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REVIEW ARTICLE

Laparoscopic procedures during pregnancy and the risks of anesthesia: what does an obstetrician need to know?

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Abstract
Background Nonobstetric surgery may be necessary during any stage of gestation.
Methods The purpose of this article is to review the current recommendations (using Medline search for the relevant publications) for the perioperative anesthetic management of pregnant women undergoing laparoscopy for indications unrelated to pregnancy.
Results The current estimates of the incidence of nonobstetric surgery in pregnancy range from 1% to 2%. Laparoscopy is the most common surgical procedure performed in the first trimester of pregnancy, whereas appendectomy is the most common procedure performed during the remainder of pregnancy.
Conclusions In the past pregnancy was considered as an absolute contraindication to laparoscopy. However, recent years have brought an extensive experience with this technique during gestation.

Keywords Pregnancy · Surgery · Nonobstetric · General · Laparoscopy · Obstetric anesthesia · Safety · Complications

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Surgery during pregnancy

In the United States nearly 80,000 pregnant women undergo nonobstetric surgery each year [1, 2]. Estimates of the incidence of nonobstetric surgery in pregnancy, which may be required for a number of medical indications, and at any gestational age, range from 1 to 2% [1–4]. The timing and indications for the surgical procedure seem critical to the maternal and fetal outcome. Maternal nonobstetric surgery conducted during pregnancy necessitates modification of both surgical and anesthetic techniques.

Laparoscopy is the most common surgical procedure performed in the first trimester of pregnancy, whereas appendectomy is the most common procedure performed during the remainder of pregnancy [4–7]. In the past, pregnancy was considered as an absolute contraindication to laparoscopy [4]. However, recent years have brought an extensive experience with this technique during gestation. Similar to the general population, pregnant women and their fetuses could benefit from the reduced manipulation associated with laparoscopy [5, 7]. In general, laparoscopy is well tolerated by both mother and fetus during pregnancy [6, 7]

The goal of this article is to review the current recommendations for the perioperative anesthetic management of pregnant women undergoing laparoscopy for indications unrelated to pregnancy.

Anesthesia for nonobstetric surgery

Although the safety of nonobstetric surgery and anesthesia in pregnancy has been well established for nearly every operative procedure [1–14], the choice of anesthesia for nonobstetric surgery including laparoscopy still poses a

clinical dilemma for all parties involved including the parturient, the surgeon, the obstetrician and the obstetric anesthesiologist. Close interdisciplinary communication and cooperation between the surgeon, the obstetric anesthesiologist and the obstetrician is essential in the provision of optimal perioperative care for these high-risk patients [3, 6, 7, 9–20].

The choice of anesthesia is generally guided by maternal indications, and the site and nature of surgical procedure planned. Most abdominal surgical procedures, including laparoscopy, however, require general anesthesia and muscle relaxation.

The mother

The pregnancy-induced anatomical and physiological changes (Table 1) [11, 19, 20] must be fully appreciated to ensure optimal multidisciplinary perioperative care [2, 11, 20]. This knowledge is essential to tailor a safe anesthetic plan for this high-risk group of patients. Preservation of maternal hemodynamic stability, uteroplacental blood flow, and avoidance of maternal and fetal hypoxia throughout surgery is mandatory (Table 2) [13–19]. Avoidance of preterm labor is critical, and obstetric involvement in patient care throughout surgery is needed [15, 17]. The mother should be fully informed about the low risks of teratogenicity associated with the modern anesthetic agents that are in current use [1, 2, 15, 17].

Table 1 Physiological changes during pregnancy of anesthetic significance/implications

Major body system affected	Change ("+" increase or "−" decrease) (%)
Central nervous system	
Minimal alveolar concentration (MAC) for potent inhalational agents	−40
Cardiovascular system	
Peripheral vascular resistance (PVR)	−15
Heart rate (HR)	+15
Stroke volume (SV)	+30
Blood volume (BP)	+35
Cardiac output (CO)	+40
Plasma volume (PV)	+45
Pulmonary system	
Functional residual capacity (FRC)	−20
HCO_3	−15
$PaCO_2$	−15
PaO_2	+10
Respiratory rate (RR)	+15
Oxygen consumption	+20
Tidal volume (VT)	+40
Minute ventilation (MV)	+50
Hematological system	
Hemoglobin	−20
Clotting factors	+50 to 200
Renal system	
Glomerular filtration rate (GFR)	+50

Table 2 Principles of safe obstetric anesthesia practice

1. Understanding the anatomical and physiological changes of pregnancy
2. Maintaining an adequate uteroplacental blood flow
3. Avoiding and treating hypotension
4. Avoiding aorto-caval compression
5. Selecting anesthetic drugs and techniques with good record for safety
6. Employing regional anesthesia whenever possible
7. Remembering that no anesthetic agent drug has been proven teratogenic in humans
8. Making appropriate perioperative adjustments in technique as guided by the results
9. Providing fetal surveillance and monitoring uterine activity whenever feasible

The fetus

The hazards to the fetus may come from teratogenic effects of drugs administered in the perioperative period, including anesthetic agents, from premature labor, from alterations in uteroplacental blood flow, and from maternal hypoxia and/or acidosis [2, 17]. Since the period of organogenesis is during the first trimester of pregnancy, it is commonly advised that all but truly emergent surgery be postponed until later in pregnancy to avoid potential teratogenicity and intrauterine fetal death. Premature labor is more likely in the third trimester. Although the risks to the fetus are quite real, careful management should minimize potential fetal harm [1–10, 21–23]. The principles of safe obstetric anesthesia practice are outlined in Table 2.

There are three determinants (Table 3) [24] of transplacental drug transfer from the mother to the fetus. The studies of transplacental drug transfer in humans are difficult for ethical considerations, and the applicability of animal studies as models for the human placenta is limited because the anatomy and function of the placenta are species-specific [17].

Since it is clear that virtually every drug and every inhalation anesthetic is teratogenic to some species under

Table 3 Major determinants of transplacental drug transfer

1. Physical and chemical property of the drug
2. Characteristics of the maternal, placental and fetal circulations
3. Anatomy and physiology of the placenta

certain conditions, there is no *best* anesthetic agent [1–4, 25–30]. None, has as yet, been identified as a definite human teratogen [30–35].

Although the evidence currently remains encouraging, we cannot assume that some potential for teratogenicity does not exist. It is therefore most prudent to postpone elective surgical procedures until after pregnancy [1–8, 35]. If this is not possible then the first trimester should be avoided.

Preanesthetic medications

Although nonobstetric patients often receive various preanesthetic medications prior to anesthesia; sedative drugs are usually avoided in pregnancy. If necessary, the anesthesiologist may give a small dose of a benzodiazepine (e.g., midazolam 0.5–2 mg) and/or an opioid (e.g., fentanyl 25–50 μg) intravenously [15, 19]. Small doses of these drugs should result in minimal fetal depression.

In selected cases, it may be necessary to administer an anticholinergic agent, which decreases secretions and lessens the likelihood of bradycardia during anesthesia. When anticholinergic agent is indicated, glycopyrrolate may be given intramuscularly 30–60 min before the induction of anesthesia or intravenously just before the administration of anesthesia. Glycopyrrolate does not readily cross the placenta, and it is the anticholinergic agent of choice [3, 15, 19].

Metoclopramide is a procainamide derivative that is a cholinergic agonist peripherally and a dopamine receptor antagonist centrally. A 10-mg intravenous dose of metoclopramide increases lower esophageal sphincter tone that has an antiemetic effect and reduces gastric volume by increasing gastric peristalsis. Metoclopramide can have a significant effect on gastric volume in as little as 15 min. Metoclopramide crosses the placenta, but studies have reported no significant effects on the fetus [15].

The pregnant women should also receive 30 ml of sodium bicitrate orally prior to induction of general anesthesia for nonobstetric surgery to reduce gastric acidity [2, 3].

The drugs of anesthesia

The diagnosis of any medical condition requiring laparoscopic surgical procedure during pregnancy often raises questions about the safety of both surgery itself and anesthesia in a gravid state, which are first directed to the obstetrician [1–4, 22, 35]. This section provides a review of the most common drugs used during the course of anesthesia, and their impact on the mother and fetus.

The fundamentals of pharmacology and the effects of drugs of anesthesia on the mother and fetus must be fully understood, and appreciated by all the members of the multidisciplinary team of experts (including not only the anesthesiologist but also the surgeon and the obstetrician) involved in the perioperative care of pregnant women undergoing laparoscopy and other nonpregnancy-related surgical procedures.

Outline

1. Intravenous induction agents
   a. Propofol
   b. Barbiturates
   c. Ketamine
   d. Etomidate
   e. Benzodiazepines
2. Opioid receptor agonists
3. Neuromuscular blocking drugs
   a. Succinylcholine
   b. Rocuronium
   c. Vecuronium
   d. Atracurium
4. Potent inhalational agents
5. Nitrous oxide

Intravenous induction agents

When selecting an intravenous induction agent, the primary goals are threefold: 1. to preserve maternal blood pressure, cardiac output, and uterine blood flow; 2. to minimize fetal depression; and 3. to ensure maternal hypnosis and amnesia [1–4, 15, 19].

Propofol

Propofol is a popular intravenous induction agent for general anesthesia in the obstetric patient [36]. Propofol allows a rapid, smooth induction of anesthesia. The drug produces dose-dependent decreases in cardiac output and arterial blood pressure. Propofol attenuates the cardiovascular response to laryngoscopy and intubation more effectively than does thiopental [25]. Propofol may also be administered by continuous intravenous infusion for the maintenance of anesthesia.

Propofol is a lipophilic agent with a low molecular weight, and it rapidly crosses the placenta. Dailland et al. [27] observed that the umbilical venous/maternal venous blood concentration ratio at delivery was 0.70. The authors also observed that propofol was rapidly cleared from the neonatal circulation, and they detected low concentrations of propofol in breast milk.

Propofol blunts the hypertensive response to laryngoscopy and intubation more effectively than the other induction agents; thus it may be a good choice for the induction of general anesthesia in hypertensive patients (e.g., parturients with pregnancy-induced hypertension) [28].

Barbiturates

Thiopental, thiamylal, and methohexital are the barbiturates commonly used for anesthesia. These drugs are very short-acting and are primarily used for induction of general anesthesia [36]. Barbiturates produce unconsciousness in one arm-to-brain circulation time (30 s). Recovery from the induction dose occurs in approximately 5–9 min as a result of their high-lipid solubility and rapid redistribution. Barbiturates decrease arterial blood pressure and cardiac output in a dose-dependent manner [36].

Thiopental rapidly crosses the placenta, and it can be detected in umbilical venous blood within 30 s of administration. The umbilical venous blood concentration peaks in 1 min. However, with doses of less than 4 mg/kg, peak barbiturate concentrations in the fetal brain rarely exceed the threshold for depression [3].

Ketamine

Ketamine is a congener of phencyclidine (PCP) [21]. The mode of action of ketamine is not well defined, but it may include antagonism at the *N*-methyl-D-aspartate (NMDA) receptors. Ketamine is usually employed as an induction agent; it produces unconsciousness in 30–60 s after intravenous induction dose, which may last for 15–20 min [36].

Ketamine is a very useful induction agent in obstetric patients [3, 15, 19]. It has a rapid onset of action, it provides both analgesia and hypnosis, and it reliably provides amnesia. In addition, its sympathomimetic properties are advantageous in patients with asthma or modest hypovolemia. Clinical studies have suggested that the use of ketamine is associated with a decreased incidence of maternal awareness when compared with administration of thiopental [30].

Ketamine should be avoided in hypertensive patients. Large doses of ketamine increase uterine tone. However, an induction dose of 1 mg/kg does not increase uterine tone [30, 36]. Ketamine rapidly crosses the placenta, and it reaches a maximum concentration in the fetus approximately 1.5–2.0 min after administration [16, 21].

Etomidate

Etomidate is an imidazole-containing hypnotic unrelated to other intravenous induction anesthetic agents. It is commonly used for intravenous induction of general anesthesia [36]. Etomidate is an intravenous induction agent that has been used in obstetric anesthesia practice since 1979. Etomidate produces a rapid onset of anesthesia in one arm-to-brain circulation time. It undergoes rapid hydrolysis, which results in a rapid recovery period. It produces a dose-dependent decrease in tidal volume and the respiratory rate [15, 19].

Etomidate also may result in the suppression of fetal serum cortisol concentrations, although it is unclear whether this level of suppression is clinically significant. Etomidate causes little cardiovascular depression; thus it is an excellent choice in patients with hemodynamic instability [19].

Benzodiazepines

Benzodiazepines used for anesthesia include midazolam, diazepam, and lorazepam [36]. These drugs are often used for sedation, amnesia, and as adjuncts to general anesthesia. Barbiturates produce amnestic, anticonvulsant, hypnotic, sedative, and muscle-relaxant effects in a dose-dependent manner [15, 19, 36]. Both midazolam and diazepam redistribute rapidly. Benzodiazepines produce a mild systemic vasodilatation and reduction in cardiac output. Benzodiazepines cross the placenta and may lead to a depressed neonate. When administered in the first trimester of pregnancy benzodiazepines may lead to birth defects (cleft lip and palate) [1, 2, 15].

Midazolam is a short-acting, water-soluble benzodiazepine that has few adverse hemodynamic effects and provides hypnosis and amnesia. Midazolam rapidly crosses the placenta, although it may not cross as rapidly as thiopental and diazepam [15, 19, 29].

Opioid receptor agonists

Fentanyl, sufentanil, alfentanil, remifentanil, morphine, and meperidine are the most popular opioid receptor agonists (opioids) used in modern general anesthesia [37]. Their primary effect is analgesia. Therefore, they are used to supplement other (e.g., potent inhalational and/or intravenous) agents during induction and/or maintenance of general anesthesia. The opioids differ in their potency, pharmacokinetics, and the side effects. Their mechanism of action involves binding at the specific receptors in the brain and spinal cord [2, 37].

Opioids and induction agents decrease the fetal heart rate (FHR) variability and fetal depression; possibly to a greater extent than the potent inhalational agents [1, 4, 16]. However, fetal respiratory depression is relevant only if Cesarean section is to be performed at the same time as the laparoscopic or any other nonpregnancy-related surgical procedure.

Neuromuscular blocking agents

Neuromuscular blocking agents are categorized by their mechanism of action as depolarizing (e.g., succinylcholine), and nondepolarizing agents (e.g., vecuronium, rocuronium). Neuromuscular blocking agents provide relaxation of the skeletal muscles to facilitate intubation of the trachea, controlled mechanical ventilation of the lungs, and optimal surgical (operating) conductions [38]. These drugs have structural similarities to the endogenous neurotransmitter acetylcholine (Ach).

A small dose of a nondepolarizing muscle relaxant may be given 3–5 min before induction of general anesthesia to prevent fasciculations after the administration of succinylcholine [15]. Alternatively, this small dose may serve as a priming dose if a nondepolarizing agent will be used to achieve muscle relaxation.

Succinylcholine

The depolarizing agent succinylcholine remains the muscle relaxant of choice for most obstetric patients. This dose provides complete muscle relaxation and optimal conditions for laryngoscopy and intubation within approximately 45 s of intravenous administration [3, 38]. Succinylcholine is highly ionized and water soluble and only small amounts cross the placenta. Maternal administration of succinylcholine rarely affects fetal neuromuscular function.

Succinylcholine is rapidly metabolized by plasma pseudocholinesterase. Pseudocholinesterase activity decreases 30% during pregnancy, but recovery from succinylcholine is not prolonged [1, 15]. The parturient's increased volume of distribution offsets the effect of the decreased pseudocholinesterase activity. The obstetric anesthesiologist should confirm the return of neuromuscular function before giving additional doses of muscle relaxant.

Rocuronium

Rocuronium is a suitable alternative to succinylcholine when a nondepolarizing agent is preferred for rapid sequence induction of general anesthesia in the pregnant patient [15, 38]. Magorian et al. [39] demonstrated that a larger dose of rocuronium (0.9 or 1.2 mg/kg) results in an onset of paralysis similar to that provided by succinylcholine, but that the duration of action is prolonged.

Vecuronium

Vecuronium may be administered when the use of succinylcholine is contraindicated; however, it has a significantly slower onset of action. Moreover, the duration of the neuromuscular blockade may be prolonged [15].

Atracurium

Atracurium is a less desirable agent for rapid sequence induction of anesthesia. The high dose required for a rapid onset of action may result in significant histamine release and hypotension [38]. The isomer cisatracurium does not have these undesirable side effects, but its relatively slow onset makes it undesirable for use during rapid sequence induction of general anesthesia.

Regardless of the choice of muscle relaxant, laryngoscopy and intubation should not be attempted until adequate muscle relaxation has occurred [3, 15]. The use of a nerve stimulator allows an objective assessment of the onset of paralysis and also guides the administration of additional doses of muscle relaxant. Only very small amounts of the nondepolarizing muscle relaxants cross the placenta; thus the fetus rarely is affected. In most cases, the anesthesiologist should not attempt ventilation before insertion of the endotracheal tube [19, 20].

Potent inhalational agents

Dosages of potent inhalational agents are expressed as minimal alveolar concentration (MAC), which inhibits movement in response to a skin incision in 50% of patients [40]. Potent inhalational agents in adults are usually administered for the maintenance phase of general anesthesia. The potent inhalational agents in use today include isoflurane, desflurane and sevoflurane.

Potent inhalational agents can affect the fetus indirectly by causing maternal hypotension and/or hypoxia or directly by depressing the fetal cardiovascular or central nervous system [1, 3]. Studies in an animal model (gravid ewes) have shown minimal maternal and fetal effects with administration of moderate (e.g., 0.75-1.0 MAC) concentration of volatile halogenated agents. However, higher concentrations of volatile halogenated agents (e.g., 2.0 MAC), associated with prolonged exposure have been shown to cause maternal hypotension, decreased utero-placental blood flow and affect the fetus (e.g., fetal hypoxia and acidosis) [1].

Nitrous oxide

Nitrous oxide is a clear, colorless, and odorless gas, which produces general anesthesia through the interactions with the cellular membranes within the central nervous system [40]. Uptake and elimination of nitrous oxide are rapid, primarily as a result of its low blood–gas partition coefficient. It produces some analgesia, and in concentrations greater than 60% may produce amnesia.

Because of its high solubility nitrous oxide may diffuse into the cuff of an endotracheal tube and lead to a marked increase in cuff pressure, which could result in significant

airway management complications (e.g., high cuff pressure-related ischemia of the tracheal mucosa) [41–44]. This may be particularly important in pregnant patients because of physiological changes of pregnancy, which include narrowing of the airway secondary to edema.

Laparoscopic procedures in pregnancy

Similar to the general population, pregnant women and their fetuses could benefit from the reduced manipulation associated with laparoscopy. In the past, pregnancy was considered as an absolute contraindication to laparoscopy [4]. However, recent years have brought an extensive experience with this technique during gestation [7]. In general, laparoscopy is well tolerated by both mother and fetus during pregnancy [9, 10]. Case series have reported increased utilization of laparoscopy in the pregnant patient with minimal apparent adverse effects, if any, compared with laparotomy. However, by the end of the second trimester, the size of the uterus often interferes with the laparoscopic view and approach and open surgery may be indicated [45].

Laparoscopic surgery during pregnancy is a challenging procedure that many surgeons are reluctant to perform. However, there are many benefits of laparoscopic surgery over conventional open approach for the pregnant patients. These include less postoperative pain, earlier return of normal respiratory and gastrointestinal function, faster return to normal activity level, and shorter hospital stay [2, 4]. However, many laparoscopy-specific maternal and fetal implications still exist. These include: 1. risk of uterine and/or fetal trauma, 2. risk of fetal acidosis from carbon dioxide absorption, 3. decreased maternal cardiac output, and 4. risk of decreased uteroplacental blood flow secondary to increased intraperitoneal pressure [4]. Careful anesthetic and surgical technique is necessary to avoid complications of laparoscopy in the pregnant state.

Reedy et al. [46] studied 2,233 laparoscopic and 2,491 open laparotomy cases from 2 million deliveries in Sweden from 1973 to 1993. Outcomes evaluated birth weight, gestational duration, intrauterine growth restriction, congenital malformations, stillbirths, and neonatal deaths. There were no statistically significant differences comparing the laparoscopy group with the laparotomy group [46].

The Society of American Gastrointestinal Endoscopic Surgeons [10] has issued Guidelines for Laparoscopic Surgery During Pregnancy, which recommend the following: 1. deferring the surgery until the second trimester, 2. using intermittent pneumatic compression devices to prevent thrombosis resulting from lower extremity stasis, 3. monitoring fetal wellbeing and maternal uterine contractions, 4. monitoring maternal end-tidal carbon dioxide concentration, and arterial blood gas measurements, 5. using an open technique to open an abdomen, 6. avoiding aorto-caval compression and hypotension, 7. maintaining low pneumoperitoneum pressures (below 15 mmHg), and 8. obtaining early obstetric consultation.

General anesthesia is used for the vast majority of laparoscopic nonobstetric surgery in pregnancy. Endotracheal intubation with positive pressure ventilation is favored for several reasons: 1. the risk of regurgitation from increased intra-abdominal pressure, 2. the need for controlled ventilation to prevent hypercapnia, 3. the need for relatively high-peak airway pressures, 4. the need for muscle relaxation (paralysis), and 5. the need for the placement of a nasogastic tube [4].

The creation of pneumoperitoneum my lead to a decreased lung compliance and increased peak airway pressures. These changes may be further exacerbated by the Trendelenburg position. Hunter et al. [47] showed that pneumoperitoneum with carbon dioxide can induce a mild metabolic acidosis with an increase in heart rate and blood pressure compared with controls in sheep experimental studies. However, this acidosis was not clinically significant and was likely secondary to carbon dioxide re-absorption [47]. Hyperventilation, which may be necessary to maintain physiological maternal end-tidal carbon dioxide concentration, may reduce uteroplacental blood flow and fetal oxygen delivery. Fetal heart rate and maternal uterine contractions should be continuously monitored by a trained individual (e.g., Labor and Delivery nurse).

Appendicitis is the most common operative indication for nonobstetric surgery in pregnancy, with an occurrence of about 1 in 1,500 pregnancies. However, the clinical diagnosis of appendicitis is more difficult in the pregnant patient [48]. It is generally believed that as pregnancy progresses, and the uterus enlarges it pushes the appendix superiorly. However, clinical studies have shown that the majority of pregnant women presenting with appendicitis have right lower quadrant pain, not right upper quadrant pain [49]. Other clinical signs used to diagnose appendicitis may not have the reliability in the pregnant patient. The risk of a perforated appendix on the fetus may be substantial, with fetal loss occurring approximately 20% of the time in that setting [50]. Computed tomography imaging can be useful in diagnosing appendicitis, although the fetal radiation exposure should be considered.

Pregnancy is not a contraindication to the laparoscopic approach to appendicitis or symptomatic cholelithiasis. We believe that laparoscopic operations, when performed by experienced surgeons, are safe and even preferable for the mother and the fetus. Intraoperatively, the surgeon should try to avoid manipulation of the uterus during the procedure. Perioperative fetal monitoring should be used in pregnancies older than 23–24 weeks.

Obstetricians may also recommend tocolytics to prevent preterm labor, as this may complicate the early postoperative course [3, 7].

Halkic et al. [7] conducted a retrospective chart review study designed to evaluate the safety of laparoscopic appendectomy and cholecystectomy in pregnant women. Out of the total number of 3,356 laparoscopic procedures performed at their institution between 1990 and 2005 the authors identified 16 cases of laparoscopic surgery performed on pregnant women. The laparoscopic surgeries on these 16 parturients were performed either in the second or third trimester of pregnancy (between 22 and 32 weeks of gestation). These included 11 cases of laparoscopic appendectomies and 5 cases of laparoscopic cholecystectomies. Three patients were in their second trimester (weeks 22, 23, and 25), and 13 were in the third trimester, weeks 27 (three patients), 28 (five patients), 31 (three patients), and 32 (two patients). No maternal or fetal morbidity was reported. The authors concluded that laparoscopic management of appendicitis and biliary colic during pregnancy is safe; however they recommended that the second trimester is preferable for laparoscopic cholecystectomy [7].

Respiratory changes during laparoscopy

Intraperitoneal insufflation of carbon dioxide (CO_2) to create pneumoperitoneum for laparoscopic procedure leads to several important changes in the respiratory system (Table 4). First, pneumoperitoneum decreases the lung and thoracic wall compliance. In healthy subjects compliance is on average reduced by 40% [51]. Second, pneumoperitoneum elevates the diaphragm leading to reduction in the functional residual capacity of the lungs. Third, pneumoperitoneum increases peak airway pressures. Fourth, pneumoperitoneum increases the partial pressure of arterial carbon dioxide ($PaCO_2$). The partial pressure of arterial carbon dioxide increases (on average 15–20%) as a result of absorption of CO_2 from the peritoneal cavity. Four principal respiratory complications of pneumoperitoneum include: carbon dioxide-induced subcutaneous emphysema, endobronchial intubation and gas embolism [51].

Table 4 Major respiratory changes during laparoscopy

1. Decreased lung and thoracic wall compliance
2. Reduction in the functional residual capacity of the lungs
3. Increased peak airway pressures
4. Increased partial pressure of arterial carbon dioxide

Cardiovascular changes during laparoscopy

Intraperitoneal insufflation of CO_2 to create pneumoperitoneum for laparoscopic procedure also leads to several important changes in the cardiovascular system. Major hemodynamic changes during laparoscopy result from combined physiological effects of patient positioning, pneumoperitoneum, anesthesia and absorption of CO_2 (hypercapnia). In healthy subjects intraperitoneal insufflation of CO_2 during laparoscopy decreases cardiac output, while simultaneously increasing systemic and pulmonary vascular resistance and blood pressure. The steeper the tilt during laparoscopy, the greater is the decrease in cardiac output.

Summary

Optimum perioperative management of pregnant women presenting for the laparoscopic procedures for indications not related to pregnancy requires a thorough understanding of pregnancy-induced changes in maternal anatomy and physiology, fetal physiology, and the pharmacokinetics and pharmacodynamics of the drugs administered during the course of anesthesia [1–7, 52–60].

A successful maternal and fetal outcome is dependent on multidisciplinary (e.g. the surgeon, the obstetric anesthesiologist, the obstetrician) expert perioperative management of both the surgical disease process and the anesthesia. The ultimate goal of perioperative anesthetic care of these patients is to provide safe anesthesia to the mother while simultaneously minimizing the (potential) risks of anesthetics to the fetus [2, 3, 56, 59].

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