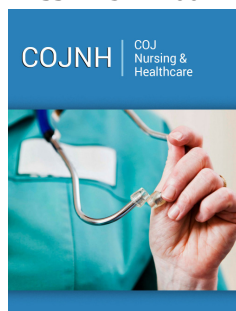# Perioperative Considerations in Laparoscopic Surgery During Pregnancy

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Abstract

Laparoscopy once considered as contraindicated, is being increasingly used in pregnant patient requiring abdominal surgeries without apparent increase in complications. Being minimally invasive offer multiple benefits compared to laparotomy. In addition, laparoscopy is associated with three-fold reduced obstetrical complications such as preterm labour with or without preterm delivery, miscarriage and still birth, when compared with laparotomy. In selected patients, diagnostic laparoscopy can be an alternative to radiologic imaging. Laparoscopic surgeries can be performed at any stage of pregnancy depending on the technical feasibility and clinical judgment. This article highlighted some important physiological changes during pregnancy and its potential consequences of the perioperative period. Some common surgical and peri-operative issues has been addressed with recent society based guideline and recommendations.

Introduction

Laparoscopic surgery during pregnancy was once considered as contraindicated, but with advancement in understanding of its principle and technology, laparoscopy is now being increasingly used without apparent increase in complications rate. Laparoscopic techniques are used as minimally invasive procedure that previously required open laparotomy. The advantages of laparoscopic procedures are similar to non-pregnant women, nevertheless, main reason for avoiding laparoscopy was concern over fetal well-being. Laparoscopic procedures during pregnancy carries the following potential concerns:

A. Maternal hemodynamic changes due to increase in abdominal pressure from the pneumoperitoneum could decrease utero-placental perfusion leading to fetal hypoxia.

B. Iatrogenic mechanical insult to the gravid uterus and fetus, including preterm delivery, fetal loss, abortion, uterine rupture and direct or indirect fetal injuries.

C. Maternal and Fetal Acidosis from absorption of carbon-di-oxide [1-3].

During the last decade, multiple case reports, clinical studies and meta-analysis have proven the safety and feasibility of laparoscopic procedure during pregnancy, resulting in paradigm shift, and it is being used for even complex procedures [4-10]. Laparoscopic surgery being minimally invasive offers similar benefits as in non-pregnant state such as less postoperative pain, postoperative ileus, reduced hospital stay, earlier functional recovery and overall well-being. Other benefit of laparoscopy includes lower incidence of infection and incisional hernia, lower rate of thrombo-embolism, reduced manipulation of uterus [10-13].

Laparoscopy has special advantages during pregnancy as the anatomical location of abdominal organ may shift due to enlarged uterus and their exact locations may be difficult to predict and if they are subjected to laparotomy may require a quite longer incision to find and localise the target organ. In selected patients, diagnostic laparoscopy can be an alternative to radiologic imaging as this not only avoid the fetal radiation exposure, it provides direct visualisation of pathology, and allows any therapeutic intervention at the same setting [14]. Radiological imaging is still preferred over diagnostic laparoscopy for evaluation of acute abdomen during pregnancy [15,16]. When imaging is unavailable or inconclusive, Diagnostic laparoscopy can be considered. However, laparoscopy should be used very judiciously, as there may be an increased risk of preterm labour and fetal demise after diagnostic laparoscopic procedures [17,18].

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Maternal and fetal safety

Patient requiring abdominal surgery during pregnancy, in term of general well being and postoperative recovery, Laparoscopy appears to be associated with similar advantages as of non-pregnant patient undergoing laparoscopic surgery compared to laparotomy [10-13]. In addition, laparoscopy is associated with three fold reduced obstetrical complications such as preterm labour with or without preterm delivery, miscarriage and still birth, when compared with laparotomy [19-21]. Regarding the fetal safety after laparoscopy, prospective studies in human pregnancy are lacking. However, there are few case report and series failed to demonstrate any appreciable effects due to laparoscopy. Theoretically, laparoscopy may interact with multiple physiological changes during pregnancy, alteration of these physiology can adversely affect the developing fetus. Laparoscopic surgeries can be performed at any stage of pregnancy [22]. Although, technically challenging in the third trimester of pregnancy, laparoscopic can be used even in third trimester in experienced hand.

While it is easier technically in the first trimester, there is inherit risk of spontaneous abortion and potential teratogenesis of perioperative medications during organogenesis phase in first trimester. This has led many clinician delaying the surgery until the second trimester of pregnancy [22,23]. Some authors have suggested that the gestational age limit for successful laparoscopy should be between 26 to 28 weeks [24].

The decision to proceed to surgery or postponement until after parturition is an individualized decision based on the risk of maternal and fetal risk benefit ratio. The feasibility and success of laparoscopy in the third trimester depends on number of clinical factors such as Body Mass Index (BMI), size of gravid uterus, co-existing medical and obstetrical conditions, nature of the disorder being treated, experience of the surgeon etc. As such there is no absolute cut off gestational period beyond which laparoscopy cannot be performed, it's depends on technical feasibility and clinical judgment [22-25].

Physiologic changes in pregnancy

Pregnancy is associated with number of physiological changes in cardio-respiratory, haematological and other organ systems. Minute ventilation is increased by 50% higher than the non-pregnant women making them physiologically in a state of maternal respiratory alkalosis with its fetal counterpart in mild respiratory acidosis facilitating the oxygen delivery and carbon-di-oxide removal from the fetal circulation. As the pregnancy progresses, the enlarging uterus pushed the abdominal content and diaphragm upward resulting limiting the free space for normal lung expansion which in term leads to reduced Functional Residual Capacity (FRC) by 20% and decrease in expiratory reserve volume and residual volume and the same time the oxygen consumption in increased by 20-40% for growing fetus, placenta and increased metabolic activity of other organ system. This reduced FRC with increased metabolic demand for oxygen can potentially make pregnant women more prone for hypoxia, hypercarbia and other

respiratory complications [26]. Significant cardiovascular changes in pregnancy include increased in blood volume and cardiac output, mild dilutional anemia. These changes allow the mother and fetus to be adequately oxygenated [27].

Often overlooked are the changes in the haematological factors like mild anemia, increased n leucocyte counts increased in coagulation factors VII, XII, fibrinogen and reduced antithrombin III resulting in potential risk of venous thromboembolism [26,27]. When we come to the diagnosis of acute abdomen in pregnancy, sometime it is challenging. Physiological changes in pregnancy leading to nausea, vomiting due to reduced bowel motility, are common. Leucocytosis is considered normal in pregnancy. Presence of low grade fever, mild hypotension, physiological hyperventilation and anorexia are often normal in pregnancy. Moreover the enlarging gravid uterus pushed the abdominal content upward, altering the landmarks and true clinical picture of a particular condition, example the appendix may present as cholecystitis.

Abdominal surgery in pregnancy

About 2% of all pregnant women require abdominal surgical interventions during pregnancy for non-obstretical reason. The major issues for any abdominal surgery in a pregnant women are optimal care for maternal and fetal well being with best surgical approach [28-30]. The most common indication for non-obstretic surgery during pregnancy is appendectomy followed by cholecystectomy. Common indications for laparoscopic surgery during pregnancy are as follows

A.   Acute appendicitis

B.   Acute cholecystitis/ Cholelithiasis

C.   Acute abdomen of unknown etiology

D.   Adnexal torsion/ Tumour

E.   Symptomatic ovarian cyst

F.   Symptomatic myoma

G.   Trauma

H.   Pelvic or other gynecological malignancy surgery

Anaesthetic consideration

To ensure maternal and fetal safety, understanding of physiological changes and pharmacological adoptation to pregnancy and the effect of pathophysiology of disease itself is required. Avoidance of potentially harmful drug at critical times during fetal growth and maintenance of adequate utero-placental perfusion are paramount importance for fetal safety. General anaesthesia is the technique of choice of laparoscopic surgery irrespective of pregnancy. Induction of anaesthesia: The choice of anaesthetic drugs used for induction of anaesthesia is usually based on anaesthetist preference, and the clinical status of the patient (co-existing medical conditions, hydration, gestational age etc).

None of the commonly used anaesthetic induction agents (propofol, ketyamine, thiopentone, etomidate) has been proven

to be teratogenic or to have adverse effects on developing brain. Thiopentone is no longer available in many countries. Pre-oxygenation is routine in all pregnant patients, it prolonged the apnea period considerably. All pregnant women should be considered as difficult airway due to anatomical and physiological changes of pregnancy [31]. Adequate preoxygenation with 100% oxygen for 5 minutes is will take 3 minutes to decrease the saturation from 100% to 90% in a non-obese pregnant women in contrast to 9 minutes in non-pregnant and the desaturation time reduces to 90 second in a morbidly obese pregnant patient [31].

Although the incidence of aspiration at induction of anaesthesia in a properly fasted pregnant patient is low, Rapid Sequence Induction (RSI) of anaesthesia after adequate preoxygenation and with cricoid pressure is a safe technique in all pregnant patients irrespective of fasting status. Routine application of cricoid pressure, is debatable and many author no more advocate the routine application of cricoid pressure, its effectiveness is not only questionable, it often worsen the intubating condition and make an easy looking airway into a difficult one. It may also decrease the tone of lower esophageal sphincter [32]. Airway management of pregnant women with difficult airway is similar to that for a non-pregnant patient, although when the fetus is viable, due consideration to be given for both maternal and fetal status during the intubation process.

Obstetrical consultation

A preoperative consultation with senior obstetrician should be obtained in all pregnant women who need laproscopic surgical procedure, but waiting for consultation with obstetrics should not delay definitive surgical treatment as that may increase the maternal risk. Preoperative and postoperative fetal assessment is recommended whenever possible [13]. Fetal Heart Rate (FHR) should be confirmed usually with a transabdominal doppler device and it should be documented both immediately before induction of anaesthesia and immediately after the surgery. Transabdominal fetal monitoring during the pneumoperitoneum is usually not possible. Whenever the intraoperative fetal monitoring is necessary, FHR can be monitored abdominally through steep leftward tilt or transvaginal ultrasound assessment of the FHR [11,33].

Patient positioning

Depending on the surgical procedure, patient is placed either supine trendelenburg, reverse trendelenburg or lithotomy position. When any pregnant patient is placed in supine position, the gravid uterus exert pressure on the inferior vena cava and possibly aorta resulting in reduced venous return to the heart resulting in reduced cardiac output and maternal hypotension. Pregnant patients beyond the first trimester should be placed in the left lateral decubitus position or leftward tilt to avoid aorto-caval compression. Such left ward position may be a hindrance for the surgeon, instead of left lateral position, a carefully prepared wedge placing on left side of pt flank can also be used to displace the gravid uterus falling

directly on the aorta and vena cava. Once the pneumoperitoneum is created, patient's position can be adjusted to allow gravity to aid with surgical visualisation or use of extra port or hand-assist device to bring the adnexa in the operative area [3,22]. Extreme position for surgical comfort may not be feasible. The degree of positioning depends on patient build, co-morbid conditions the gestational age.

Placement of surgical trocar

Pregnant patients undergoing laparoscopic surgery are potentially at risk of trocar injury, inadvertent placement into uterus has been reported [34]. Abdominal access can be safely done with either open(Hasson), closed or optical trocar technique, when used appropriately as per the expertise of the surgeon. To establish pneumoperitoneum using Veress needle can be inserted in 1-2cm below costal region in midclavicular line [3,22] The stomach should be properly deflated if a blind technique is used to minimize the risk of entering into stomach. Some surgeons preferred an open trocar technique over blind Veress needle for safety concern. The abdominal domain is altered after first trimester of pregnancy, to improve safety, initial trocar placement should be altered as per the gestational age to account for the increased size of the gravid uterus [22,35-37].

Supra-umbilical placement of primary port is a common and safe practice, we recommend the initial port placement to be at least 6cm above the fundal height keeping abdominal wall elevated. Other alternating trocar placement sites are sub-xiphoid, left or right upper quadrant with corresponding lateral displacement of the uterus to avoid uterine injury. Single port laparoscopy, also known as Laparo Endoscopic Single-site Surgery (LESS) utilities a single large port through which multiple operating channels are introduced. It is technically challenging beyond the first trimester as the enlarging uterus make the working abdominal space greatly restricted [38,39].

Insufflation pressure

Maintenance of abdominal pressure well below the recommended level is mandatory specially in pregnant patients to avoid the possible unwanted effects on maternal pulmonary function and haemodynamic, particularly uterine blood flow due to increased abdominal pressure. During pregnancy, the diaphragm is already displaced upward, increasing abdominal pressure may further splint the diaphragm making it more restrictive. Minimal abdominal pressure that allow adequate space to operate should be used. Abdominal pressure should be keep below 12mmHg and should never exceed 15mHg [22]. Gas-less laparoscopy may be an alternative and safer alternative to traditional carbon-di-oxide pneumoperitoneum, but require specialized abdominal wall lifting devices to create a working space inside the abdomen [39,40].

Intra-operative carbon-dioxide monitoring

Because carbon-dioxide exchange occurs with pneumoperitoneum, with absorption of excess carbon-dioxide in

abscess of deliberate hyperventilation, the resulting hypercarbia may have deleterious effects to the fetus including fetal acidosis [40-43]. However, fetal acidosis with pneumoperitoneum has not been documented in human fetus [24]. Concerns over potential harmful effects hypercarba led to the expert to recommend for maternal monitoring of CO_2 [22]. Measurement of End-Tidal CO_2 (ET CO_2) is adequate for intraoperative CO_2 in laparoscopic surgery using CO_2 pneumoperitoneum. There was debate on use of ET CO_2 over Arterial Blood Gas (ABG) as during pregnancy there might be changes in ventilation- perfusion mismatch resulting in gap between arterial to End-Tidal CO_2.

However, subsequent studies failed to demonstrate such a large gap. Several large studies have demonstrated that ET CO_2 is reliable and reflect adequately the blood CO_2 in pregnant women, making routine blood gas monitoring unnecessary [24,44-46]. If respiratory acidosis due to CO_2 is suspected and confirmed, it should be reversed immediately by hyperventilating the mother, decreasing the intrabdominal pressure. If these measures are ineffective, holding the surgery and temporarily deflation of the abdomen along with hyperventilation should be done to reduce the acidosis and improve the placental blood flow and fetal oxygenation [24].

Thromboprophylaxis

Pregnancy is a thrombogenic state, pregnant patients are at higher risk of developing Deep Venous Thrombosis (DVT) with an incidence of 0.1-0.2%, the risk is further increased by pneumoperitoneum due to venous stasis [20]. Intrabdominal pressure of 12mmHg causes a significant venous stasis in lower limb that cannot be completely reversed with intermittent pneumatic compression devices [47,48]. There is no clear guideline or recommendation on the use of heparin or fractionated heparin or mechanical pneumatic compression devices as prophylaxis for DVT in pregnant patients. The society of American Gastrointestinal and endoscopic surgeons has recommended use of intermittent pneumatic compression devices and early postoperative ambulation for all pregnant patients undergoing laparoscopic surgical procedures [22].

American College of Chest Physicians (ACCP) clinical practice guideline on the on thromboprophylaxis recommends either mechanical or pharmacological thromboprophylaxis for pregnant patients undergoing surgical procedures [49]. We suggest to use low molecular weight heparin along with pneumatic devices as thromboprophylaxis for laparoscopic procedure likely to take more than 1 hour, intermittent pneumatic compression device is a reasonable alternative for shorter procedure. Low molecular heparin has proven safe during pregnancy and is the agent of choice for pharmacological thromboprophylaxis [50].

Prophylactic tocolysis

There is no evidence to support the routine use of tocolytic drug to inhibit the uterine activity and preterm labour. Similarly no evidence to support the use preoperative glucocorticoid therapy. However, these medication should be used in consultation with obstetrician in the management of threatened preterm labour. Only effective measure that may reduce the risk of premature uterine contraction is by minimizing the manipulation of the uterus.

Postoperative care

post operatively FHR and uterine activity should be monitored as appropriate for gestational age and documented in recovery room. Region analgesia in the form of abdominal blocks, epidural analgesia are ideal choice for postoperative analgesia in pregnant patients. Paracetamol and Opioid analgesics can be safely used as needed for the postoperative pain. Non-steroidal Anti-Inflammatory Drugs (NSAIDS) should be avoided if possible, especially after 32 week as they may cause premature closure of fetal ductus arteriosus. The presence of a recent abdominal surgery does not preclude pushing in the second stage of labour, cesarean section is performed for standard obstetrical indications only [51].

Common Laparoscopic Procedures During Pregnancy

Cholecystectomy

laparoscopic cholecystectomy is the treatment of choice for symptomatic cholelithiasis irrespective of gestational age. Non-operative conservative management of symptomatic cholelithiasis during pregnancy is no more recommended as there are higher rate of recurrent symptoms, preterm labour in upto 20% and fetal loss in 10-60% of cases, depending on the disease severity. There has been no report of increased miscarriage after first trimester or preterm delivery after third trimester of laparoscopic cholecystectomy. When compared with open cholecystectomy, laparoscopic cholecystectomy is associated with reduced rate of miscarriage and preterm labour [52-57].

Laparoscopic appendectomy

Laparoscopic appendectomy is preferred over laparotomy in pregnant patients with acute appendicitis. Because of high rate of complications like peritonitis, fetal demise, preterm labour, non-operative medical management of uncomplicated acute appendicitis during pregnancy is not recommended. Proper radiological diagnosis is essential before subjecting to laparoscopy on clinical suspicion only as negative laparoscopy for presumed appendicitis may be associated with increased maternal morbidity, preterm delivery or even fetal demise. When the diagnosis is uncertain after ultrasound and clinical findings, Magnetic Resonance Imaging (MRI) is the preferred imaging tool to establish an accurate diagnosis [58-63].

Adnexal masses

There is about 2% incidence of adnexal masses during pregnancy, most of these adnexal masses (less than 6cm) that appear during first trimester are functional ovarian cyst and resolve spontaneously by the end of 2nd trimester. Persistent asymptomatic masses should be evaluated regularly with ultrasound and tumour marker (CA-125, LDH) for potential malignant transformation. Laparoscopy is safer than laparotomy during pregnancy with symptomatic ovarian masses at all trimester. Observation is

warranted for all asymptomatic cystic mass less than 6 cm before subjecting them to surgery [64-69]. 10-15% of all adnexal masses undergo torsion, Laparoscopy is the technique of choice for both diagnosis and treatment in the pregnant patient with torsion of adnexal masses. For small adnexal mass when the tissue are completely viable, simple laparoscopic detorsion can be done. However, most torsion are presented late and often require complete surgical excision [69-71].

Summary and Recommendation

A. Laparoscopy can be safely performed during any trimester of pregnancy when surgery is indicated.

B. There is no maximum gestational age beyond which laparoscopy cannot be performed, although the optimal timing is between 26-28 weeks.

C. In the absence of access to imaging modalities, laparoscopy may be used selectively in the workup and treatment of acute abdominal processes in pregnancy.

D. Laparoscopy offers similar benefits to pregnant and non-pregnant patients compared to laparotomy.

E. Pregnant patients are at higher risk of regurgitation and aspiration, Rapid sequence induction is the preferred technique for induction of anaesthesia.

F. From 2nd trimester onward, pregnant patients should be placed in left lateral position to minimise vena caval compression by gravid uterus.

G. Intraoperative and postoperative pneumatic compression devices and early postoperative ambulation are recommended prophylaxis for deep venous thrombosis in the gravid patient , pharmacologic thromboprophylaxis should be added for procedure lasting more than 1hr.

H. Initial abdominal access can be safely accomplished with an open (Hasson), Veress needle, or optical trocar technique, by surgeons experienced with these techniques, modification of initial trocar placement is necessary when the uterus is significantly enlarge.

I. Intraabdominal pressure to be maintained between 8-12mmHg and should not exceed 15mHg to avoid reduction in uterine blood flow. The level of insufflation pressure should be adjusted to the patient's physiology.

J. ET CO_2 Monitoring is mandatory and should be kept between 32-35mHg. If maternal hypercapnia is suspected or confirmed, immediate hyperventilation with reduction of intra-abdominal pressure has to be done to improve placental perfusion.

K. FHR should be monitored and documented immediately before and at the end of the procedure, when intraoperative FHR monitoring is necessary, extreme left lateral tilt or transvaginal ultrasound assessment of FHR can be done.

There is no evidence of routine tocolytic or glucocorticoid therapy in the perioperative period unless there is evidence of preterm labour.

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