

# Guidelines for diagnosis, treatment, and use of laparoscopy for surgical problems during pregnancy

Jonathan Pearl · Raymond Price ·  
William Richardson · Robert Fanelli

Received: 7 April 2011 / Accepted: 24 August 2011 / Published online: 23 September 2011  
© Springer Science+Business Media, LLC 2011

## Preamble

This document provides specific recommendations and guidelines to assist physicians in the diagnostic workup and treatment of surgical problems in pregnant patients, focusing on the use of laparoscopy. Surgical interventions during pregnancy should minimize fetal risk without compromising the safety of the mother.

Recent data show the safety and efficacy of laparoscopy during all trimesters for many surgical conditions with outcomes similar to conventional operations. Surgeons must be aware of data regarding differences in techniques used for pregnant patients to optimize outcomes.

## Disclaimer

Guidelines for clinical practice are intended to indicate preferable approaches to medical problems as established

by experts in the field. These recommendations will be based on existing data or a consensus of expert opinion when little or no data are available. Guidelines are applicable to all physicians who address the clinical problem(s) without regard to specialty training or interests, and are intended to indicate the preferable, but not necessarily the only, acceptable approaches due to the complexity of the health-care environment. Guidelines are intended to be flexible. Given the wide range of specifics in any health-care problem, the surgeon must always choose the course best suited to the individual patient and the variables in existence at the moment of decision.

Guidelines are developed under the auspices of the Society of American Gastrointestinal Endoscopic Surgeons and its various committees and approved by the Board of Governors. Each clinical practice guideline has been systematically researched, reviewed, and revised by the guidelines committee, and reviewed by an appropriate multidisciplinary team. The recommendations are therefore considered valid at the time of its production based on the data available. Each guideline is scheduled for periodic review to allow incorporation of pertinent new developments in medical research knowledge and practice.

## Introduction

Approximately 1 in 500 to 1 in 635 women will require nonobstetrical abdominal surgery during their pregnancies [1, 2]. The most common nonobstetrical surgical emergencies complicating pregnancy are acute appendicitis, cholecystitis, and intestinal obstruction [1]. Other conditions that may require operations during pregnancy include ovarian cysts, masses, or torsion, symptomatic cholelithiasis, adrenal tumors, splenic disorders, symptomatic

---

J. Pearl (✉)

Department of General Surgery, Uniformed Services University of the Health Sciences, National Naval Medical Center, 4301 Jones Bridge Road, Bethesda, MD 20814, USA  
e-mail: Jonathan.Pearl@med.navy.mil

R. Price

Intermountain Healthcare, Intermountain Surgical Specialists, Murray, UT, USA

W. Richardson

Department of Surgery, Ochsner Clinic Foundation, New Orleans, LA, USA

R. Fanelli

Surgical Specialists of Western New England, Pittsfield, MA, USA

hernias, complications of inflammatory bowel diseases, and abdominal pain of unknown etiology.

During its infancy, some argued that laparoscopy was contraindicated during pregnancy due to concerns for uterine injury and fetal perfusion. As surgeons have gained more experience with laparoscopy it has become the preferred treatment for many surgical diseases in the gravid patient [3].

## Definitions

Both the quality of the evidence and the strength of the recommendation for each of the guidelines below were assessed according to the GRADE system [4] (see Table 1). This is a 4-tiered system for assessing the quality of evidence (very low, low, moderate, or high) and a 2-tiered system for strength of the recommendation (weak or strong). Additional definitions are provided by SAGES in “The Definitions Document: A Reference for Use of SAGES Guidelines.”

## Diagnosis and workup

Managing abdominal pain in the gravid patient presents a dilemma in which the clinician must consider the risks and benefits of diagnostic modalities and therapies to both the mother and the fetus. An underlying principle to the workup of abdominal pain was stated by Sir Zachary Cope in 1921, “Earlier diagnosis means better prognosis” [5]. In pregnant women with abdominal pain, fetal outcome depends on the outcome of the mother. Optimal maternal outcome may require radiologic imaging, sometimes with ionizing radiation. A risk–benefit discussion with the patient should occur prior to any diagnostic study.

## Imaging techniques

### Ultrasound

**Guideline 1** Ultrasonographic imaging during pregnancy is safe and useful in identifying the etiology of acute abdominal pain in the pregnant patient (Moderate; Strong).

Abdominal pain in the pregnant patient can be separated into gynecologic and nongynecologic causes. When radiographic studies are required, ultrasound is considered safe, as no adverse effects to mother or fetus from ultrasound have been reported. It is the initial radiographic test of choice for most gynecologic causes of abdominal pain, including adnexal mass, torsion, placental abruption, placenta previa, uterine rupture, and fetal demise. Ultrasound is also a useful study for many nongynecologic causes of abdominal pain, including symptomatic gallstones and appendicitis [6–12] (Table 2).

### Risk of ionizing radiation

**Guideline 2** Expedient and accurate diagnosis should take precedence over concerns for ionizing radiation. Cumulative radiation dosage should be limited to 5–10 rads during pregnancy (Moderate; Strong).

Significant radiation exposure may lead to chromosomal mutations, neurologic abnormalities, mental retardation, and increased risk of childhood leukemia. Cumulating radiation dosage is the primary risk factor for adverse fetal effects, but fetal age at exposure is also important [8, 9, 13]. Fetal mortality is greatest when exposure occurs within the first week of conception. It has been recommended that the cumulative radiation dose to the conceptus during pregnancy be less than 5–10 rads [14]. As an example, the radiation dose to the conceptus for a plain

**Table 1** GRADE system for rating the quality of evidence for SAGES guidelines

Quality of evidence	Definition	Symbol used
High quality	Further research is very unlikely to alter confidence in the estimate of impact	
Moderate quality	Further research is likely to alter confidence in the estimate of impact and may change the estimate	
Low quality	Further research is very likely to alter confidence in the estimate of impact and is likely to change the estimate	
Very low quality	Any estimate of impact is uncertain	

Adapted from Guyatt et al. [4]

**Table 2** GRADE system for recommendations based on the quality of evidence for SAGES guidelines

Strong	It is very certain that benefit exceeds risk for the option considered	
Weak	Risk and benefit well balanced, patients in differing clinical situations would make different choices, or benefits available but not certain	

Adapted from Guyatt et al. [4]

**Table 3** Radiation exposure to conceptus in common radiologic studies [15, 33, 34]

Study	Radiation exposure (rads)
Abdominal radiograph	0.1–0.3
Intraoperative cholangiography	0.2
Lumbar spine radiograph	0.6
Intravenous pyelogram	0.6
Barium enema	0.7
CT of pelvis	1–5
ERCP (without pelvic shielding)	2–12.5

abdominal radiograph averages 0.1–0.3 rad, while a CT of the pelvis yields up to 5 rads of fetal exposure [15] (see Table 3 for additional radiation doses).

The most sensitive time period for central nervous system teratogenesis is between 10 and 17 weeks gestation, and routine radiographs should be avoided during this time. In later pregnancy the concern shifts from teratogenesis to increasing the risk of childhood hematologic malignancy. The background incidence of childhood cancer and leukemia is approximately 0.2–0.3%. Radiation may increase that incidence by 0.06% per 1 rad delivered to the fetus [14].

Exposure of the conceptus to 0.5 rad increases the risk of spontaneous abortion, major malformations, mental retardation, and childhood malignancy to one additional case in 6,000 above baseline risk [15]. It has been suggested that the risk of aberrant teratogenesis is negligible at 5 rads or less and that the risk of malformation is significantly increased at doses above 15 rads. No single diagnostic study should exceed 5 rads [9, 13, 14, 16–19].

#### Computed tomography

**Guideline 3** Contemporary multidetector CT protocols deliver a low radiation dose and may be used judiciously during pregnancy (Moderate; Weak).

Computed tomography (CT) may be used in the evaluation of abdominal pain in the gravid patient [20]. Radiation exposure to the fetus may be as low as 2 rads

for pelvic CT scans but can reach 5 rads when a full scan of the abdomen and pelvis is performed [8, 21, 22]. This radiation dose is considered safe but may affect teratogenesis and increase the risk of developing childhood hematologic malignancies [21]. CT protocols and radiation doses vary by institution, and the individual practitioner should be aware of the radiation exposure at his or her institution and attempt to minimize fetal radiation exposure, if possible.

#### Magnetic resonance imaging

**Guideline 4** MR imaging without the use of intravenous gadolinium can be performed at any stage of pregnancy (Low; Strong).

MRI provides excellent soft tissue imaging without ionizing radiation and is safe to use in pregnant patients. Some authors express concern about the detrimental effects of the acoustic noise to the fetus [23], but no specific adverse effects of MRI on fetal development have been reported [24–28]. Intravenous gadolinium agents cross the placenta and may be detrimental; therefore, their use during pregnancy should be confined to select cases where it is considered essential [25, 29, 30].

#### Nuclear medicine

**Guideline 5** Administration of radionuclides for diagnostic studies is generally safe for mother and fetus (Low; Weak).

Radiopharmaceuticals, including technetium-99m, can generally be administered at doses that provide whole-fetal exposure of less than 0.5 rad [31, 32], well within the safe range of fetal exposure. Consultation with a nuclear medicine radiologist or technologist should be considered prior to performing the study.

#### Cholangiography

**Guideline 6** Intraoperative and endoscopic cholangiography exposes the mother and fetus to minimal radiation and may be used selectively during pregnancy. The lower

abdomen should be shielded when performing cholangiography during pregnancy to decrease the radiation exposure to the fetus (Low; Weak).

Radiation exposure during cholangiography is estimated to be 0.2–0.5 rad [33]. Fluoroscopy generally delivers a radiation dose of up to 20 rads/min, but varies depending on the X-ray equipment used, patient positioning, and patient size. During cholangiography, the fetus should be shielded by placing a protective device between the source of ionizing radiation and the patient. Efforts should be made to shield the fetus from radiation exposure without compromising the field of view necessary for proper imaging. No adverse effects to pregnant patients or their fetuses have been reported specifically from cholangiography.

The radiation exposure during endoscopic retrograde cholangiopancreatography (ERCP) averages 2–12 rads, but can be substantially higher for long procedures [34]. ERCP also carries risks beyond the radiation exposure such as bleeding and pancreatitis. In nonpregnant patients, the risk of bleeding is 1.3% and the risk of pancreatitis is 3.5–11% [35]. These additional risks warrant the same careful risk–benefit analysis and discussion with the patient as other operative and procedural interventions [8, 18, 36–38]. Alternatives to fluoroscopy include intraoperative ultrasound and choledochoscopy. These are both acceptable methods provided the surgeon has the appropriate equipment and skills to accurately perform the examinations.

Magnetic resonance cholangiopancreatography (MRCP) is an alternative approach that is gaining widespread acceptance. It is a useful diagnostic tool but offers no therapeutic capability. It has not been studied specifically in pregnant women.

#### Surgical techniques

**Guideline 7** Diagnostic laparoscopy is safe and effective when used selectively in the workup and treatment of acute abdominal processes in pregnancy (Moderate; Strong).

Diagnostic laparoscopy provides direct visualization of intra-abdominal organs. While not enough data are available to recommend this as a primary diagnostic approach in the pregnant patient, it is a reasonable alternative to radiologic imaging. The benefits of operative exploration are avoidance of ionizing radiation, diagnostic accuracy, and the capability to treat a surgical problem at the time of diagnosis. Furthermore, it has been shown that laparoscopy can be performed safely during any trimester of pregnancy with minimal morbidity to the fetus and mother [39–51].

## Patient selection

### Preoperative decision making

**Guideline 8** Laparoscopic treatment of acute abdominal disease has the same indications in pregnant and nonpregnant patients (Moderate; Strong).

Once the decision to operate has been made, the surgical approach (laparotomy versus laparoscopy) should be determined based on the skills of the surgeon and the availability of the appropriate staff and equipment. An appropriate discussion with the patient regarding the risks and benefits of surgical intervention should be undertaken. Benefits of laparoscopy during pregnancy appear similar to those benefits in nonpregnant patients, including less postoperative pain, less postoperative ileus, decreased length of hospital stay, and faster return to work [40, 45, 52–54].

### Laparoscopy and trimester of pregnancy

**Guideline 9** Laparoscopy can be safely performed during any trimester of pregnancy (Moderate; Strong).

Operative intervention may be performed in any trimester of pregnancy. Historical recommendations were to delay surgery until the second trimester in order to reduce the rates of spontaneous abortion and preterm labor [55]. Recent literature has shown that pregnant patients may undergo laparoscopic surgery safely during any trimester without any increased risk to the mother or fetus [39, 40, 54, 56–59]. Postponing necessary operations until after parturition may, in some cases, increase the rates of complications for mother and fetus [56, 60–62].

It has been suggested that the gestational age limit for successful completion of laparoscopic surgery during pregnancy is 26–28 weeks [44]. This has been refuted by several studies in which laparoscopic cholecystectomy and appendectomy have been successfully performed late in the third trimester [57, 59, 63, 64].

Although laparoscopy can be performed safely in pregnancy with good fetal and maternal outcomes, the long-term effects to the children have not been well studied. One recent study evaluated 11 children from 1 to 8 years old and found no growth or developmental delay [51].

## Treatment

There are many advantages of using laparoscopy in the pregnant patient, including decreased fetal respiratory depression due to diminished postoperative narcotic requirements [45, 65–67], lower risk of wound complications

[65, 68, 69], diminished postoperative maternal hypoventilation [65, 66], shorter hospital stay, and decreased risk of thromboembolic events. The improved visualization in laparoscopy may reduce the risk of uterine irritability by decreasing the need for uterine manipulation [70]. Decreased uterine irritability results in lower rates of spontaneous abortion and preterm delivery [71].

#### Patient positioning

**Guideline 10** Gravid patients should be placed in the left lateral decubitus position to minimize compression of the vena cava (Moderate; Strong).

When the pregnant patient is placed in a supine position, the gravid uterus places pressure on the inferior vena cava resulting in decreased venous return to the heart. This decrease in venous return results in significant reduction in cardiac output with concomitant maternal hypotension and decreased placental perfusion during surgery [72–74]. Placing the patient in a left lateral decubitus position will shift the uterus off the vena cava improving venous return and cardiac output [72, 73].

#### Initial port placement

**Guideline 11** Initial abdominal access can be safely accomplished with an open (Hasson) technique, Veress needle, or optical trocar, if the location is adjusted according to fundal height and previous incisions (Moderate; Strong).

There has been much debate regarding abdominal access in the pregnant patient, with preferences toward either a Hasson technique or Veress needle. The concern for use of the Veress needle has been based largely on concerns for injury to the uterus or other intra-abdominal organs [75, 76]. Because the intra-abdominal domain is altered during the second and third trimesters, initially accessing the abdomen via a subcostal approach has been recommended [57, 59, 63, 70]. If the site of initial abdominal access is adjusted according to fundal height and the abdominal wall is elevated during insertion, both the Hasson technique and the Veress needle can be used safely and effectively [57, 59, 77].

It has also been recommended that trocar placement be altered from the standard configuration to account for the increased size of the uterus [78, 79]. Ultrasound-guided trocar placement has been described in the literature as an additional safeguard to avoid uterine injury [80].

#### Insufflation pressure

**Guideline 12** CO<sub>2</sub> insufflation of 10–15 mmHg can be safely used for laparoscopy in the pregnant patient (Moderate; Strong).

The potential for adverse consequences from CO<sub>2</sub> insufflation in the pregnant patient has led to apprehension over its use. As such, some authors advocate gasless laparoscopy in pregnant patients, but this technique not been widely adopted [81–88].

The pregnant patient's diaphragm is upwardly displaced by the growing fetus, which results in decreased residual lung volume and functional residual capacity [89]. Upward displacement of the diaphragm by pneumoperitoneum is more worrisome in a pregnant patient with existing restrictive pulmonary physiology. Some have recommended intra-abdominal insufflation pressures be maintained at less than 12 mmHg to avoid worsening pulmonary physiology in gravid women [50, 79]. Others have argued that insufflation less than 12 mmHg may not provide adequate visualization of the intra-abdominal cavity [57, 59]. Pressures of 15 mmHg have been used during laparoscopy in pregnant patients without increasing adverse outcomes to the patient or her fetus [57, 59].

Because CO<sub>2</sub> exchange occurs with intraperitoneal insufflation, there has been concern for deleterious effects to the fetus from pneumoperitoneum. Some animal studies have confirmed fetal acidosis with associated tachycardia, hypertension, and hypercapnia during CO<sub>2</sub> pneumoperitoneum [90–92], while other animal studies contradict these findings [93]. There are no data showing detrimental effects to human fetuses from CO<sub>2</sub> pneumoperitoneum [44].

#### Intraoperative CO<sub>2</sub> monitoring

**Guideline 13** Intraoperative CO<sub>2</sub> monitoring by capnography should be used during laparoscopy in the pregnant patient (Moderate; Strong).

Fetal acidosis and associated fetal instability in CO<sub>2</sub> pneumoperitoneum have been documented in animal studies, though no long-term effects from these changes have been identified [90–92, 94]. Fetal acidosis with insufflation has not been documented in the human fetus, but concerns over potential detrimental effects of acidosis have led to the recommendation of maternal CO<sub>2</sub> monitoring [95, 96]. Initially, there was debate over maternal blood gas monitoring of arterial carbon dioxide (PaCO<sub>2</sub>) versus end-tidal carbon dioxide (EtCO<sub>2</sub>) monitoring, but the less invasive capnography has been demonstrated to adequately reflect maternal acid-base status in humans

[97]. Several large studies have documented the safety and efficacy of EtCO<sub>2</sub> measurements in pregnant women [44, 57, 59], making routine blood gas monitoring unnecessary.

#### Venous thromboembolic (VTE) prophylaxis

**Guideline 14** Intraoperative and postoperative pneumatic compression devices and early postoperative ambulation are recommended prophylaxes for deep venous thrombosis in the gravid patient (Moderate; Strong).

Pregnancy is a hypercoagulable state with a 0.1–0.2% incidence of deep venous thrombosis [98]. CO<sub>2</sub> pneumoperitoneum may increase the risk of deep venous thrombosis by predisposing to venous stasis. Insufflation of 12 mmHg causes a significant decrease in blood flow that cannot be completely reversed with intermittent pneumatic compression devices or intermittent electric calf stimulators [99].

Although there is little research on prophylaxis for deep venous thrombosis in the pregnant patient, general principles for laparoscopic surgery apply. Because of the increased risk of thrombosis, prophylaxis with pneumatic compression devices both intraoperatively and postoperatively and early postoperative ambulation are recommended. There are no data regarding use of unfractionated or low-molecular-weight heparin for prophylaxis in pregnant patients undergoing laparoscopy, though its use has been suggested in patients undergoing extended major operations [100]. In patients who require anticoagulation during pregnancy, heparin has proven safe and is the agent of choice [101].

#### Gallbladder disease

**Guideline 15** Laparoscopic cholecystectomy is the treatment of choice in the pregnant patient with gallbladder disease, regardless of trimester (Moderate; Strong).

In the past, nonoperative management of symptomatic cholelithiasis in pregnancy has been recommended [60, 102–104]. At present, early surgical management is the treatment of choice. Early surgical management of gravid patients with symptomatic gallstones is supported by data showing recurrent symptoms in 92% of patients managed nonoperatively who present in the first trimester, 64% who present in the second trimester, and 44% who present in the third trimester [105, 106]. This delay in surgical management results in increased rates of hospitalizations, spontaneous abortions, preterm labor, and preterm delivery compared to those who undergo cholecystectomy [39, 40, 50, 52, 87–89]. Altogether, nonoperative management of symptomatic gallstones in gravid patients results in recurrent symptoms in more than 50% of patients, and 23% of

such patients develop acute cholecystitis or gallstone pancreatitis [56]. Gallstone pancreatitis results in fetal loss in 10–60% of pregnant patients [107, 108].

The significant morbidity and mortality associated with untreated gallbladder disease in the gravid patient favor surgical treatment. Laparoscopic cholecystectomy is preferred because of the salutary outcomes and favorable side-effect profile [58]. There have been no reports of fetal demise with laparoscopic cholecystectomy performed during the first and second trimesters [109]. Furthermore, decreased rates of spontaneous abortion and preterm labor have been reported in laparoscopic cholecystectomy when compared to laparotomy [110].

#### Choledocholithiasis

**Guideline 16** Choledocholithiasis during pregnancy may be managed with preoperative endoscopic retrograde cholangiopancreatography (ERCP) with sphincterotomy followed by laparoscopic cholecystectomy, laparoscopic common bile duct exploration, or postoperative ERCP (Moderate; Strong).

Complications associated with choledocholithiasis are relatively uncommon during pregnancy [111, 112]. However, these complications can result in significant morbidity and mortality making appropriate management of these patients important. There have been no trials comparing common bile duct exploration at the time of laparoscopic cholecystectomy to ERCP followed by cholecystectomy in pregnant patients. Good outcomes have been described with intraoperative common bile duct exploration, but few cases have been reported [113]. Multiple studies have demonstrated safe and effective management of common bile duct stones with preoperative ERCP followed by laparoscopic cholecystectomy [114–119].

#### Laparoscopic appendectomy

**Guideline 17** Laparoscopic appendectomy may be performed safely in pregnant patients with appendicitis (Moderate; Strong).

The laparoscopic approach is the preferred treatment for pregnant patients with presumed appendicitis [120], and the preponderance of studies have shown the technique to be safe and effective [57, 59, 121–127]. These retrospective series have shown very low rates of preterm delivery and, in most series, no reports of fetal demise.

Accurate and timely diagnosis of appendicitis in the gravid patient may minimize the risk of fetal loss and optimize outcomes. In some circumstances clinical findings may be sufficient for diagnosis. When the diagnosis remains uncertain, prompt use of ultrasound, CT, or MRI is

a useful adjunct to a more accurate diagnosis of appendicitis and decreases the rate of negative laparoscopy. However, the false-negative rates of CT and MRI studies have yet to be fully evaluated in the gravid patient, and some hospitals may not have immediate access to these radiologic modalities.

The published data overwhelmingly attest to the safety of laparoscopic appendectomy in the gravid patient, but one recent study describes a higher risk for laparoscopy compared to laparotomy [128]. This population-based study showed an odds ratio of 2.3 for fetal loss in laparoscopy compared to conventional surgery for appendicitis. This single study does not contraindicate laparoscopic appendectomy in pregnant patients, but it does illuminate a need for further research on the subject. Unless future studies bolster the above observational data, laparoscopic appendectomy remains the treatment of choice for pregnant patients.

#### Solid organ resection

**Guideline 18** Laparoscopic adrenalectomy, nephrectomy, and splenectomy are safe procedures in pregnant patients (Low; Weak).

Laparoscopic adrenalectomy during pregnancy has proven effective in the management of primary hyperaldosteronism [129], Cushing's syndrome [130–132], and pheochromocytoma [133–138]. Laparoscopic splenectomy has also become an increasingly accepted surgical approach in pregnancy [139]. Gravid patients with antiphospholipid syndrome [140], hereditary spherocytosis [141], and autoimmune thrombocytopenia purpura [139, 142, 143] have undergone laparoscopic splenectomy with good outcomes for mother and fetus. Two cases of laparoscopic nephrectomy have been reported in the first and second trimesters without any associated complications and both infants were born healthy at term [144, 145].

#### Adnexal masses

**Guideline 19** Laparoscopy is safe and effective treatment in gravid patients with symptomatic ovarian cystic masses. Observation is acceptable for all other cystic lesions provided ultrasound is not concerning for malignancy and tumor markers are normal. Initial observation is warranted for most cystic lesions <6 cm in size (Low; Strong).

The incidence of adnexal masses during pregnancy is 2% [146]. Most of these adnexal masses discovered during the first trimester are functional cysts that resolve spontaneously by the second trimester [78]. Eighty to 95% of adnexal masses  $\leq 6$  cm in diameter in pregnant patients spontaneously resolve; therefore, nonoperative management is warranted in such cases [147, 148].

Persistent masses are most commonly functional cysts or mature cystic teratomas with the incidence of malignancy reported at 2–6% [149]. Historically, the concern over malignant potential and risks associated with emergency surgery have led to elective removal of masses that persist after 16 weeks and are >6 cm in diameter [148–150]. Recent literature supports the safety of close observation in these patients when ultrasound findings are not concerning for malignancy, tumor markers (CA125, LDH) are normal, and the patient is asymptomatic [151–154]. In the event that surgery is indicated, various case reports support the use of laparoscopy in the management of adnexal masses in every trimester [155–167]. Perhaps more informative, a retrospective review of 88 pregnant women demonstrated equivalent maternal and fetal outcomes in adnexal masses managed laparoscopically and by laparotomy [70].

#### Adnexal torsion

**Guideline 20** Laparoscopy is recommended for both diagnosis and treatment of adnexal torsion unless clinical severity warrants laparotomy (Low; Strong).

Ten to 15% of adnexal masses undergo torsion [168]. Laparoscopy is the preferred method of both diagnosis and treatment in the gravid patient with adnexal torsion [169]. Multiple case reports have confirmed the safety and efficacy of laparoscopy for adnexal torsion in pregnant patients [170–174]. If diagnosed before tissue necrosis, adnexal torsion may be managed by simple laparoscopic detorsion [175]. However, with late diagnosis of torsion, adnexal infarction may ensue, which can result in peritonitis, spontaneous abortion, preterm delivery, and death [150, 176]. The gangrenous adnexa should be completely resected [177] and progesterone therapy initiated after removal of the corpus luteum, if less than 12 weeks gestation [175]. Laparotomy may be necessary as dictated by the patient's clinical condition and operative findings [178].

#### Perioperative care

##### Fetal heart monitoring

**Guideline 21** Fetal heart monitoring should occur preoperatively and postoperatively in the setting of urgent abdominal surgery during pregnancy (Moderate; Strong).

While intraoperative fetal heart rate monitoring was once thought to be the most accurate method to detect fetal distress during laparoscopy, no intraoperative fetal heart rate abnormalities have been reported in the literature [56, 110]. This has led some to recommend preoperative

and postoperative monitoring of the fetal heart rate with no increased fetal morbidity having been reported [57, 59].

#### Obstetric consultation

**Guideline 22** Obstetric consultation can be obtained pre- and/or postoperatively based on the severity of the patient's disease, gestational age, and availability of the consultant (Moderate; Strong).

Maternal and fetal monitoring should be part of any pregnant patient's care and should continue throughout her hospitalization, but the timing of a formal obstetric consultation will vary based on availability of the consultant and the severity of the patient's condition. Delaying the treatment of an acute abdominal process to obtain such a consultation should be avoided as treatment delay may increase the risk of morbidity and mortality to the mother and fetus [179].

#### Tocolytics

**Guideline 23** Tocolytics should not be used prophylactically in pregnant women undergoing surgery but should be considered perioperatively when signs of preterm labor are present (High; Strong).

Threatened preterm labor can be successfully managed with tocolytic therapy. The specific agent and indications for the use of tocolytics should be individualized and based on the recommendation of an obstetrician [180–183]. No literature supports the use of prophylactic tocolytics.

### Summary of recommendations

More data have accumulated recently as the use of laparoscopy during pregnancy has become common. Most of the data are found in case series and retrospective reviews, which limits the ability to provide absolute guidelines. Further controlled clinical studies are needed to clarify these guidelines, and revision may be necessary as new data appear. The current recommendations for laparoscopy during pregnancy are as follows:

### Diagnosis and workup

#### Imaging techniques

##### *Ultrasound*

**Guideline 1** Ultrasonographic imaging during pregnancy is safe and useful in identifying the etiology of acute abdominal pain in the pregnant patient (Moderate; Strong).

#### *Risk of ionizing radiation*

**Guideline 2** Expeditious and accurate diagnosis should take precedence over concerns for ionizing radiation. Cumulative radiation dosage should be limited to 5–10 rads during pregnancy (Moderate; Strong).

#### *Computed tomography*

**Guideline 3** Contemporary multidetector CT protocols deliver a low radiation dose to the fetus and may be used judiciously during pregnancy (Moderate; Weak).

#### *Magnetic resonance imaging*

**Guideline 4** MR imaging without intravenous gadolinium can be performed at any stage of pregnancy (Low; Strong).

#### *Nuclear medicine*

**Guideline 5** Administration of radionucleotides for diagnostic studies is generally safe for mother and fetus (Low; Weak).

#### *Cholangiography*

**Guideline 6** Intraoperative and endoscopic cholangiography exposes the mother and fetus to minimal radiation and may be used selectively during pregnancy. The lower abdomen should be shielded when performing cholangiography during pregnancy to decrease the radiation exposure to the fetus (Low; Weak).

#### Surgical techniques

**Guideline 7** Diagnostic laparoscopy is safe and effective when used selectively in the workup and treatment of acute abdominal processes in pregnancy (Moderate; Strong).

#### Patient selection

##### *Preoperative decision-making*

**Guideline 8** Laparoscopic treatment of acute abdominal disease has the same indications in pregnant and non-pregnant patients (Moderate; Strong).

##### *Laparoscopy and trimester of pregnancy*

**Guideline 9** Laparoscopy can be safely performed during any trimester of pregnancy (Moderate; Strong).

## Treatment

*Patient positioning*

**Guideline 10** Gravid patients should be placed in the left lateral decubitus position to minimize compression of the vena cava (Moderate; Strong).

*Initial port placement*

**Guideline 11** Initial abdominal access can be safely performed with an open (Hasson) technique, Veress needle, or optical trocar, if the location is adjusted according to fundal height and previous incisions (Moderate; Weak).

*Insufflation pressure*

**Guideline 12** CO<sub>2</sub> insufflation of 10–15 mmHg can be safely used for laparoscopy in the pregnant patient (Moderate; Strong).

*Intraoperative CO<sub>2</sub> monitoring*

**Guideline 13** Intraoperative CO<sub>2</sub> monitoring by capnography should be used during laparoscopy in the pregnant patient (Moderate; Strong).

*Venous thromboembolic (VTE) prophylaxis*

**Guideline 14** Intraoperative and postoperative pneumatic compression devices and early postoperative ambulation are recommended prophylaxis for deep venous thrombosis in the gravid patient (Moderate; Strong).

*Gallbladder disease*

**Guideline 15** Laparoscopic cholecystectomy is the treatment of choice in the pregnant patient with gallbladder disease, regardless of trimester (Moderate; Strong).

*Choledocholithiasis*

**Guideline 16** Choledocholithiasis during pregnancy may be managed with preoperative endoscopic retrograde cholangiopancreatography (ERCP) with sphincterotomy followed by laparoscopic cholecystectomy, laparoscopic common bile duct exploration, or postoperative ERCP (Moderate; Strong).

*Laparoscopic appendectomy*

**Guideline 17** Laparoscopic appendectomy may be performed safely in pregnant patients with appendicitis (Moderate; Strong).

*Solid-organ resection*

**Guideline 18** Laparoscopic adrenalectomy, nephrectomy, splenectomy, and mesenteric cyst excision are safe procedures in pregnant patients (Low; Weak).

*Adnexal mass*

**Guideline 19** Laparoscopy is a safe and effective treatment in gravid patients with symptomatic ovarian cystic masses. Observation is acceptable for all other cystic lesions provided ultrasound is not concerning for malignancy and tumor markers are normal. Initial observation is warranted for most cystic lesions <6 cm in size (Low; Strong).

*Adnexal torsion*

**Guideline 20** Laparoscopy is recommended for both diagnosis and treatment of adnexal torsion unless clinical severity warrants laparotomy (Low; Strong).

## Perioperative care

*Fetal heart monitoring*

**Guideline 21** Fetal heart monitoring should occur pre- and postoperatively in the setting of urgent abdominal surgery during pregnancy (Moderate; Strong).

*Obstetrical consultation*

**Guideline 22** Obstetric consultation can be obtained pre- and/or postoperatively based on the severity of the patient's disease and availability (Moderate; Strong).

*Tocolytics*

**Guideline 23** Tocolytics should not be used prophylactically in pregnant women undergoing surgery but should be considered perioperatively when signs of preterm labor are present (High, Strong).

**Disclosure** Drs. Pearl, Price, Richardson, and Fanelli have no conflicts of interest or financial ties to disclose.

**This document was prepared and revised by the SAGES Guidelines Committee:**

Jonathan P. Pearl, MD  
 Raymond R. Price, MD  
 Ziad T. Awad, MD  
 Simon Bergman, MD  
 Ronald H. Clements, MD  
 David B. Earle, MD  
 David S. Edelman, MD  
 Liane S. Feldman, MD  
 Erika K. Fellingner, MD  
 Shannon A. Fraser, MD  
 Stephen P. Haggerty, MD  
 William W. Hope, MD  
 Ifeoma J. Igboeli, MD  
 Geoffrey P. Kohn, MD  
 Henry J. Lujan, MD  
 Lisa R. Martin Hawver, MD  
 Sumeet K. Mittal, MD  
 Erica A. Moran, MD  
 David W. Overby, MD  
 Kurt E. Roberts, MD  
 John S. Roth, MD  
 Alan A. Saber, MD  
 J. R. Salameh, MD  
 Dimitrios Stefanidis, MD  
 Andrew S. Wright, MD  
 Jin S. Yoo, MD  
 Joerg Zehetner, MD  
 Marc Zerey, MD  
 William S. Richardson, MD (Co-Chair)  
 Robert D. Fanelli, MD, FACS (Chair)

It was reviewed and approved by the Board of Governors of the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), January 2011. Requests for prints should be sent to Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), 11300 West Olympic Blvd., Suite 600, Los Angeles, CA 90064. Telephone: (310) 437-0544; Fax: (310) 437 0585; e-mail: publications@sages.org. <http://www.sages.org/>. This is a revision of a SAGES publication printed September 2007.

## References

- Kammerer WS (1979) Nonobstetric surgery during pregnancy. *Med Clin North Am* 63:1157–1164
- Kort B, Katz VL, Watson WJ (1993) The effect of nonobstetric operation during pregnancy. *Surg Gynecol Obstet* 177:371–376
- Fallon WF Jr, Newman JS, Fallon GL, Malangoni MA (1995) The surgical management of intra-abdominal inflammatory conditions during pregnancy. *Surg Clin North Am* 75:15–31
- Guyatt GH, Oxman AD, Kunz R, Vist GE, Falck-Ytter Y, Alonso-Coello P, Schünemann HJ, GRADE Working Group (2008) GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ* 336:924–926
- Baer J (1932) Appendicitis in pregnancy with changes in position and axis of the normal appendix in pregnancy. *JAMA* 98:1359–1364
- Eyvazzadeh AD, Levine D (2006) Imaging of pelvic pain in the first trimester of pregnancy. *Radiol Clin North Am* 44:863–877
- (1977) Medical radiation exposure of pregnant and potentially pregnant women. National Council on Radiation Protection and Measurements report No. 54, Bethesda, MD
- Kennedy A (2000) Assessment of acute abdominal pain in the pregnant patient. *Semin Ultrasound CT MR* 21:64–77
- Toppenberg KS, Hill DA, Miller DP (1999) Safety of radiographic imaging during pregnancy. *Am Fam Physician* 59:1813–1818, 1820
- Moore C, Promes SB (2004) Ultrasound in pregnancy. *Emerg Med Clin North Am* 22:697–722
- Lim HK, Bae SH, Seo GS (1992) Diagnosis of acute appendicitis in pregnant women: value of sonography. *AJR Am J Roentgenol* 159:539–542
- Nelson MJ, Cavalieri R, Graham D, Sanders RC (1986) Cysts in pregnancy discovered by sonography. *J Clin Ultrasound* 14:509–512
- Timins JK (2001) Radiation during pregnancy. *N J Med* 98:29–33
- Karam PA (2000) Determining and reporting fetal radiation exposure from diagnostic radiation. *Health Phys* 79:S85–S90
- Chen MM, Coakley FV, Kaimal A, Laros RK Jr (2008) Guidelines for computed tomography and magnetic resonance imaging use during pregnancy and lactation. *Obstet Gynecol* 112(2 Pt 1):333–340
- (1977) Medical radiation exposure of pregnant and potentially pregnant women. National Council on Radiation Protection and Measurements report No 54: Bethesda, MD
- Doll R, Wakeford R (1997) Risk of childhood cancer from fetal irradiation. *Br J Radiol* 70:130–139
- Osei EK, Faulkner K (1999) Fetal doses from radiological examinations. *Br J Radiol* 72:773–780
- Lowe SA (2004) Diagnostic radiography in pregnancy: risks and reality. *Aust N Z J Obstet Gynaecol* 44:191–196
- Menias CO, Elsayes KM, Peterson CM, Huete A, Gratz BI, Bhalla S (2007) CT of pregnancy-related complications. *Emerg Radiol* 13(6):299–306
- Hurwitz LM, Yoshizumi T, Reiman RE, Goodman PC, Paulson EK, Frush DP, Toncheva G, Nguyen G, Barnes L (2006) Radiation dose to the fetus from body MDCT during early gestation. *AJR Am J Roentgenol* 186:871–876
- Forsted DH, Kalbhen CL (2002) CT of pregnant women for urinary tract calculi, pulmonary thromboembolism, and acute appendicitis. *AJR Am J Roentgenol* 178:1285
- Patel SJ, Reede DL, Katz DS, Subramaniam R, Amorosa JK (2007) Imaging the pregnant patient for nonobstetric conditions: algorithms and radiation dose considerations. *Radiographics* 27:1705–1722
- De Wilde JP, Rivers AW, Price DL (2005) A review of the current use of magnetic resonance imaging in pregnancy and safety implications for the fetus. *Prog Biophys Mol Biol* 87:335–353
- Garcia-Bournissen F, Shrim A, Koren G (2006) Safety of gadolinium during pregnancy. *Can Fam Physician* 52:309–310
- Nagayama M, Watanabe Y, Okumura A, Amoh Y, Nakashita S, Dodo Y (2002) Fast MR imaging in obstetrics. *Radiographics* 22:563–580 (discussion 580–562)

27. Leyendecker JR, Gorengaut V, Brown JJ (2004) MR imaging of maternal diseases of the abdomen and pelvis during pregnancy and the immediate postpartum period. *Radiographics* 24: 1301–1316
28. McKenna DA, Meehan CP, Alhajeri AN, Regan MC, O’Keeffe DP (2007) The use of MRI to demonstrate small bowel obstruction during pregnancy. *Br J Radiol* 80:e11–e14
29. Birchard KR, Brown MA, Hyslop WB, Firat Z, Semelka RC (2005) MRI of acute abdominal and pelvic pain in pregnant patients. *AJR Am J Roentgenol* 184:452–458
30. Brown MA, Birchard KR, Semelka RC (2005) Magnetic resonance evaluation of pregnant patients with acute abdominal pain. *Semin Ultrasound CT MR* 26:206–211
31. Adelstein SJ (1999) Administered radionuclides in pregnancy. *Teratology* 59:236–239
32. Schaefer C, Meister R, Wentzack R, Weber-Schoendorfer C (2009) Fetal outcome after technetium scintigraphy in early pregnancy. *Reprod Toxicol* 28:161–166
33. Karthikesalingam A, Markar SR, Weerakkody R, Walsh SR, Carroll N, Praseedom RK (2009) Radiation exposure during laparoscopic cholecystectomy with routine intraoperative cholangiography. *Surg Endosc* 23:1845–1848
34. Jorgensen JE, Rubenstein JH, Goodsitt MM, Elta GH (2010) Radiation doses to ERCP patients are significantly lower with experienced endoscopists. *Gastrointest Endosc* 72:58–65
35. Andriulli A, Loperfido S, Napolitano G, Niro G, Valvano MR, Spirito F, Pilotto A, Forlano R (2007) Incidence rates of post-ERCP complications: a systematic survey of prospective studies. *Am J Gastroenterol* 102(8):1781–1788
36. Qureshi WA, Rajan E, Adler DG, Davila RE, Hirota WK, Jacobson BC, Leighton JA, Zuckerman MJ, Hambrick RD, Fanelli RD, Baron T, Faigel DO (2005) ASGE guideline: guidelines for endoscopy in pregnant and lactating women. *Gastrointest Endosc* 61:357–362
37. Quan WL, Chia CK, Yim HB (2006) Safety of endoscopic procedures during pregnancy. *Singapore Med J* 47:525–528
38. Tang SJ, Mayo MJ, Rodriguez-Frias E, Armstrong L, Tang L, Sreenarasimhaiah J, Lara LF, Rockey DC (2009) Safety and utility of ERCP during pregnancy. *Gastrointest Endosc* 69:453–461
39. Reedy MB, Kallen B, Kuehl TJ (1997) Laparoscopy during pregnancy: a study of five fetal outcome parameters with use of the Swedish Health Registry. *Am J Obstet Gynecol* 177: 673–679
40. Reedy MB, Galan HL, Richards WE, Preece CK, Wetter PA, Kuehl TJ (1997) Laparoscopy during pregnancy. A survey of laparoendoscopic surgeons. *J Reprod Med* 42:33–38
41. Gurbuz AT, Peetz ME (1997) The acute abdomen in the pregnant patient. Is there a role for laparoscopy? *Surg Endosc* 11:98–102
42. Buser KB (2002) Laparoscopic surgery in the pregnant patient—one surgeon’s experience in a small rural hospital. *JLS* 6: 121–124
43. Lachman E, Schienfeld A, Voss E, Gino G, Boldes R, Levine S, Borstien M, Stark M (1999) Pregnancy and laparoscopic surgery. *J Am Assoc Gynecol Laparosc* 6:347–351
44. Fatum M, Rojansky N (2001) Laparoscopic surgery during pregnancy. *Obstet Gynecol Surg* 56:50–59
45. Curet MJ, Allen D, Josloff RK, Pitcher DE, Curet LB, Miscall BG, Zucker KA (1996) Laparoscopy during pregnancy. *Arch Surg* 131:546–550 (discussion 550–541)
46. Conron RW Jr, Abbruzzi K, Cochrane SO, Sarno AJ, Cochrane PJ (1999) Laparoscopic procedures in pregnancy. *Am Surg* 65: 259–263
47. Al-Fozan H, Tulandi T (2002) Safety and risks of laparoscopy in pregnancy. *Curr Opin Obstet Gynecol* 14:375–379
48. Amos JD, Schorr SJ, Norman PF, Poole GV, Thomae KR, Mancino AT, Hall TJ, Scott-Conner CE (1996) Laparoscopic surgery during pregnancy. *Am J Surg* 171:435–437
49. Nezhat FR, Tazuke S, Nezhat CH, Seidman DS, Phillips DR, Nezhat CR (1997) Laparoscopy during pregnancy: a literature review. *JLS* 1:17–27
50. [No authors listed] (1998) Guidelines for laparoscopic surgery during pregnancy. Society of American Gastrointestinal Endoscopic Surgeons (SAGES). *Surg Endosc* 12:189–190
51. Rizzo AG (2003) Laparoscopic surgery in pregnancy: long-term follow-up. *J Laparoendosc Adv Surg Tech A* 13:11–15
52. Andreoli M, Servakov M, Meyers P, Mann WJ Jr (1999) Laparoscopic surgery during pregnancy. *J Am Assoc Gynecol Laparosc* 6:229–233
53. Shay DC, Bhavani-Shankar K, Datta S (2001) Laparoscopic surgery during pregnancy. *Anesthesiol Clin North Am* 19:57–67
54. Oelsner G, Stockheim D, Soriano D, Goldenberg M, Seidman DS, Cohen SB, Admon D, Novikov I, Maschiach S, Carp HJ, Anderman S, Ben-Ami M, Ben-Arie A, Hagay Z, Bustan M, Shalev E, Carp H, Gemer O, Golan A, Holzinger M, Beyth Y, Horowitz A, Hamani Y, Keis M, Lavie O, Luxman D, Rojansky N, Taichner G, Yafe C, Zohar S, Bilanca B (2003) Pregnancy outcome after laparoscopy or laparotomy in pregnancy. *J Am Assoc Gynecol Laparosc* 10:200–204
55. McKellar DP, Anderson CT, Boynton CJ, Peoples JB (1992) Cholecystectomy during pregnancy without fetal loss. *Surg Gynecol Obstet* 174:465–468
56. Glasgow RE, Visser BC, Harris HW, Patti MG, Kilpatrick SJ, Mulvihill SJ (1998) Changing management of gallstone disease during pregnancy. *Surg Endosc* 12:241–246
57. Affleck DG, Handrahan DL, Egger MJ, Price RR (1999) The laparoscopic management of appendicitis and cholelithiasis during pregnancy. *Am J Surg* 178:523–529
58. Barone JE, Bears S, Chen S, Tsai J, Russell JC (1999) Outcome study of cholecystectomy during pregnancy. *Am J Surg* 177: 232–236
59. Rollins MD, Chan KJ, Price RR (2004) Laparoscopy for appendicitis and cholelithiasis during pregnancy: a new standard of care. *Surg Endosc* 18(2):237–241
60. Davis A, Katz VL, Cox R (1995) Gallbladder disease in pregnancy. *J Reprod Med* 40:759–762
61. Muench J, Albrink M, Serafini F, Rosemurgy A, Carey L, Murr MM (2001) Delay in treatment of biliary disease during pregnancy increases morbidity and can be avoided with safe laparoscopic cholecystectomy. *Am Surg* 67:539–542 (discussion 542–533)
62. Visser BC, Glasgow RE, Mulvihill KK, Mulvihill SJ (2001) Safety and timing of nonobstetric abdominal surgery in pregnancy. *Dig Surg* 18:409–417
63. Geisler JP, Rose SL, Mernitz CS, Warner JL, Hiett AK (1998) Non-gynecologic laparoscopy in second and third trimester pregnancy: obstetric implications. *JLS* 2:235–238
64. Stepp K, Falcone T (2004) Laparoscopy in the second trimester of pregnancy. *Obstet Gynecol Clin North Am* 31:485–496, vii
65. Pucci RO, Seed RW (1991) Case report of laparoscopic cholecystectomy in the third trimester of pregnancy. *Am J Obstet Gynecol* 165:401–402
66. Weber AM, Bloom GP, Allan TR, Curry SL (1991) Laparoscopic cholecystectomy during pregnancy. *Obstet Gynecol* 78: 958–959
67. Williams JK, Rosemurgy AS, Albrink MH, Parsons MT, Stock S (1995) Laparoscopic cholecystectomy in pregnancy. A case report. *J Reprod Med* 40:243–245
68. Arvidsson D, Gerdin E (1991) Laparoscopic cholecystectomy during pregnancy. *Surg Laparosc Endosc* 1:193–194

69. Costantino GN, Vincent GJ, Mukalian GG, Kliefoth WL Jr (1994) Laparoscopic cholecystectomy in pregnancy. *J Laparosc Surg* 4:161–164
70. Soriano D, Yefet Y, Seidman DS, Goldenberg M, Mashiah S, Oelsner G (1999) Laparoscopy versus laparotomy in the management of adnexal masses during pregnancy. *Fertil Steril* 71:955–960
71. Curet MJ (2000) Special problems in laparoscopic surgery. Previous abdominal surgery, obesity, and pregnancy. *Surg Clin North Am* 80:1093–1110
72. Elkayam U, GN (1982) Cardiovascular physiology of pregnancy. Alan R. Liss, New York
73. Clark SL, Cotton DB, Pivarnik JM, Lee W, Hankins GD, Benedetti TJ, Phelan JP (1991) Position change and central hemodynamic profile during normal third-trimester pregnancy and post partum. *Am J Obstet Gynecol* 164:883–887
74. Gordon MC (2002) Maternal physiology in pregnancy. In: Gabbe SG, Niebyl JR, Simpson JL (eds) *Obstetrics: normal and problem pregnancies*. Churchill Livingstone, Philadelphia, pp 63–91
75. Friedman JD, Ramsey PS, Ramin KD, Berry C (2002) Pneumomnion and pregnancy loss after second-trimester laparoscopic surgery. *Obstet Gynecol* 99:512–513
76. Halpern NB (1998) Laparoscopic cholecystectomy in pregnancy: a review of published experiences and clinical considerations. *Semin Laparosc Surg* 5:129–134
77. Lemaire BM, van Erp WF (1997) Laparoscopic surgery during pregnancy. *Surg Endosc* 11:15–18
78. Canis M, Rabischong B, Houle C, Botchorishvili R, Jardon K, Safi A, Wattiez A, Mage G, Pouly JL, Bruhat MA (2002) Laparoscopic management of adnexal masses: a gold standard? *Curr Opin Obstet Gynecol* 14:423–428
79. Malangoni MA (2003) Gastrointestinal surgery and pregnancy. *Gastroenterol Clin North Am* 32:181–200
80. Wang CJ, Yen CF, Lee CL, Soong YK (2002) Minilaparoscopic cystectomy and appendectomy in late second trimester. *JSLs* 6:373–375
81. Akira S, Yamanaka A, Ishihara T, Takeshita T, Araki T (1999) Gasless laparoscopic ovarian cystectomy during pregnancy: comparison with laparotomy. *Am J Obstet Gynecol* 180:554–557
82. Murakami T, Noda T, Okamura C, Terada Y, Morito Y, Okamura K (2003) Cul-de-sac packing with a metreurynter in gasless laparoscopic cystectomy during pregnancy. *J Am Assoc Gynecol Laparosc* 10:421–423
83. Schmidt T, Nawroth F, Foth D, Rein DT, Romer T, Mallmann P (2001) Gasless laparoscopy as an option for conservative therapy of adnexal pedical torsion with twin pregnancy. *J Am Assoc Gynecol Laparosc* 8:621–622
84. Römer T, Bojahr B, Schwesinger G (2002) Treatment of a torqued hematosalpinx in the thirteenth week of pregnancy using gasless laparoscopy. *J Am Assoc Gynecol Laparosc* 9:89–92
85. Melgrati L, Damiani A, Franzoni G, Marziali M, Sesti F (2005) Isobaric (gasless) laparoscopic myomectomy during pregnancy. *J Minim Invasive Gynecol* 12:379–381
86. Matsumoto T, Nishi M, Yokota M, Ito M (1999) Laparoscopic treatment of uterine prolapse during pregnancy. *Obstet Gynecol* 93:849
87. Oguri H, Taniguchi K, Fukaya T (2005) Gasless laparoscopic management of ovarian cysts during pregnancy. *Int J Gynaecol Obstet* 91:258–259
88. Iafrati MD, Yarnell R, Schwaitzberg SD (1995) Gasless laparoscopic cholecystectomy in pregnancy. *J Laparosc Surg* 5:127–130
89. Hume RF, Killiam AP (1990) Maternal physiology. In: Scott JR, KiSaia J, Hammon DB (eds) *Obstetrics and gynecology*. JB Lippincott, Philadelphia, pp 93–100
90. Hunter JG, Swanstrom L, Thornburg K (1995) Carbon dioxide pneumoperitoneum induces fetal acidosis in a pregnant ewe model. *Surg Endosc* 9:272–277 (discussion 277–279)
91. Reedy MB, Galan HL, Bean-Lijewski JD, Carnes A, Knight AB, Kuehl TJ (1995) Maternal and fetal effects of laparoscopic insufflation in the gravid baboon. *J Am Assoc Gynecol Laparosc* 2:399–406
92. Curet MJ, Vogt DA, Schob O, Qualls C, Izquierdo LA, Zucker KA (1996) Effects of CO<sub>2</sub> pneumoperitoneum in pregnant ewes. *J Surg Res* 63:339–344
93. Barnard JM, Chaffin D, Droste S, Tierney A, Phernetton T (1995) Fetal response to carbon dioxide pneumoperitoneum in the pregnant ewe. *Obstet Gynecol* 85:669–674
94. Cruz AM, Southerland LC, Duke T, Townsend HG, Ferguson JG, Crone LA (1996) Intraabdominal carbon dioxide insufflation in the pregnant ewe. Uterine blood flow, intraamniotic pressure, and cardiopulmonary effects. *Anesthesiology* 85:1395–1402
95. Soper NJ, Hunter JG, Petrie RH (1992) Laparoscopic cholecystectomy during pregnancy. *Surg Endosc* 6:115–117
96. Comitalo JB, Lynch D (1994) Laparoscopic cholecystectomy in the pregnant patient. *Surg Laparosc Endosc* 4:268–271
97. Bhavani-Shankar K, Steinbrook RA, Brooks DC, Datta S (2000) Arterial to end-tidal carbon dioxide pressure difference during laparoscopic surgery in pregnancy. *Anesthesiology* 93:370–373
98. Melnick DM, Wahl WL, Dalton VK (2004) Management of general surgical problems in the pregnant patient. *Am J Surg* 187:170–180
99. Jorgensen JO, Lalak NJ, North L, Hanel K, Hunt DR, Morris DL (1994) Venous stasis during laparoscopic cholecystectomy. *Surg Laparosc Endosc* 4:128–133
100. [No authors listed] (1992) Risk of and prophylaxis for venous thromboembolism in hospital patients. *Thromboembolic Risk Factors (THRIFT) Consensus Group*. *BMJ* 305:567–574
101. Casele HL (2006) The use of unfractionated heparin and low molecular weight heparins in pregnancy. *Clin Obstet Gynecol* 49:895–905
102. Hiatt JR, Hiatt JC, Williams RA, Klein SR (1986) Biliary disease in pregnancy: strategy for surgical management. *Am J Surg* 151:263–265
103. Ghumman E, Barry M, Grace PA (1997) Management of gallstones in pregnancy. *Br J Surg* 84:1646–1650
104. Chamogeorgakis T, Lo Menzo E, Smink RD Jr, Feuerstein B, Fantazzio M, Kaufman J, Brennan EJ, Russell R (1999) Laparoscopic cholecystectomy during pregnancy: three case reports. *JSLs* 3:67–69
105. Steinbrook RA, Brooks DC, Datta S (1996) Laparoscopic cholecystectomy during pregnancy. Review of anesthetic management, surgical considerations. *Surg Endosc* 10:511–515
106. Date RS, Kaushal M, Ramesh A (2008) A review of the management of gallstone disease and its complications in pregnancy. *Am J Surg* 196:599–608
107. Scott LD (1992) Gallstone disease and pancreatitis in pregnancy. *Gastroenterol Clin North Am* 21:803–815
108. Printen KJ, Ott RA (1978) Cholecystectomy during pregnancy. *Am Surg* 44:432–434
109. Jelin EB, Smink DS, Vernon AH, Brooks DC (2008) Management of biliary tract disease during pregnancy: a decision analysis. *Surg Endosc* 22:54–60
110. Graham G, Baxi L, Tharakan T (1998) Laparoscopic cholecystectomy during pregnancy: a case series and review of the literature. *Obstet Gynecol Surg* 53:566–574
111. DeVore GR (1980) Acute abdominal pain in the pregnant patient due to pancreatitis, acute appendicitis, cholecystitis, or peptic ulcer disease. *Clin Perinatol* 7:349–369
112. Borum ML (1998) Hepatobiliary diseases in women. *Med Clin North Am* 82:51–75

113. Tuech JJ, Binelli C, Aube C, Pessaux P, Fauvet R, Descamps P, Arnaud JP (2000) Management of choledocholithiasis during pregnancy by magnetic resonance cholangiography and laparoscopic common bile duct stone extraction. *Surg Laparosc Endosc Percutan Tech* 10:323–325
114. Baillie J, Cairns SR, Putman WS, Cotton PB (1990) Endoscopic management of choledocholithiasis during pregnancy. *Surg Gynecol Obstet* 171:1–4
115. Sungler P, Heinerman PM, Steiner H, Waclawiczek HW, Holzinger J, Mayer F, Heuberger A, Boeckl O (2000) Laparoscopic cholecystectomy and interventional endoscopy for gallstone complications during pregnancy. *Surg Endosc* 14:267–271
116. Cosenza CA, Saffari B, Jabbour N, Stain SC, Garry D, Parekh D, Selby RR (1999) Surgical management of biliary gallstone disease during pregnancy. *Am J Surg* 178:545–548
117. Barthel JS, Chowdhury T, Miedema BW (1998) Endoscopic sphincterotomy for the treatment of gallstone pancreatitis during pregnancy. *Surg Endosc* 12:394–399
118. Scapa E (1995) To do or not to do an endoscopic retrograde cholangiopancreatography in acute biliary pancreatitis? *Surg Laparosc Endosc* 5:453–454
119. Andreoli M, Sayegh SK, Hofer R, Matthews G, Mann WJ (1996) Laparoscopic cholecystectomy for recurrent gallstone pancreatitis during pregnancy. *South Med J* 89:1114–1115
120. Korndorffer JR Jr, Fellingner E, Reed W (2010) SAGES guideline for laparoscopic appendectomy. *Surg Endosc* 24:757–761
121. Schwartzberg BS, Conyers JA, Moore JA (1997) First trimester of pregnancy laparoscopic procedures. *Surg Endosc* 11:1216–1217
122. Thomas SJ, Brisson P (1998) Laparoscopic appendectomy and cholecystectomy during pregnancy: six case reports. *JLS* 2:41–46
123. Barnes SL, Shane MD, Schoemann MB, Bernard AC, Boulanger BR (2004) Laparoscopic appendectomy after 30 weeks pregnancy: report of two cases and description of technique. *Am Surg* 70:733–736
124. de Perrot M, Jenny A, Morales M, Kohlik M, Morel P (2000) Laparoscopic appendectomy during pregnancy. *Surg Laparosc Endosc Percutan Tech* 10:368–371
125. Schreiber JH (1990) Laparoscopic appendectomy in pregnancy. *Surg Endosc* 4:100–102
126. Sadot E, Telem DA, Arora M, Butala P, Nguyen SQ, Divino CM (2010) Laparoscopy: a safe approach to appendicitis during pregnancy. *Surg Endosc* 24:383–389
127. Lemieux P, Rheume P, Levesque I, Bujold E, Brochu G (2009) Laparoscopic appendectomy in pregnant patients: a review of 45 cases. *Surg Endosc* 23:1701–1705
128. McGory ML, Zingmond DS, Tillou A, Hiatt JR, Ko CY, Cryer HM (2007) Negative appendectomy in pregnant women is associated with a substantial risk of fetal loss. *J Am Coll Surg* 205:534–540
129. Shalhav AL, Landman J, Afane J, Levi R, Clayman RV (2000) Laparoscopic adrenalectomy for primary hyperaldosteronism during pregnancy. *J Laparoendosc Adv Surg Tech A* 10:169–171
130. Finkenstedt G, Gasser RW, Hofle G, Lhotta K, Kolle D, Gschwendtner A, Janetschek G (1999) Pheochromocytoma and subclinical Cushing's syndrome during pregnancy: diagnosis, medical pre-treatment and cure by laparoscopic unilateral adrenalectomy. *J Endocrinol Invest* 22:551–557
131. Aishima M, Tanaka M, Haraoka M, Naito S (2000) Retroperitoneal laparoscopic adrenalectomy in a pregnant woman with Cushing's syndrome. *J Urol* 164:770–771
132. Lo CY, Lo CM, Lam KY (2002) Cushing's syndrome secondary to adrenal adenoma during pregnancy. *Surg Endosc* 16:219–220
133. Janetschek G, Finkenstedt G, Gasser R, Waibel UG, Peschel R, Bartsch G, Neumann HP (1998) Laparoscopic surgery for pheochromocytoma: adrenalectomy, partial resection, excision of paragangliomas. *J Urol* 160:330–334
134. Demeure MJ, Carlsen B, Traul D, Budney C, Lalande B, Lipinski A, Cruikshank D, Kotchen T, Wilson S (1998) Laparoscopic removal of a right adrenal pheochromocytoma in a pregnant woman. *J Laparoendosc Adv Surg Tech A* 8:315–319
135. Pace DE, Chiasson PM, Schlachta CM, Mamazza J, Caddeu MO, Poulin EC (2002) Minimally invasive adrenalectomy for pheochromocytoma during pregnancy. *Surg Laparosc Endosc Percutan Tech* 12:122–125
136. Gagner M, Breton G, Pharand D, Pomp A (1996) Is laparoscopic adrenalectomy indicated for pheochromocytomas? *Surgery* 120:1076–1079 (discussion 1079–1080)
137. Wolf A, Goretzki PE, Rohrborn A, Feldkamp J, Simon D, Scherbaum WA, Roher HD (2004) Pheochromocytoma during pregnancy: laparoscopic and conventional surgical treatment of two cases. *Exp Clin Endocrinol Diabetes* 112:98–101
138. Kim PT, Kreisman SH, Vaughn R, Panton ON (2006) Laparoscopic adrenalectomy for pheochromocytoma in pregnancy. *Can J Surg* 49:62–63
139. Griffiths J, Sia W, Shapiro AM, Tataryn I, Turner AR (2005) Laparoscopic splenectomy for the treatment of refractory immune thrombocytopenia in pregnancy. *J Obstet Gynaecol Can* 27:771–774
140. Hardwick RH, Slade RR, Smith PA, Thompson MH (1999) Laparoscopic splenectomy in pregnancy. *J Laparoendosc Adv Surg Tech A* 9:439–440
141. Allran CF Jr, Weiss CA III, Park AE (2002) Urgent laparoscopic splenectomy in a morbidly obese pregnant woman: case report and literature review. *J Laparoendosc Adv Surg Tech A* 12:445–447
142. Iwase K, Higaki J, Yoon HE, Mikata S, Tanaka Y, Takahashi T, Hatanaka K, Tamaki T, Hori S, Mitsuda N, Kamiike W (2001) Hand-assisted laparoscopic splenectomy for idiopathic thrombocytopenic purpura during pregnancy. *Surg Laparosc Endosc Percutan Tech* 11:53–56
143. Anglin BV, Rutherford C, Ramus R, Lieser M, Jones DB (2001) Immune thrombocytopenic purpura during pregnancy: laparoscopic treatment. *JLS* 5:63–67
144. O'Connor JP, Biyani CS, Taylor J, Agarwal V, Curley PJ, Browning AJ (2004) Laparoscopic nephrectomy for renal-cell carcinoma during pregnancy. *J Endourol* 18:871–874
145. Sainsbury DC, Dorkin TJ, MacPhail S, Soomro NA (2004) Laparoscopic radical nephrectomy in first-trimester pregnancy. *Urology* 64:1231.e7–8
146. Bozzo M, Buscaglia M, Ferrazzi E (1997) The management of persistent adnexal masses in pregnancy. *Am J Obstet Gynecol* 177:981–982
147. Thornton JG, Wells M (1987) Ovarian cysts in pregnancy: does ultrasound make traditional management inappropriate? *Obstet Gynecol* 69:717–721
148. Grimes WH Jr, Bartholomew RA, Colvin ED, Fish JS, Lester WM (1954) Ovarian cyst complicating pregnancy. *Am J Obstet Gynecol* 68:594–605
149. Sherard GB III, Hodson CA, Williams HJ, Semer DA, Hadi HA, Tait DL (2003) Adnexal masses and pregnancy: a 12-year experience. *Am J Obstet Gynecol* 189:358–362 (discussion 362–353)
150. Hess LW, Peaceman A, O'Brien WF, Winkel CA, Cruikshank DP, Morrison JC (1988) Adnexal mass occurring with intrauterine pregnancy: report of fifty-four patients requiring laparotomy for definitive management. *Am J Obstet Gynecol* 158:1029–1034

151. Schmeler KM, Mayo-Smith WW, Peipert JF, Weitzen S, Manuel MD, Gordinier ME (2005) Adnexal masses in pregnancy: surgery compared with observation. *Obstet Gynecol* 105:1098–1103
152. Zanetta G, Mariani E, Lissoni A, Ceruti P, Trio D, Strobelt N, Mariani S (2003) A prospective study of the role of ultrasound in the management of adnexal masses in pregnancy. *BJOG* 110:578–583
153. Condous G, Khalid A, Okaro E, Bourne T (2004) Should we be examining the ovaries in pregnancy? Prevalence and natural history of adnexal pathology detected at first-trimester sonography. *Ultrasound Obstet Gynecol* 24:62–66
154. [No authors listed] (2007) ACOG Practice Bulletin. Management of adnexal masses. *Obstet Gynecol* 110:201–214
155. Nezhat F, Nezhat C, Silfen SL, Fehnel SH (1991) Laparoscopic ovarian cystectomy during pregnancy. *J Laparoendosc Surg* 1:161–164
156. Parker WH, Levine RL, Howard FM, Sansone B, Berek JS (1994) A multicenter study of laparoscopic management of selected cystic adnexal masses in postmenopausal women. *J Am Coll Surg* 179:733–737
157. Tazuke SI, Nezhat FR, Nezhat CH, Seidman DS, Phillips DR, Nezhat CR (1997) Laparoscopic management of pelvic pathology during pregnancy. *J Am Assoc Gynecol Laparosc* 4:605–608
158. Chung MK, Chung RP (2001) Laparoscopic extracorporeal oophorectomy and ovarian cystectomy in second trimester pregnant obese patients. *JSLA* 5:273–277
159. Yuen PM, Chang AM (1997) Laparoscopic management of adnexal mass during pregnancy. *Acta Obstet Gynecol Scand* 76:173–176
160. Loh FH, Chua SP, Khalil R, Ng SC (1998) Case report of ruptured endometriotic cyst in pregnancy treated by laparoscopic ovarian cystectomy. *Singapore Med J* 39:368–369
161. Stepp KJ, Tulikangas PK, Goldberg JM, Attaran M, Falcone T (2003) Laparoscopy for adnexal masses in the second trimester of pregnancy. *J Am Assoc Gynecol Laparosc* 10:55–59
162. Neiswender LL, Toub DB (1997) Laparoscopic excision of pelvic masses during pregnancy. *J Am Assoc Gynecol Laparosc* 4:269–272
163. Yuen PM, Ng PS, Leung PL, Rogers MS (2004) Outcome in laparoscopic management of persistent adnexal mass during the second trimester of pregnancy. *Surg Endosc* 18:1354–1357
164. Parker J, Watkins W, Robinson H, Byrne D (1995) Laparoscopic adnexal surgery during pregnancy: a case of heterotopic tubal pregnancy treated by laparoscopic salpingectomy. *Aust N Z J Obstet Gynaecol* 35:208–210
165. Moore RD, Smith WG (1999) Laparoscopic management of adnexal masses in pregnant women. *J Reprod Med* 44:97–100
166. Lin YH, Hwang JL, Huang LW, Seow KM (2003) Successful laparoscopic management of a huge ovarian tumor in the 27th week of pregnancy. A case report. *J Reprod Med* 48:834–836
167. Mathevet P, Nessah K, Dargent D, Mellier G (2003) Laparoscopic management of adnexal masses in pregnancy: a case series. *Eur J Obstet Gynecol Reprod Biol* 108:217–222
168. Struyk AP, Treffers PE (1984) Ovarian tumors in pregnancy. *Acta Obstet Gynecol Scand* 63:421–424
169. Nichols DH, Julian PJ (1985) Torsion of the adnexa. *Clin Obstet Gynecol* 28:375–380
170. Mage G, Canis M, Manhes H, Pouly JL, Bruhat MA (1989) Laparoscopic management of adnexal torsion. A review of 35 cases. *J Reprod Med* 34:520–524
171. Garzarelli S, Mazzuca N (1994) One laparoscopic puncture for treatment of ovarian cysts with adnexal torsion in early pregnancy. A report of two cases. *J Reprod Med* 39:985–986
172. Morice P, Louis-Sylvestre C, Chapron C, Dubuisson JB (1997) Laparoscopy for adnexal torsion in pregnant women. *J Reprod Med* 42:435–439
173. Abu-Musa A, Nassar A, Usta I, Khalil A, Hussein M (2001) Laparoscopic unwinding and cystectomy of twisted dermoid cyst during second trimester of pregnancy. *J Am Assoc Gynecol Laparosc* 8:456–460
174. Bassil S, Steinhart U, Donnez J (1999) Successful laparoscopic management of adnexal torsion during week 25 of a twin pregnancy. *Hum Reprod* 14:855–857
175. Argenta PA, Yeagley TJ, Ott G, Sondheimer SJ (2000) Torsion of the uterine adnexa. Pathologic correlations and current management trends. *J Reprod Med* 45:831–836
176. Tarraza HM, Moore RD (1997) Gynecologic causes of the acute abdomen and the acute abdomen in pregnancy. *Surg Clin North Am* 77:1371–1394
177. Oelsner G, Bider D, Goldenberg M, Admon D, Mashiach S (1993) Long-term follow-up of the twisted ischemic adnexa managed by detorsion. *Fertil Steril* 60:976–979
178. Cappell MS, Friedel D (2003) Abdominal pain during pregnancy. *Gastroenterol Clin North Am* 32:1–58
179. Sharp HT (2002) The acute abdomen during pregnancy. *Clin Obstet Gynecol* 45:405–413
180. Katz VL, Farmer RM (1999) Controversies in tocolytic therapy. *Clin Obstet Gynecol* 42:802–819
181. Berkman ND, Thorp JM Jr, Lohr KN, Carey TS, Hartmann KE, Gavin NI, Hasselblad V, Ilicula AE (2003) Tocolytic treatment for the management of preterm labor: a review of the evidence. *Am J Obstet Gynecol* 188:1648–1659
182. Tan TC, Devendra K, Tan LK, Tan HK (2006) Tocolytic treatment for the management of preterm labour: a systematic review. *Singapore Med J* 47:361–366
183. Romero R, Sibai BM, Sanchez-Ramos L, Valenzuela GJ, Veille JC, Tabor B, Perry KG, Varner M, Goodwin TM, Lane R, Smith J, Shangold G, Creasy GW (2000) An oxytocin receptor antagonist (atosiban) in the treatment of preterm labor: a randomized, double-blind, placebo-controlled trial with tocolytic rescue. *Am J Obstet Gynecol* 182:1173–1183