 is the gas of choice in operative laparoscopy, due to the rapid rate of absorption, high solubility, rapid clearance from the body via the alveoli, and non-explosive nature when electrosurgery is utilized. However, CO_2 pneumoperitoneum can result in physiologically significant hypercarbia and respiratory acidosis.[95] The risk of hypercarbia and acidosis is best minimized by maintaining the intra-abdominal pressure to less than 20 mm Hg and by short operative time.[96] The CO_2 that is absorbed across the peritoneal surface first equilibrates within the bloodstream, then with longer operative time with skeletal muscle, viscera, and finally bone. The patients who undergo a prolonged laparoscopic procedure are at risk of maintaining hypercarbia and acidosis postoperatively until all excess CO_2 is eliminated from the tissue. Hypercarbia and respiratory acidosis can be monitored to some extent by capnography which measures end-tidal CO_2 concentration in the endotracheal tubes. If a rise in end-tidal CO_2 is detected, CO_2 elimination via the alveoli can be increased using controlled hyperventilation. The limitation of capnography is that while it is sensitive, end-tidal CO_2 is not fool-proof in estimating CO_2 arterial pressure. When ventilation-perfusion mismatch is present, and the amount of ventilation is greater relative to perfusion, gas from such ventilation will contain less pCO_2 than the actual $paCO_2$, resulting in falsely normal or low end-tidal CO_2 readings.[97] Similar discrepancy between end-tidal CO_2 and $paCO_2$, and subsequent acidosis, have been demonstrated also in operative laparoscopy patients with compromised cardiopulmonary status.[98] For such patients, monitoring of arterial $paCO_2$ and pH is preferable to limit the risk of hypercarbia and acidosis. The close monitoring of CO_2 is also important considering the potential direct effect of CO_2 in increasing mean arterial pressure and total peripheral resistance index, leading to increased afterload which could limit cardiac output.[99]

Although most pregnant patients are young and healthy, the altered physiology of pregnancy renders them to have decreased cardiopulmonary reserve.[100] CO_2 pneumoperitoneum may have significant effects. Limited studies of pneumoperitoneum in pregnant sheep have demonstrated increased fetal arterial blood pressure, tachycardia and respiratory acidosis, which were only partially corrected with alteration in ventilator settings based on maternal capnography results.[101-103] In one study, the fetal respiratory acidosis was not demonstrated when pneumoperitoneum was established with N_2O.[102] There are currently no studies published regarding the effects of CO_2 pneumoperitoneum on human maternal hemodynamics, hypercarbia and acid-base balance. The question regarding the safety of operative laparoscopy using CO_2 pneumoperitoneum remains. One of the case reports addressed this issue and used the laparolift technique rather than insufflation with CO_2.[53] More studies comparing different gas use on fetal well-being are needed to ascertain which is the safest during pregnancy.

An additional potential danger is the risk of exposure to intraabdominal smoke, generated by electrosurgery and lasers, with resultant production of increased levels of noxious gases, most importantly carbon monoxide.[104,105] We have recently measured the levels of serum carboxyhemoglobin in women undergoing prolonged operative laparoscopic procedures.[106] No increase in the levels of carboxyhemoglobin was detected, and this was attributed to the rapid evacuation of intra-abdominal smoke generated during surgery.

CONCLUSION

We highlight here the issues surrounding the management of adnexal mass in pregnancy, risks of any surgery during pregnancy, and all the known experience of laparoscopic surgery during pregnancy. While a majority of ovarian cysts diagnosed in early pregnancy are functional cysts which will usually resolve spontaneously by 12-24 weeks gestational age, those that persist at 15-16 weeks and those that present with earlier complications require surgical intervention. Surgical intervention in general may be safe if there is no inflammatory process, and when manipulation of uterus and cervix is avoided. Operative laparoscopy performed by a skilled and trained laparoscopist appears to be safe during pregnancy by the limited case reports available in the literature and may provide more options in managing a pregnant patient with potentially surgical pathology. However, several issues regarding the effect of CO_2 pneumoperitoneum on the maternal and fetal hemodynamics and acid-base balance remain. We propose that further studies performed in a prospective, controlled or randomized setting are needed to assess truly the safety, efficacy, and advantages of operative laparoscopy over laparotomy.

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