Laparoscopic Surgery in Pregnancy: Precautions and Complications

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INTRODUCTION

Since the advent of laparoscopic surgery in the 1980s, laparoscopic surgery has been popularized by surgeons throughout the world. However, routine laparoscopic surgery has been slow to catch the pregnant patient. Treatment of surgical disease in the gravid patient requires a unique and careful approach where safety of both the mother and the fetus are considered.

During pregnancy, due to the physiological changes that take place in the mother and considering the presence of a living fetus in utero, surgical conditions are handled with a lot of care and cautions. In past, pregnancy was considered to be absolutely contraindicated for laparoscopic intervention, but with better understanding of physiology of pregnancy and improved anesthetic and laparoscopic techniques, emergency laparoscopic procedures such as diagnostic laparoscopy for pain abdomen, appendicectomy, splenectomy, pheochromocytoma, and cholecystectomy are feasible in pregnancy. Lachman et al. have already reported 300 laparoscopic procedures during pregnancy.

The advantages of laparoscopic surgery are similar for pregnant and nonpregnant women; nevertheless, this procedure had been avoided during pregnancy because of concerns that it may be harmful to the fetus. Potential concerns include:

- The rise in intra-abdominal pressure during pneumoperitoneum could decrease uteroplacental blood flow and result in fetal hypoxia.
- Fetal acidosis could develop from absorption of carbon dioxide (CO_2).
- The fetus could be injured directly or indirectly if the uterus is perforated by a trocar or Veress needle.
- Uterine perforation may result in preterm premature rupture of the membranes and preterm delivery.

However, multiple case reports and case series describing the safe performance of laparoscopic procedures in pregnant patients have been published, resulting in a paradigm shift. Appendicitis, gallbladder disease, mesenteric cysts, and adnexal masses/torsion have been successfully managed laparoscopically during pregnancy. More advanced laparoscopic procedures, such as radical nephrectomy, splenectomy, adrenalectomy, retroperitoneal lymphadenectomy, and ventral hernia repair, have also been reported in gravid patients.

The responsibility of caring for two patients during one operation and the concern over potential harm to the unborn fetus due to the pneumoperitoneum and/or instrumentation are factors that have played a role in the delay of adapting laparoscopic surgery to the pregnant patient (**Fig. 1**). However, recent evidence suggests that not only is laparoscopic surgery safe in the pregnant patient in all three trimesters, but it is also often preferable.

During pregnancy, usually all surgical procedures are avoided to minimize various risks of anesthesia and

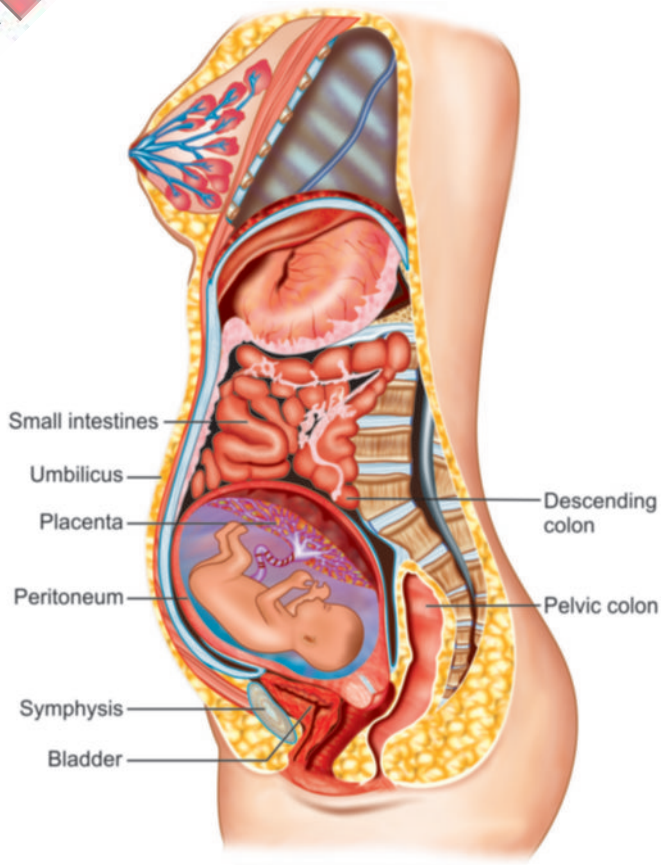

Fig. 1: Anatomical changes inside abdominal cavity during pregnancy.

procedure to mother and fetus. At times, emergency surgical conditions make it absolutely necessary for intervention. With increasing progress in minimal access surgery more and more surgeons have found the skill and interest to perform the emergency procedures laparoscopically. Laparoscopy was first done in pregnancy for diagnosis and evaluation. The first laparoscopic appendicectomy in pregnancy was performed by Scheiber in 1990. The first laparoscopic cholecystectomy in laparoscopy was first done in pregnancy for diagnosis and evaluation of acute abdominal pain in 1980.

However, surgical intervention in pregnant ladies needs special consideration of well-being of both mother and fetus; if intrauterine viable fetus is present, and in cases of ectopic pregnancy or heterotrophic pregnancy, the pathophysiological changes brought about during pregnancy should be considered for the safety of patient **(Fig. 2)**. Furthermore, with advancement of pregnancy laparoscopic diagnosis and procedures become more challengingly difficult as the gravid uterus displaces the organs and becomes completely an abdominal organ.

Up-to-date the data on laparoscopic procedures during pregnancy are still limited, but with growing ability of minimal access surgeons, the recent accumulating data shows that laparoscopic procedures such as diagnostic laparoscopy, adnexal surgery, appendicectomy, splenectomy, cholecystectomy, and management of ectopic and heterotrophic pregnancies are relatively safe and effective during pregnancy, if certain precautions are taken. But of course like all surgical procedures in pregnancy, there is an increased risk of certain complications with laparoscopic intervention in pregnancy.

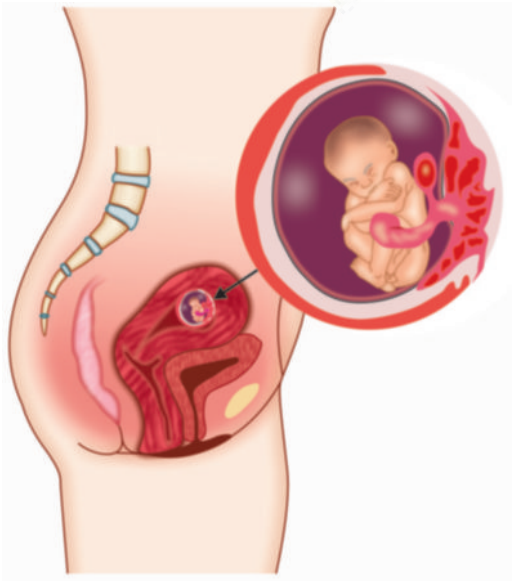

Fig. 2: Proper evaluation of patient is necessary to evaluate pathophysiological changes.

PHYSIOLOGICAL CHANGES IN PREGNANCY

Almost all the organ systems undergo physiological changes in pregnancy. These changes should be considered during operative procedures in pregnancy.

Gastrointestinal System

Due to enlarged gravid uterus, stomach is pushed toward diaphragm and assumes a more horizontal position. The viscera, such as transverse, ascending, and descending colon, are displaced, so location of abdominal pain and tenderness, especially in condition such as appendicitis, is altered. The hormonally-induced decrease lower esophageal sphincter tone causes gastroesophageal regurgitation which places the pregnant lady at higher risk of aspiration, so nasogastric tube suction and careful airway management is necessary for all pregnant patients undergoing laparoscopy.

Cardiovascular and Hematological Changes

Cardiac output and blood volume increase by 30–40%, but as RBC volume does not expand by same ratio, this results in physiological anemia, especially noticed in the second trimester. After 20 weeks' gestation, the gravid uterus compresses the aorta and inferior vena cava and may cause supine hypotension syndrome; so during surgery, the patient should be positioned in lateral recumbent position to avoid vena caval compression. A vasomotor block caused by spinal anesthesia produces more severe hypotension than in nonpregnant individuals. During pregnancy, WBC count increases to 12,000–14,900/mm.

A hypercoagulable state is physiologically developed in pregnancy due to increase in fibrinogen and other coagulation factors such as factor VII, factor VIII, factor IX, and factor X. Thus, the risk of thromboembolism increases in pregnancy.

Respiratory System

Due to enlarging gravid uterus, gradually the chest movements are restricted. There is an increase in minute ventilation and oxygen consumption and decrease in residual volume, also mixed venous oxygen content and functional reserve capacity also decreases so the patient is prone to hypoxemia and hypocapnia. $PaCO_2$ of 28–32 mm Hg, pH of 7.44, and decreased bicarbonate levels are detected due to chronic respiratory alkalosis which has to be maintained during pregnancy. The patient gains more weight during pregnancy and there is more edema in soft tissues of neck, so the anesthetist may face more difficulties in airway management.

Urinary System

Hydroureter, decreased urethral peristalsis, and bladder expansion increase incidence of urinary tract infection. There is an increased retention of water and electrolytes.

Other Changes

In addition to the respiratory changes, there are mild hematologic abnormalities in the pregnant patient. Levels of fibrinogen, factor VII, and factor XII are increased, whereas there are decreased levels of antithrombin III, all of which result in an increased risk of venous thromboembolism. When considering the acute abdomen in a pregnant patient, making the correct diagnosis may often be difficult. Nausea and vomiting, leukocytosis, low-grade fever, mild hypotension, and anorexia are common. The gravid uterus pushes the abdominal contents cephalad, displacing organs and inhibiting the migration of the omentum, causing altered landmarks and often distorting the clinical picture. During the second and third trimesters, the gravid uterus may cause decreased gastric motility and may lead to an increased risk of gastroesophageal reflux disease (GERD) and aspiration as well.

FETAL CONSIDERATION

Fetus is a hidden patient in the womb of the pregnant mother and its health should be considered by surgeon and anesthetist both. It is important to:

- Maintain uteroplacental blood flow and oxygenation. Decreased uteroplacental blood flow may be due to maternal hypotension or increase in uterine artery resistance.
- Maternal hypoxia causes fetal hypoxia and metabolic acidosis and in long-term; it may be fatal to infant, so it should be prevented.
- Avoid teratogenic drugs during anesthesia. Cocaine is known to have teratogenic effect so products containing cocaine should be avoided. Diazepam and nitrous oxide are considered safe during anesthesia as no teratogenicity was detected clinically.
- Avoid preterm labor. Try to manipulate uterus minimum as possible. Although, there is an increased incidence of spontaneous abortion, premature delivery, and low birth weight following anesthesia but in emergency situations operation is unavoidable.

EFFECTS OF PNEUMOPERITONEUM IN PREGNANCY DURING LAPAROSCOPIC PROCEDURE

In pregnant patient, the pneumoperitoneum increases the intra-abdominal pressure and this causes decreased inferior vena caval return to the heart, hence decreased cardiac output. With reverse Trendelenburg position, decreased cardiac output is even worsened, cardiac index decreases, and when this is combined with mothers hypoxia can cause fetal death. Increased intra-abdominal pressure also leads to decreased uterine blood flow and increased intrauterine pressure; these may, in turn cause fetal hypoxia and may lead to fetal death. Pneumoperitoneum decreases the diaphragmatic movement; in pregnant lady, already the movement of diaphragm is decreased due to bulky uterus, this further decreases the movement due to pneumoperitoneum causing increased peak airway pressure, decreased functional reserve capacity, increased ventilation–perfusion mismatch, decreased thoracic cavity compliance, and increased pleural pressure.

The use of CO_2 for causing pneumoperitoneum leads to hypercarbia and further hypoxemia. The CO_2 absorbs across the peritoneum and leads to respiratory acidosis in the patient and her fetus. If pCO_2 increases above 40 mm Hg, decreased removal of CO_2 occurs leading to fetal acidosis. Fetal tachycardia and hypotension may develop as a result of fetal hypocarbia. This can be corrected by maintaining mild maternal respiratory alkalosis, by hyperventilating the mother during surgery. Monitoring maternal arterial blood gases is better than monitoring $PaCO_2$ during laparoscopic procedures.

N_2O as the gas for pneumo-peritonization will not cause fetal respiratory acidosis, but it is highly combustible.

CRITERIA FOR PATIENT SELECTION

A safe laparoscopic procedure can be performed in all the three trimesters of pregnancy from 2 to 31 weeks.

During the first trimester, there is increase risk of abortion up to 12% also risk of teratogenesis increases in first trimester. In the third trimester, there is a 40% risk of preterm labor and 30% risk of premature birth. Also the visualization in laparoscopic procedure is decreased due to enlarged uterus.

Therefore, second trimester is considered as the safest time for laparoscopic surgery in pregnancy. The risk of abortion is not increased, no risk of teratogenesis, and risk of preterm labor is only 5% in second trimester.

ADVANTAGES OF LAPAROSCOPY IN PREGNANCY

- Short hospital stay
- Early return to normal activities
- Small incision, so rapid postoperative recovery and less incision complications such as hernia, postoperative wound infection and pain
- Less uterine manipulation and hence decreased uterine irritability and fetal loss

Risks of Laparoscopy in Pregnancy

- More chance of uterine injury during port entry as uterus becomes an abdominal organ after first trimester **(Fig. 3)**
- Problems associated with pneumo-peritonization as discussed already

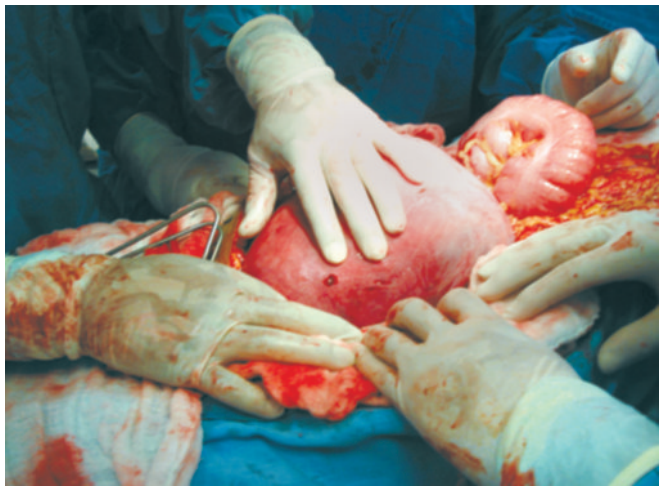

Fig. 3: Injury of pregnant uterus.

- CO_2 absorption causes increased CO_2 pressure and decreased arterial pH
- Risk of exposure to intra-abdominal smoke including carbon monoxide generated by electrosurgery and laser

Strategies for Safe Laparoscopic Surgery in Pregnancy

- Surgery should be done in second trimester.
- If patient presents in late third trimester, surgery should be postponed if possible until after delivery.
- Nasogastric incubation is a must in all cases, as there is a high risk of aspiration into the lungs.
- Patient can be placed in dorsal lithotomy position in the first-half of pregnancy, but in second-half to prevent inferior vena cava compression patient is ideally placed in lateral recumbent position.
- Hypotension should be avoided, proper fluid replacement should be done.
- Ideal method for commencing pneumoperitoneum is open Hasson trocar method. Placement of trocar depends on the size of gravid uterus.
- Tocolysis is indicated if signs of uterine irritability are present.
- Decrease operation time by using adequate number of ports, and using the most experienced surgeons.
- Maternal hyperventilation to maintain end-tidal CO_2 pressure at 32 mm Hg
- Lower CO_2 insufflations pressure of <12 mm Hg should be used to avoid fetal acidosis.
- Electrocautery should be used with care; the smokes containing carbon monoxide should be evacuated promptly to avoid toxic effect to fetus.
- Entry of all instruments must be under direct vision; care should be taken to avoid injury to the gravid uterus.
- All specimens should be removed with endobag to avoid spillage.
- Manipulators should never be fixed to vagina or cervix.

SAGES (Society of American Gastrointestinal Endoscopic Surgery) Recommendations

- Obstetrical consultation should be obtained pre-operatively.
- When possible, operative intervention should be deferred until the second trimester, when fetal risk is lowest.
- Pneumoperitoneum enhances lower extremity venous stasis already present in the gravid patient and pregnancy induces a hypercoagulable state. Therefore, pneumatic compression devices should be utilized whenever possible.
- Fetal and uterine status, as maternal end tidal CO_2 and/or arterial blood gases, should be monitored.
- The uterus should be protected with a lead shield if intraoperative cholangiography is a possibility.
- Fluoroscopy should be utilized selectively.
- Given the enlarged gravid uterus, abdominal access should be attained using an open technique.
- Dependent positioning should be utilized to shift the uterus away from the inferior vena cava.
- Pneumoperitoneum pressures should be kept at 10 mm Hg.
- Further studies into methods that increase the safety of laparoscopy in pregnant patient should be done.

DISCUSSION

Advances in laparoscopic surgery have led to development of methods to perform abdominal surgery and reduce morbidity using minimal access surgery techniques. In 1999, Lachman et al. reported on a series of pregnant women undergoing 518 surgical procedures. Cholecystectomy (45%) is the most common procedures performed during pregnancy followed by adnexal surgery (34%) and appendicectomy (15%).

Operative procedures are postponed in pregnant patient until after delivery, but in acute emergency conditions even if the patient is pregnant, operation should be performed.

According to the recent studies done, the second trimester is ideal for laparoscopic intervention.

Most cases reported and small series indicate that laparoscopy can be safely performed during pregnancy. The incidence of prematurity and intrauterine growth restriction was reported to be higher in the open surgical group too.

Two recent studies suggest that there is no difference in fetal outcome for patient with singleton pregnancies undergoing laparoscopy or laparotomy. In one study, the resultant children born after laparoscopic surgery was performed on their mother during their intrauterine life, were monitored and no evidence of developmental or physical abnormality was detected during the study period. Despite the growing clinical experience suggesting that laparoscopy is as safe as laparotomy in pregnancy, more long-term clinical studies are required.

CONCLUSION

A laparoscopic access to pathology in pregnancy has many benefits for the patient, but it is important that the surgeon and anesthetist both have an immense knowledge of maternal fetal physiology. An experienced surgeon can continue to perform laparoscopy safely in all trimesters by without significant increases in either maternal or fetal morbidity or mortality. Further controlled clinical studies are needed to clarify many other unknown issues, and revision may be necessary as new data appear.

BIBLIOGRAPHY

1. Adelstein S. Administered radionuclides in pregnancy. Teratology.1999;59(4):236-9.
2. Affleck DG, Handrahan DL, Egger MJ, Price RR. The laparoscopic management of appendicitis and cholelithiasis during pregnancy. Am J Surg. 1999;178(6):523-9.
3. Akira S, Yamanaka A, Ishihara T, Takeshita T, Araki T. Gasless laparoscopic ovarian cystectomy during pregnancy: comparison with laparotomy. Am J Obstet Gynecol. 1999;180(3 Pt1):554-7.
4. Al-Fozan H, Tulandi T. Safety and risks of laparoscopy in pregnancy. Curr Opin Obstet Gynecol. 2002;14:375-9.
5. Ames Castro M, Shipp TD, Castro EE, Ouzounian J, Rao P. The use of helical computed tomography in pregnancy for the diagnosis of acute appendicitis. Am J Obstet Gynecol. 2001;184:954-7.
6. Amos JD, Schorr SJ, Norman PF, Poole GV, Thomae KR, Mancino AT, et al. Laparoscopic surgery during pregnancy. Am J Surg. 1996;171(4):435-7.
7. Andreoli M, Servakov M, Meyers P, Mann Jr WJ. Laparoscopic surgery during pregnancy. J Am Assoc Gynecol Laparosc. 1999;6(2):229-33.
8. Andriulli A, Loperfido S, Napolitano G, Niro G, a Valvano MR, Spirito F, et al. Incidence rates of post-ERCP complications: a systematic survey of prospective studies. Am J Gastroenterol. 2007;102(8):1781-8.
9. Arvidsson D, Gerdin E. Laparoscopic cholecystectomy during pregnancy. Surg Laparosc Endosc. 1991;1(3):195-4.
10. Barone JE, et al. Outcome study of cholecystectomy during pregnancy. Am J Surg.1999;177(3):232-5.
11. Buser KB. Laparoscopic surgery in the pregnant patient-one surgeon's experience in a small rural hospital. 2002;6(2):121-4.
12. Canis M, Rabischong B, Houlle C, Botchorishvili R, Jardon K, Safi A, et al. Laparoscopic management of adnexal masses: a gold standard? Curr Opin Obstet Gynecol. 2002;14(4):423-8.
13. Clark SL, Cotton DB, Pivarnik JM, Lee W, Hankins GD, Benedetti TJ, et al. Position change and central hemodynamic profile during normal third-trimester pregnancy and post- partum. Am J Obstet Gynecol. 1991;164(3):883-7.
14. Conron RW Jr, Abbruzzi K, Cochrane SO, Sarno AJ, Cochrane PJ. Laparoscopic procedures in pregnancy. Am Surg. 1999;65(3):259-63.
15. Cosenza CA, Saffari B, Jabbour N, Stain SC, Carry D, Parekh D, et al. Surgical management of biliary gallstone disease during pregnancy. Am J Surg. 1999;178:545-8.
16. Costantino GN, Vincent GJ, Mukalian GG, Kliefoth WL Jr. Laparoscopic cholecystectomy in pregnancy. J Laparoendosc Surg. 1994;4(2):161-4.
17. Curet MJ. Special problems in laparoscopic surgery. Previous abdominal surgery, obesity, and pregnancy. Surg Clin North Am. 2000;80(4):1093-110.
18. Curet MJ, Vogt DA, Schob O, Qualls C, Izquierdo LA, Zucker KA. Effects of CO_2 pneumoperitoneum in pregnant ewes. J Surg Res. 1996;63(1):339-44.
19. Curet MJ, Allen D, Josloff RK, Pitcher DE, Curet LB, Miscall BG, et al. Laparoscopy during pregnancy. Arch Surg. 1996;131(5): 546-50; discussion 550-51.
20. Davis A, Katz VL, Cox R. Gallbladder disease in pregnancy. J Reprod Med. 1995;40:759-62.
21. De Wilde JP, Rivers AW, Price DL. A review of the current use of magnetic resonance imaging in pregnancy and safety implications for the fetus. Prog Biophys Mol Biol. 2005;87 (2-3):335-53.
22. Doll R, Wakeford R. Risk of childhood cancer from fetal irradiation. Br J Radiol. 1997;70:130-09.
23. Elkayam UGN. Cardiovascular physiology of pregnancy. Cardiac problems in pregnancy: diagnosis and management of maternal and fetal disease. New York: Alan R Liss; 1982. p. 5.
24. Eyvazzadeh AD, Levine D. Imaging of pelvic pain in the first trimester of pregnancy. Radiol Clin North Am. 2006;44(6): 863-77.
25. Fallon WF Jr, Newman JS, Fallon GL, Malangoni MA. The surgical management of intra-abdominal inflammatory conditions during pregnancy. Surg Clin North Am. 1995;75(1):15-31.
26. Fatum M, Rojansky N. Laparoscopic surgery during pregnancy. Obstet Gynecol Surv. 2001;56:50-9.
27. Forsted DH, Kalbhen CL. CT of pregnant women for urinary tract calculi, pulmonary thromboembolism, and acute appendicitis. Am J Roentgenol. 2002;178(5):1285.
28. Friedman JD, Ramsey PS, Ramin KD, Berry C. Pneumoamnion and pregnancy loss after second-trimester laparoscopic surgery. Obstet Gynecol. 2002;99(3):512-3.
29. Garcia-Bournissen F, Shrim A, Koren G. Safety of gadolinium during pregnancy. Can Fam Physician. 2006;52:309-10.
30. Geisler JP, Rose SL, Mernitz CS, Warner JL, Hiett AK. Non-gynecologic laparoscopy in second and third trimester pregnancy: obstetric implications. JSLS. 1998;2(3):235-8.
31. Glasgow RE, Visser BC, Harris HW, Patti MG, Kilpatrick SJ, Mulvihill SJ. Changing management of gallstone disease during pregnancy. Surg Endosc. 1998;12:241-6.
32. Gordon MC. Maternal physiology in pregnancy. In: Gabbe SG, Niebyl JR, Simpson JL (Eds). Obstetrics: Normal and Problem Pregnancies. Philadelphia: Churchill Livingstone: 2002. pp. 63-91.
33. Graham G, Baxi L, Tharakan T. Laparoscopic cholecystectomy during pregnancy: a case series and review of the literature. Obstet Gynecol Surv. 1998;53:566-74.
34. Guidelines for laparoscopic surgery during pregnancy. Surg Endosc.1998;12(2):189-90.
35. Gurbuz AT, Peetz ME. The acute abdomen in the pregnant patient: is there a role for laparoscopy? Surg Endosc. 1997;11:98-102.
36. Halpern NB. Laparoscopic cholecystectomy in pregnancy: a review of published experiences and clinical considerations. Semin Laparosc Surg. 1998;5(2):129-34.
37. Hiatt JR, Hiatt JC, Williams RA, Klein SR. Biliary disease in pregnancy: strategy for surgical management. Am J Surg. 1986;151:263-5.
38. Hume RF, Killiam AP. Maternal physiology, in obstetrics and gynecology. In: Scott JR, KiSaia J, Hammon DB (Eds). Philadelphia: JB Lippincott; 1990. pp. 93-100.
39. Hunter JG, Swanstrom L, Thornburg K. Carbon dioxide pneumoperitoneum induces fetal acidos is in a pregnant ewe model. Surg Endosc. 1995;9(3):272-7; discussion 277-9.
40. Hurwitz LM, Yoshizumi T, Reiman RE, Goodman PC, Paulson EK, Frush DP, et al. Radiation dose to the fetus from body MDCT during early gestation. Am J Roentgenol. 2005;186(3):871-6.
41. Iafrati MD, Yarnell R, Schwaitzberg SD. Gasless laparoscopic cholecystectomy in pregnancy. J Laparoendosc Surg. 1995;5(2):127-30.
42. Kammerer WS. Nonobstetric surgery during pregnancy. Med Clin North Am. 1979;63:1157-64.

43. Karam PA. Determining and reporting fetal radiation exposure from diagnostic radiation. Health Phys. 2000;79(5):S85-90.
44. Kennedy A. Assessment of acute abdominal pain in the pregnant patient. Semin Ultrasound CT MR. 2000;21(1):64-77.
45. Kort B, Katz VL, Watson WJ. The effect of nonobstetric operation during pregnancy. Surg Gynecol Obstet. 1993;177:371-6.
46. Lachman E, Schienfeld A, Voss E, Gino G, Boldes R, Levine S, et al. Pregnancy and laparoscopic surgery. J Am Assoc Gynecol Laparosc. 1999;6(3):347-51.
47. Lemaire BM, van Erp WF. Laparoscopic surgery during pregnancy. Surg Endosc. 1997;11:15-8.
48. Leyendecker JR, Gorengaut V, Brown JJ. MR imaging of maternal diseases of the abdomen and pelvis during pregnancy and the immediate postpartum period. Radiographics. 2004;24(5):1301-16.
49. Lim HK, Bae SH, Seo GS. Diagnosis of acute appendicitis in pregnant women: value of sonography. Am J Roentgenol. 1992;159:539-42.
50. Lowe SA. Diagnostic radiography in pregnancy: risks and reality. Aust NZ J Obstet Gynaecol. 2004;44(3):191-6.
51. Malangoni MA. Gastrointestinal surgery and pregnancy. Gastroenterol Clin North Am. 2003;32(1):181-200.
52. Matsumoto T, Mutsumasa N, Miyuki Y, Masaharu I. Laparoscopic treatment of uterine prolapse during pregnancy. Obstet Gynecol. 1999;93 (5 pt2):849.
53. McKellar DP, Anderson CT, Boynton CJ, Peoples JB. Cholecystectomy during pregnancy without fetal loss. Surg Gynecol Obstet. 1992;174(6):465-8.
54. McKenna DA, Meeha CP, Alhajeri AN, Regan MC, O'Keeffe DP. The use of MRI to demonstrate small bowel obstruction during pregnancy. Br J Radiol. 2007;80(949):11e-14e.
55. Medical radiation exposure of pregnant and potentially pregnant women (1977). Report No. 054–National Council on Radiation Protection and Measurements. [online] Available from https://ncrponline.org/shop/reports/report-no-054-medical-radiation-exposure-of-pregnant-and-potentially-pregnant-women-1977/# [Last accessed August, 2020].
56. Melgrati L, Damiani A, Franzoni G, Marziali M, Sesti F. Isobaric (gasless) laparoscopic myomectomy during pregnancy. J Minim Invasive Gynecol. 2005;12(4):379381.
57. Menias CO, Elsayes KM, Peterson CM, Huete A, Gratz BI, Bhalla S. CT of pregnancy-related complications. Emerg Radiol. 2007;13(6):299-306.
58. Moore C, Promes SB. Ultrasound in pregnancy. Emerg Med Clin North Am. 2004;22(3):697-722.
59. Muench J, Albrink M, Serafini F, Rosemurgy A, Carey L, Murr MM. Delay in treatment of biliary disease during pregnancy increases morbidity and can be avoided with safe laparoscopic cholecystectomy. Am Surg. 2001;67(6):539-42; discussion 542-3.
60. Murakami T, Noda T, Okamura C, Terada Y, Morito Y, Okamura K. Cul-de-sac packing with a metreurynter in gasless laparoscopic cystectomy during pregnancy. J Am Assoc Gynecol Laparosc. 2003;10(3):421-3.
61. Nagayama M, Watanabe Y, Okumura A, Amoh Y, Nakashita S, Dodo Y. Fast MR imaging in obstetrics. Radiographics. 2002; 22(3):563-80; discussion 580-2.
62. Nelson MJ, Cavalieri R, Graham D, Sanders RC. Cysts in pregnancy discovered by sonography. J Clin Ultrasound. 1986;14(7):509-12.
63. Nezhat FR, Tazuke S, Nezhat CH, Seidman DS, Phillips DR, Nezhat CR. Laparoscopy during pregnancy: a literature review. JSLS. 1997;1(1):17-27.
64. Oelsner G, Stockheim D, Soriano David, Goldenberg M, Seidman DS, Cohen SB, et al. Pregnancy outcome after laparoscopy or laparotomy in pregnancy. J Am Assoc Gynecol Laparosc. 2003;10(2):200-4.
65. Oguri H, Taniguchi K, Fukaya T. Gasless laparoscopic management of ovarian cysts during pregnancy. Int J Gynaecol Obstet. 2005;91(3):258-9.
66. Osei EK, Faulkner K. Fetal doses from radiological examinations. Br J Radiol. 1999;72(860):773-80.
67. Pucci RO, Seed RW. Case report of laparoscopic cholecystectomy in the third trimester of pregnancy. Am J Obstet Gynecol. 1991;165(2):401-2.
68. Quan WL, Chia CK, Yim HB. Safety of endoscopical procedures during pregnancy. Singapore Med J. 2006;47(6):525-8.
69. Qureshi WA, Rajan E, Adler DG, Davila RE, Hirota WK, Jacobson BC, et al. ASGE guideline: guidelines for endoscopy in pregnant and lactating women. Gastrointest Endosc. 2005;61(3):357-62.
70. Reedy MB, Galan HL, Bean-Lijewski JD, Carnes A, Knight AB, Kuehl TJ. Maternal and fetal effects of laparoscopic insufflation in the gravid baboon. J Am Assoc Gynecol Laparosc. 1995; 2(4):399-406.
71. Reedy MB, Kallen B, Kuehl TJ. Laparoscopy during pregnancy: a study of five fetal outcome parameters with use of the Swedish Health Registry. Am J Obstet Gynecol. 1997;177:673-9.
72. Reedy MB, Galan HL, Richards WE, Preece CK, Wetter PA, Kuehl TJ. Laparoscopy during pregnancy. A survey of laparoendoscopic surgeons. J Reprod Med. 1997;42(1):33-8.
73. Rizzo AG. Laparoscopic surgery in pregnancy: long-term follow-up. J Laparoendosc Adv Surg Tech A. 2003;13(1):11-5.
74. Rollins MD, Chan KJ, Price RR. Laparoscopy for appendicitis and cholelithiasis during pregnancy: a new standard of care. Surg Endosc. 2004;18(2):237-41.
75. Römer T, Bojahr B, Schwesinger G. Treatment of a torqued hematosalpinx in the thirteenth week of pregnancy using gasless laparoscopy. J Am Assoc Gynecol Laparosc. 2002;9(1):89-92.
76. Schmidt T, Nawroth F, Foth D, Rein DT, Römer T, Mallmann P. Gasless laparoscopy as an option for conservative therapy of adnexal pedical torsion with twin pregnancy. J Am Assoc Gynecol Laparosc. 2001;8(4):621-2.
77. Scott LD. Gallstone disease and pancreatitis in pregnancy. Gastroenterol Clin North Am. 1992;21:803-15.
78. Shay DC, Bhavani-Shankar K, Datta S. Laparoscopic surgery during pregnancy. Anesthesiol Clin North Am. 2001;19(1):57-67.
79. Society of American Gastrointestinal Endoscopic Surgeons (SAGES). Guidelines for laparoscopic surgery during pregnancy. Surg Endosc. 1998;12:189-90.