EuropeAnatolia Health Sciences Journal E-ISSN: 2980-3861

REVIEW ARTICLE
Volume:3 Issue:1 Year:2025 https://doi.org/10.5281/zenodo.15237009

The Utilization of Laparoscopy In Clinical Practice - A Narrative Review

Laparoskopinin Klinik Pratikte Kullanımı - Derleme Makalesi

Ahmet Coşkan[1]

[1]Private Gölcük Medar Hospital

ABSTRACT

Laparoscopic surgery (L/S) is a minimally invasive alternative to traditional laparotomy. It is a diagnostic and therapeutic modality for minor and major surgical procedures. Many procedures traditionally performed using open laparotomy can now be performed laparoscopically. L/S has numerous benefits, including smaller incisions, shorter hospital stays, and shorter recovery times. L/S also allows the surgeon to visualize and magnify the anatomy and existing pathology better.
Laparoscopic procedures during pregnancy have been viewed with controversy because of the idea that laparoscopic techniques may reduce maternal lung compliance, leading to hypoventilation, hypercarbia, fetal acidosis, aortocaval compression, and direct uterine and fetal trauma. The most common indications for laparoscopic surgery during pregnancy are cholelithiasis, appendicitis, persistent ovarian cysts, and adnexal torsion. The problems that the anesthesiologist will encounter in a pregnant patient undergoing laparoscopic surgery are not only maternal and fetal factors and prevention of premature labor but also the physiological and mechanical effects of CO_2 pneumoperitoneum and patient position.
The indications for laparoscopic surgery are the same as for open procedures. L/S aims to perform a surgical procedure similar to the standard technique without opening the peritoneal membrane. Laparoscopy has two absolute contraindications: the patient's inability to tolerate general anesthesia and the surgeon's inexperience and lack of skill in the specific procedure or technique. Laparoscopy reduces morbidity, reduces hospital stay, and improves cosmetic results.

Keywords: Laparoscopy, Pregnancy, Laparotomy, Minimally Invasive, Pneumoperitoneum.

ÖZET

Laparoskopik cerrahi (L/S), geleneksel laparotomiye minimal invaziv bir alternatiftir. Tanı ve tedavi yöntemi olarak ve küçük ve büyük cerrahi prosedürleri gerçekleştirmek için kullanılır. Geleneksel olarak açık laparotomi kullanılarak yapılan birçok işlem artık laparoskopik olarak gerçekleştirilebilmektedir. L/S'nin, daha küçük insizyonlar, hastanede kalış süresinin azalması ve iyileşme süresinin azalması dahil olmak üzere sayısız faydası vardır. L/S ayrıca cerrahın anatomi ve var olan patolojiyi daha iyi görselleştirmesini ve büyütmesini sağlar.
Gebelikte laparoskopik prosedürlere, laparoskopik tekniğin maternal akciğer kompliansını azaltarak hipoventilasyon, hiperkarbi, fetal asidoz, aortakaval kompresyon ve direkt uterin ve fetal travmaya neden olabileceği düşüncesiyle tartışmalı yaklaşılmaktaydı. Gebelikte laparoskopik cerrahi gerektiren en sık endikasyonlar kolelitiazis, appendisitis, persistan over kisti ve adneksial torsiyondur. Laparoskopik cerrahi geçirecek gebe hastada anestezistin karşılaşacağı problemler sadece maternal ve fetal faktörler ve erken eylemin önlenmesi değil aynı zamanda CO_2 pnömoperitoneumun ve hasta pozisyonunun fizyolojik ve mekanik etkileridir.
Laparoskopik cerrahi endikasyonları, açık prosedür ile aynıdır. L/S'nin amacı, periton zarını açmadan cerrahi işlemi standart tekniğe benzer şekilde gerçekleştirmektir. Laparoskopinin iki mutlak kontrendikasyonu vardır: hastanın genel anesteziyi tolere edememesi ve cerrahın deneyimsizliği ve spesifik prosedür veya teknikle ilgili becerinin eksik olmasıdır. Laparoskopi morbiditenin azalmasına, hastanede bekleme süresinin azalmasına ve kozmetik sonuçların iyileşmesine neden olur.

Anahtar Kelimeler: Laparoskopi, Gebelik, Laparotomi, Minimal Invaziv, Pnömoperitoneum.

INTRODUCTION

The advantages of laparoscopic surgery are similar for pregnant and nonpregnant women; however, this procedure is generally avoided in pregnancy due to concerns that it may be harmful to the fetus. Potential problems include: (i) Increased intra-abdominal pressure during pneumoperitoneum may reduce uteroplacental blood flow and cause fetal hypoxia. (ii) Carbon dioxide absorption may develop fetal acidosis. (iii) Perforation of the uterus by a trocar or Veress needle may cause direct or indirect injury to the fetus. (iv) Uterine perforation may lead to preterm labor or preterm premature rupture of membranes (1).

Corresponding Author: Ahmet Coşkan, e-mail: drahmetcoskan@gmail.com
Received: 27.01.2025, Accepted: 18.03.2025, Published Online: 20.04.2025
Cited: Coşkan A. The Utilization of Laparoscopy In Clinical Practice - A Narrative Review. Europeanatolia Health Sciences Journal. 2025;3(1):43-50. https://doi.org/10.5281/zenodo.15237009

A paradigm shift has occurred in the last decade with the publication of many case reports and case series regarding the safety of laparoscopic surgery in pregnancy. Laparoscopic management of appendicitis, gallbladder disease, mesenteric cysts, adnexal masses, and adnexal torsion in pregnancy can now be successfully performed. Additionally, successful treatments of advanced laparoscopic procedures such as radical nephrectomy, salpingectomy, adrenalectomy, retroperitoneal lymphadenectomy, and abdominal hernia repair in pregnant women have been reported (2).

Pneumoperitoneum may alter maternal hemodynamics, arterial oxygenation, and acid-base balance as a result of carbon dioxide absorption, pressure on the uteroplacental vessels, and upward displacement of the diaphragm (residual lung volume and functional residual capacity are also reduced in pregnancy). Hemodynamic changes include decreased cardiac index, increased mean arterial pressure, and increased systemic vascular resistance. Various animal models have been used to evaluate the maternal and fetal effects of increased intra-abdominal pressure associated with carbon dioxide pneumoperitoneum. For example, no maternal or fetal adverse effects were observed in pregnant baboon models at intra-abdominal pressures of up to 10 mmHg. However, respiratory acidosis develops at pressures of 20 mmHg despite an increased maternal respiratory rate. Maternal hypercarbia is due to the absorption of carbon dioxide in the abdominal cavity. There is no change in fetal Doppler examinations performed after the procedure (3).

An experimental study conducted on pregnant sheep models observed that materno-placental blood flow decreased by 61% at 20 mmHg intra-abdominal pressures (4). However, this situation did not disrupt fetoplacental perfusion, fetal pH, and blood gas values in procedures lasting less than one hour. In another pregnant sheep model, fetal tachycardia, hypertension, and hypercarbia developed due to carbon dioxide pneumoperitoneum, and this situation is probably due to fetal carbon dioxide absorption. These changes were reversed by mildly inducing maternal respiratory alkalosis. It was also observed that these changes did not occur using nitrous oxide for pneumoperitoneum. In a fourth pregnant sheep model study, progressive fetal hypotension and bradycardia developed with 15 mmHg carbon dioxide insufflation for 60 minutes (5). After the pneumoperitoneum was resolved, uterine blood flow returned to normal, and fetal partial carbon dioxide pressure and pH decreased within approximately one hour. However, fetal oxygen saturation remained depressed, and fetal cardiovascular status remained impaired for 2 hours (6).

Studies evaluating the safety of laparoscopy in human pregnancies are insufficient. However, many case series have reported that laparoscopy is safe for the fetus and mother throughout pregnancy (all 3 trimesters). The best available studies are from retrospective studies. The Swedish Health Organization compared 2181 pregnant women who underwent laparoscopy at less than 20 weeks of gestation with 1522 patients from a similar population who underwent laparotomy (7). There were no significant differences between the groups in terms of birth weight, gestational age, intrauterine growth retardation, congenital malformations, stillbirth, and neonatal death. In addition, although no adverse outcomes were reported in the long term, the data are insufficient.

However, some studies on laparoscopic appendectomy performed during pregnancy have suggested that laparoscopy increases the rate of fetal loss and premature birth, and this has raised concerns. In a meta-analysis conducted in 2012, which included 11 studies and 3415 patients, it was observed that the risk of fetal loss was higher in pregnant women who underwent laparoscopic appendectomy compared to those who underwent open appendectomy (8). The rate of fetal loss was 7% in the laparoscopic appendectomy group and 3% in the open appendectomy group. However, the studies that comprised this meta-analysis have deficiencies in the study design phase regarding parameters such as patient age, gestational age, appendicitis complication status, and surgeon skill. Although there is low-level evidence that laparoscopic appendectomy performed during pregnancy increases the rate of pregnancy loss, this information does not provide sufficiently strong data regarding the type of appendectomy to be performed during pregnancy (9).

INDICATIONS of LAPAROSCOPY

Once the indication for surgery has been established, the type of surgical approach (laparotomy or laparoscopy) depends on the surgeon's skill and appropriate personnel and equipment availability. Indications for laparoscopy in the acute abdomen are the same for pregnant and nonpregnant patients. Laparoscopy is contraindicated if there is hemodynamic instability. Laparotomy is often preferred if a sizeable ovarian mass is detected on preoperative ultrasonographic examination, if the patient has had multiple previous abdominal surgeries, or if there is a history of a disease that may cause adhesions (such as intraabdominal-pelvic tuberculosis) (10).

Advantages

The advantages of laparoscopic surgery in pregnancy are the same as in nonpregnant patients: much less postoperative pain, less postoperative ileus, fewer intraabdominal adhesions, shorter hospital stay, and faster return to daily activities.

Laparoscopy may also have pregnancy-specific benefits. For example, laparoscopy involves much less uterine manipulation than laparotomy. In addition, avoiding a large abdominal scar reduces cosmetic results and postoperative discomfort (less narcotic analgesic requirement, better respiratory effort). The laparoscopic approach provides a much better surgical image with optical magnification, light, and other technical advantages (11).

Timing

Laparoscopy can be performed throughout pregnancy. However, like all other surgical approaches, it is most appropriate in the early second trimester.

If surgery is required in the last trimester of pregnancy, the enlarged uterus may interfere with the optic region and impair visualization. However, cases of appendicitis, cholecystectomy, intussusception, and adnexal masses that were successfully treated laparoscopically in the last trimester up to the 34th week of gestation have been reported. The applicability of laparoscopic surgery in the previous trimester also depends on other individual clinical factors of the patient (patient's body habitus, uterine dimensions- such as polyhydramnios and large fetus for gestational age- the presence of accompanying medical and obstetric factors, etc.). There is no upper limit of gestational age determined for the laparoscopic approach. If technically possible and the clinical situation is appropriate, laparoscopy can be performed in the early third trimester (12).

Although laparoscopy performed in the first trimester is technically more manageable, the organogenesis period is risky for potential teratogens, even if theoretically. If the patient also has a clinical condition of threatened miscarriage, surgical intervention can be postponed to overcome this condition. However, in some clinical situations, delaying surgical intervention may not be possible. For example, surgical intervention should not be delayed in the presence of suspicion of ovarian torsion (12, 13).

PROCEDURE

Placing an oro or nasogastric tube in the stomach before the procedure minimizes the possibility of perforating a distended stomach and reduces the risk of aspirating stomach contents. A Foley catheter is also placed in the bladder (14).

Thromboprophylaxis

There are no adequate randomized controlled trial data to support the use of unfractionated or low molecular weight heparin or intermittent pneumatic compression for venous thromboprophylaxis in pregnant women undergoing laparoscopic surgery.

The Society of American Gastrointestinal and Endoscopic Surgeons recommends using pneumatic compression devices in the lower extremities of pregnant women undergoing laparoscopic procedures (15).

The American College of Chest Physicians (ACCP) published a clinical practice guideline for treating and preventing thrombosis in 2012. It recommended mechanical or pharmacological thromboprophylaxis for all pregnant women undergoing surgery (16). Low molecular weight heparin is suggested if the laparoscopic procedure (related to gynecologic or general surgery) lasts longer than 45 minutes. It stated that mechanical thromboprophylaxis is a reasonable alternative for short surgical procedures.

Prophylactic Tocolysis

No evidence supports the use of tocolysis or glucocorticoids as prophylactic. However, these drugs are undoubtedly indicated in the method and treatment of preterm labor.

Position Of The Patient

Depending on the planned procedure, the patient is placed in a supine or low lithotomy position. If the pregnancy is greater than 16 weeks, a 15-degree left lateral rotation of the surgical table significantly reduces the pressure on the aorta and inferior vena cava. The left lateral rotation of the operating table removes the uterus from these large vascular structures in this way. However, this position may cause the uterus to restrict the surgeon's field of vision and make the surgical procedure more difficult to perform. The patient's lying position in left lateral rotation can be temporarily corrected to facilitate manipulation (17).

The Trendelenburg position is given to perform pelvic procedures more comfortably and to remove the intestines from the surgical field. The degree of Trendelenburg position that the pregnant woman can tolerate varies depending on the age of the pregnancy, the patient's body habitus, and accompanying risk factors. Performing a left lateral rotation of 30 degrees increases visualization of the appendix and gallbladder, facilitating laparoscopic appendectomy and cholecystectomy in the third trimester (17, 18).

In addition, this position allows the pregnant uterus to move away from the inferior vena cava and opens the right paracolic space. Trocar entry: All patients undergoing laparoscopy are at risk of trocar injury. In the presence of a gravid uterus, trocar placement and the creation of pneumoperitoneum become both more complex and potentially more dangerous. Cases of inadvertent insertion of the Veress needle into the uterus have been reported (17).

The most commonly used primary trocar entry point is the supraumbilical entry. The recommended entry point for this entry is made at least 6 cm above the uterine fundus by elevating the anterior abdominal wall (Figure 1). This entry point provides sufficient space between the laparoscope and the uterus for appropriate visualization and instrumentation. With advancing gestational age, subxiphoidal, right upper quadrant, or left upper quadrant entries can be preferred to avoid the enlarged uterus. Lateral displacement of the uterus during trocar entry can reduce the risk of uterine and fetal injury. The Hasson (open) and Veress needle techniques have been used to create pneumoperitoneum in pregnant women (15). Since the Veress needle technique is a blind entry, it carries a risk of uterine/fetal injury, especially in umbilical entries. Although the blind entry technique is used successfully, in the third trimester, the Veress needle can be inserted more safely in the midclavicular line, 1-2 cm below the costal margin, from the right or left upper quadrant.

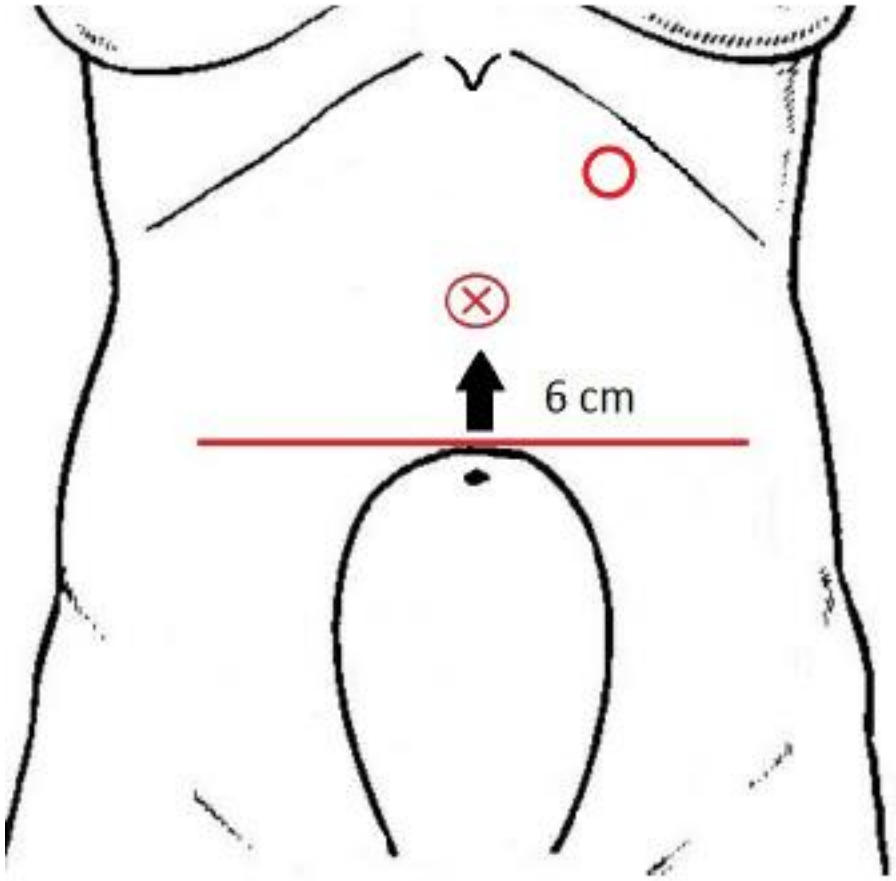

Figure 1. Port placement in pregnancy: One preferred Veress needle entry site is the left upper quadrant entry site (open red circle). Gastric decompression with an oro or nasogastric tube before needle entry minimizes the risk of gastric perforation. If the Veress needle is angled caudally by approximately 15 degrees, the risk of splenic injury is reduced. Placement of the supraumbilical port at least 6 cm above the uterine fundus (circle with an x mark) using the Hasson technique further reduces the risk of organ perforation compared to other methods.

Some surgeons believe using an open technique for trocar placement is safer. Considering the applicability of both methods, the surgeon should use the technique he/she is experienced in and feels comfortable with. Transcervical instruments should never be used in the presence of pregnancy for uterine manipulation (19).

Laparoendoscopic single-site surgery (LESS) or single-port laparoscopy are performed using a single skin incision and a multichannel operating port. A small number of pregnant women have been reported to have undergone surgery using LESS. More studies are needed on using the LESS technique in pregnant women (20).

Pneumoperitoneum

Although increased intra-abdominal pressure is needed to obtain adequate images, low intra-abdominal pressure is essential because increased carbon dioxide can cause hemodynamic and respiratory side effects in pregnant women. Intra-abdominal pressure should be maintained between 8 and 12 mmHg and not exceed 15 mmHg (21).

Gasless laparoscopy is a safer alternative to the traditional method (carbon dioxide pneumoperitoneum). However, a unique device is required to lift the anterior abdominal wall. Another described technique is the combined method (combined pneumoperitoneum and anterior abdominal wall lift), which

increases intra-abdominal pressure less. Carbon dioxide pneumoperitoneum is associated with shorter operative times and potentially lower maternal-fetal mortality (22).

Several extensive studies have concluded that routine intraoperative blood gas measurement is not necessary in pregnant women. Respiratory acidosis has not been reported as long as end-tidal carbon dioxide pressure is around 32-34 mmHg.

Fetal Assessment

Fetal heart rate should be assessed and documented before and after the procedure. Fetal handheld Doppler devices are usually used for this purpose. Transabdominal fetal monitoring is generally not possible due to the pneumoperitoneum created during a laparoscopic intervention in the second trimester. If fetal monitoring is necessary during the procedure, the transabdominal fetal monitor is placed perpendicular to the left abdominal wall. Another method is to assess fetal heart rate with transvaginal ultrasound (23).

In the presence or suspicion of maternal acidosis, rapid hyperventilation of the mother and reduction of intra-abdominal pressure rapidly correct acidosis. This increases placental blood flow and fetal oxygenation, thus providing fetal resuscitation (23).

POSTOPERATIVE CARE

Fetal heart rate and uterine activity should be monitored in the recovery room according to gestational age. Opioids and antiemetic drugs are medications that may be used to control postoperative pain and nausea. Nonsteroidal anti-inflammatory drugs should be avoided, especially after the 32nd week of pregnancy, because they can cause premature closure of the ductus arteriosus. Cesarean section should be preferred if there is a standard obstetric indication. The presence of a laparoscopic port incision does not prevent pushing in the second stage of labor (24).

CONCLUSION

In conclusion, laparoscopic surgery is a safe and effective surgical option for pregnant women. Although this procedure can be performed up to the 34th week, the most appropriate time is the early second trimester. Pregnant women should be placed on the operating table in a left lateral rotation position to reduce pressure on the inferior vena cava and aorta. In low-risk pregnancies, pneumatic decompression devices can be used for short laparoscopic procedures, while low molecular weight heparin is recommended for thromboprophylaxis in procedures lasting longer than 45 minutes. There is no evidence that the open entry technique is superior to the closed (blind) technique. Intra-abdominal pressure should be maintained between 8-12 mmHg and not exceed 15 mmHg. Avoiding these levels will prevent placental blood flow from being affected. Keeping the end-tidal carbon dioxide pressure around 32-34 mmHg does not carry a risk of developing respiratory acidosis. In cases of suspected or present maternal acidosis, rapid hyperventilation of the mother and reduction of intra-abdominal pressure rapidly correct acidosis.

DESCRIPTIONS

Funding

There is no specific funding related to this research.

AI Statement

The authors used AI and AI-assisted Technologies (Grammarly and MS Word Editor) in the writing process. These technologies improved the readability and language of the work but did not replace key authoring tasks such as producing scientific or medical insights, drawing scientific conclusions, or providing clinical recommendations. The authors are ultimately responsible and accountable for the contents of the whole work.

Competing interests

The authors declare that they have no competing interests.

Consent for Publication

The original article is not under consideration by another publication, and its substance, tables, or figures have not been published previously and will only be published elsewhere.

Data Availability

The data supporting this study's findings are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Ethical Declaration

As this was a narrative review article, no Ethics committee approval was required. Additionally, as no patient was enrolled, no informed consent was obtained.

REFERENCES

1. Kumar SS, Collings AT, Wunker C, et al. SAGES guidelines for the use of laparoscopy during pregnancy. Surg Endosc. 2024;38(6):2947-2963. doi:10.1007/s00464-024-10810-1

2. Dvash S, Pekar M, Melcer Y, Weiner Y, Vaknin Z, Smorgick N. Adnexal Torsion in Pregnancy Managed by Laparoscopy Is Associated with Favorable Obstetric Outcomes. J Minim Invasive Gynecol. 2020;27(6):1295-1299. doi:10.1016/j.jmig.2019.09.783

3. Song G, Jiang Y, Liu Q, Lin H, Qin J. CO2 pneumoperitoneum pressure: an important factor influenced ovarian function after laparoscopy. Ann Palliat Med. 2021;10(8):9326-9327. doi:10.21037/apm-2021-05

4. Song G, Jiang Y, Liu Q, Lin H, Qin J. CO2 pneumoperitoneum pressure: an important factor influenced ovarian function after laparoscopy. Ann Palliat Med. 2021;10(8):9326-9327. doi:10.21037/apm-2021-05

5. Uemura K, McClaine RJ, de la Fuente SG, et al. Maternal insufflation during the second trimester equivalent produces hypercapnia, acidosis, and prolonged hypoxia in fetal sheep. Anesthesiology. 2004;101(6):1332-1338. doi:10.1097/00000542-200412000-00013

6. Smith RB, Biller E, Hu C, et al. Impact of pneumoperitoneum pressure during laparoscopic hysterectomy: A randomized controlled trial. Eur J Obstet Gynecol Reprod Biol. 2023;280:73-77. doi:10.1016/j.ejogrb.2022.11.011

7. Wai PY, Ruby JA, Davis KA, Roberts AC, Roberts KE. Laparoscopic ventral hernia repair during pregnancy. Hernia. 2009;13(5):559-563. doi:10.1007/s10029-009-0476-3

8. Wilasrusmee C, Sukrat B, McEvoy M, Attia J, Thakkinstian A. Systematic review and meta-analysis of safety of laparoscopic versus open appendicectomy for suspected appendicitis in pregnancy. Br J Surg. 2012;99(11):1470-1478. doi:10.1002/bjs.8889

9. Walker HG, Al Samaraee A, Mills SJ, Kalbassi MR. Laparoscopic appendicectomy in pregnancy: a systematic review of the published evidence. Int J Surg. 2014;12(11):1235-1241. doi:10.1016/j.ijsu.2014.08.406

10. Hu H, Choi JDW, Edye MB, Aitken T, Kapurubandara S. Gastric Injury at Laparoscopy for Gynecologic Indications: A Systematic Review. J Minim Invasive Gynecol. 2022;29(11):1224-1230. doi:10.1016/j.jmig.2022.09.058

11. Berlund P, Reddington C, Cheng C, Healey M. Constipation After Elective Laparoscopy for Benign Gynecological Indications-A Prospective Observational Study. J Minim Invasive Gynecol. 2023;30(10):827-832. doi:10.1016/j.jmig.2023.06.005

12. Solomon N, Warshaviak M, Gimple A, Ashwal E, Levin I, Tzur T. Obstetrical outcomes following laparoscopy during pregnancy: a retrospective case-control study. Arch Gynecol Obstet. 2020;302(6):1421-1427. doi:10.1007/s00404-020-05767-0

13. Chen S, Zhang G, Hua K, Ding J. Single-port laparoscopy versus conventional laparoscopy of benign adnexal masses during pregnancy: a retrospective case-control study. J Int Med Res. 2022;50(10):3000605221128153. doi:10.1177/03000605221128153

14. Marcos-Ramírez ER, Guerra-Leza K, Téllez-Aguilera A, Benavides-Zavala TE, Fernández-Treviño JR, Maldonado GEM. Laparoscopic cholecystectomy during pregnancy. Colecistectomía laparoscópica durante el embarazo. Cir Cir. 2022;90(1):29-33. doi:10.24875/CIRU.20001053

15. Pearl J, Price R, Richardson W, Fanelli R; Society of American Gastrointestinal Endoscopic Surgeons. Guidelines for diagnosis, treatment, and use of laparoscopy for surgical problems during pregnancy. Surg Endosc. 2011;25(11):3479-3492. doi:10.1007/s00464-011-1927-3

16. Guyatt GH, Akl EA, Crowther M, Gutterman DD, Schuünemann HJ; American College of Chest Physicians Antithrombotic Therapy and Prevention of Thrombosis Panel. Executive summary: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines [published correction appears in Chest. 2012 Apr;141(4):1129. Dosage error in article text] [published correction appears in Chest. 2012 Dec;142(6):1698. Dosage error in article text]. Chest. 2012;141(2 Suppl):7S-47S. doi:10.1378/chest.1412S3

17. Barnes SL, Shane MD, Schoemann MB, Bernard AC, Boulanger BR. Laparoscopic appendectomy after 30 weeks pregnancy: report of two cases and description of technique. Am Surg. 2004;70(8):733-736.

18. Sen G, Nagabhushan JS, Joypaul V. Laparoscopic cholecystectomy in third trimester of pregnancy. J Obstet Gynaecol. 2002;22(5):556-557. doi:10.1080/014436102760298863

19. García EG, de Miguel Manso S, Tejedor JG, de Andrés Asenjo B, Escudero VP, Martín JIG. Transcervical drainage of abdominal-pelvic abscess after laparoscopic sacrocolpopexy. Int Urogynecol J. 2021;32(3):581-585. doi:10.1007/s00192-020-04366-6

20. Ranjan A, Joshi KS, Pajai S, Mohammad S. Laparoendoscopic Single-Site Surgery (LESS): A Shift in Gynecological Minimally Invasive Surgery. Cureus. 2022;14(12):e32205. Published 2022 Dec 5. doi:10.7759/cureus.32205

21. Jiang M, Zhao G, Huang A, et al. Comparison of a new gasless method and the conventional CO2 pneumoperitoneum method in laparoendoscopic single-site cholecystectomy: a prospective randomized clinical trial. Updates Surg. 2021;73(6):2231-2238. doi:10.1007/s13304-021-01154-9

22. Demirayak G. A different technique in gasless laparoendoscopic single-site hysterectomy. J Obstet Gynaecol. 2017;37(5):622-626. doi:10.1080/01443615.2017.1282444

23. Rezai S, Giovane RA, Minton H, et al. Laparoendoscopic Single-Site Surgery for Management of Heterotopic Pregnancy: A Case Report and Review of Literature. Case Rep Obstet Gynecol. 2018;2018:7232637. Published 2018 Jul 4. doi:10.1155/2018/7232637

24. Nan X, Chan E, Wong KSC, et al. Laparoscopic Cholecystectomy in Pregnancy: A Seven-Year Retrospective Study From an Australian Tertiary Center. Cureus. 2023;15(12):e50034. Published 2023 Dec 6. doi:10.7759/cureus.50034