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Non-obstetrical robotic-assisted laparoscopic surgery in pregnancy: a systematic literature review

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Abstract:

Urologic and gynecologic surgeons are the top utilizers of robotic surgery; however, non-obstetrical robotic-assisted laparoscopic surgery (RALS) in pregnant patients is infrequent. A systematic literature review was performed to ascertain the frequency, indication and complications of RALS in pregnancy. Results showed thirty-eight pregnancies from eleven publications between 2008-2020. Five cases were for urologic indication and thirty-three for gynecologic indication. Minimal surgical alterations were required. Although no adverse maternal-fetal outcomes were reported, there are not enough cases published to determine safety. This review demonstrates the feasibility of RALS for the pregnant population in the hands of competent robotic surgeons.

Introduction:

The use of robotic-assisted laparoscopic surgery (RALS) has become a mainstay of many surgical specialties. As more specialties have adopted its use and surgeons began to expand its reach, RALS has become a common option for many patients for various indications, including intraperitoneal, retroperitoneal, thoracic, and pelvic procedures. Currently, urological and gynecologic surgeons utilize RALS at the highest frequency and for a wide breadth of indications.[1] Uniquely, these specialties' pelvic procedures adapt well to robotic surgery, as it facilitates visualization and manipulation within a confined space. Despite its common use by gynecologists, the incorporation of RALS into the care of pregnant patients is rare. Historically, there have been concerns that the unique parameters necessitated by laparoscopic surgery were incompatible with the physiologic changes in pregnancy. Laparoscopy has since been deemed relatively safe,[2] with modest adjustments to compensate for the gravid physiology and anatomy, yet the robotic iteration of this technique lags behind. One in 500 women require non-obstetrical intraperitoneal surgery during pregnancy; 64.8% of these surgical interventions are performed laparoscopically.[3] Herein, a systematic literature review was performed in order to quantify the application of RALS in pregnant patients, catalogue the types of indications for which it was employed, and review any complications of this technique thus far.

Methods:

We conducted a search using Ovid MEDLINE, PubMed, and Scopus from 2000 to January 21, 2020 as the da Vinci surgical system was approved around 2000 by the Food and Drug Administration. Relevant papers addressing robotic surgery in pregnancy were identified. No limitations were made based on study design or language. We adopted the following search terms: (pregnancy OR antepartum OR pregnan* OR matern* OR obstetric*) AND ((robotic AND surgical AND procedures) OR (robotic AND surgery) OR ((robot* OR (((

robot-assisted) OR (robotic-assisted)) AND laparoscop*)) AND ((minimally AND invasive AND surgery) OR (minimally AND invasive AND surgical AND procedures))) OR (robot-assisted AND surgery)) OR ("da vinci" OR davinci))). The systematic review followed the Preferred Reporting Items of Systematic Reviews and Meta-analysis (PRISMA) guidelines.[4] See appendix for the full search strategies.

The search yielded 1298 articles. Eligibility of the studies was independently reviewed by two authors (C.C. and J.G.). Studies were included that addressed non-obstetric transabdominal robotic surgery occurring during pregnancy. Studies including robotic cerclage placement, robotic fetoscopic surgery, robotic surgery for ectopic pregnancy, robotic surgery postpartum and studies without detailed clinical data were excluded. Disagreements were resolved by deliberation with a third reviewer (H.A.K). The reference lists of all included studies were examined to help identify studies not captured by the initial search. A total of 11 studies were included in the final literature review (Figure 1).

Results:

Thirty-eight patients who underwent RALS during pregnancy met the inclusion criteria in eleven publications (Table 1). The mean maternal age was 30.0 $\pm$ 6.3 years with 75% multiparous (n=27) and 25% primiparous (n=9). All of the RALS occurred in the second trimester with a mean gestational age of 18.7 weeks (range: 14-23) (Table 1). Mode of entry into the abdomen was reported in 8 of the 11 publications. Three reported using Veress needle, 3 using direct entry, and 2 Hasson technique (Table 2). Seven of the 11 publications (63.6%) endorsed maintaining a pneumoperitoneum less than or equal to 12mmHg. Estimated blood loss (EBL) ranged from 0 cc to 350cc. EBL was $\leq$ 50 cc for 83.3% (30/36), 51 to 200 cc for 13.8% (5/36), and > 200 cc for 2.7% (1/36) of patients. Mean surgical duration was 104 minutes (range: 60-270). Discharge from the hospital was on or before postoperative day (POD) 1 for 89% of patients (25/28) with only 11% (3/28) discharged beyond POD 1 (range: POD4-POD6). No intraoperative maternal or fetal complications were recorded during any of the surgeries (Table 1).

The indication for RALS was ovarian in 33 (87%) and urologic in 5 (13%). The types of RALS performed for the ovarian category were as follows: ovarian cystectomy (n=25, 76.4%), oophorectomy (n=5, 14.7%), salpingo-oophorectomy (n=3, 8.8%). One patient received both left salpingo-oophorectomy and right partial ovarian cystectomy. Of these cases, 3 performed an omentectomy (9.1%), 2 performed pelvic washings (6.1%), and 1 performed a bilateral pelvic lymph node dissection (3.0%). Additionally, one publication had a series of nineteen cases and the data was reported in aggregate; they did not report standard deviation for gestational age at surgery and surgical duration, so these standard deviations could not be calculated in our review.[5] The types of RALS performed for the urologic category included adrenalectomy (n=3, 60.0%) and partial nephrectomy (n=2, 40%). The indications for the adrenalectomies were pheochromocytoma (n=1), Cushing syndrome (n=1), and subclinical Cushing syndrome (n=1).

The recorded postoperative surgical complications were one postoperative pneumonia requiring readmission and antibiotics, and one patient complaining of pain at the trocar sites at

2 weeks postoperatively. Six of the thirty-eight patients (15.7%) had malignant pathology and one underwent chemotherapy during pregnancy.[6]

Obstetrical outcomes were reported for a limited number of cases. Eight patients had a vaginal delivery and 4 had cesarean delivery with 2 of them being scheduled (1 for cancer biopsies at time of cesarean section and 1 for unspecified indication). The mean gestational age at delivery was 38.3 weeks, with only 2 patients delivering < 37 weeks. Neonatal outcomes were reported for a limited number of cases (n=11), and all had a healthy neonate at delivery. There was one case of preterm premature rupture of membranes at 30 weeks for which the RALS was done at 19 weeks. However, the neonatal outcome was not reported for this case.

Discussion:

Approximately 1 in 500 women will require non-obstetrical abdominal surgery during their pregnancy, most commonly for appendicitis, cholecystitis and small bowel obstruction.[7-9] The most common gynecologic indication is adnexal masses, which occur at a rate between 1/81 and 1/6000 pregnancies.[10] Persistent masses pose a clinical challenge on whether to observe or intervene, but literature shows between 2% and 6% of these masses are malignant.[10] Management of ovarian masses is operative based on persistence, size and ultrasound characteristics.[11] Urologically, pheochromocytoma occurs in 1 in 50,000 pregnancies, and renal cell carcinoma in women of child bearing age occur < 5/100,000 cases per year.[12,13]

Since its inception, robotic surgery has been rapidly incorporated into the repertoires of surgeons across the nation since its approval. Although results vary depending on the surgery type, evidence often shows shortened duration of hospital stay, lower conversion rates, and lower blood loss.[14-16] The three-dimensional visualization and dynamic articulation seem well suited for performing surgery while sharing the abdomen with a gravid uterus. Our systematic review demonstrates low implementation of robotic surgery for non-obstetrical indications in pregnant patients, with only thirty-eight cases in the last twenty years, and nineteen of those cases representing a single institution experience. Even rarer were urological indications, representing only 5 of the thirty-eight cases within the literature.

It is not unprecedented for newer techniques to lag behind when it comes to their application in the pregnant patient populations. In fact, laparoscopic surgery itself was suspected to be a contraindication in pregnancy in general. It was hypothesized that the pneumoperitoneum necessary for laparoscopy would endanger both the mother and fetus. Specifically, the carbon dioxide exposure was thought to be harmful to the developing fetus. For the pregnant patient, there were concerns that the increased intraabdominal pressure from the pneumoperitoneum would compress the inferior vena cava (IVC), dampen venous return, and cause insufficient ventilation due to the intraabdominal pressure exerted on the diaphragm.[17,18] However, it has since been shown that laparoscopic surgery does not entail additional risk, and was superior in length of stay, diet advancement, and narcotic use.[2] The use of the robot builds on the advantages of laparoscopy while not demanding any additional parameters that could pose risk to patient or fetus. Specifically, its superior visualization, ergonomic movements, tremor filtration, and multiple degree articulations may prove useful while navigating a gravid uterus using a reduced intraabdominal pressure. In fact, in non-pregnant patients, RALS has been shown to have similar operative time and conversion rates when compared to traditional laparoscopy for adrenal surgeries.[14,19]

Robotic-assisted obstetrical cases, specifically cerclage placement and resection of ectopic pregnancies, were excluded from our systematic review. Recently, a large systematic review with sixty-four patients undergoing robotic cerclages was already published.[20] Additionally, because cerclage is performed on the uterus itself, it does not impose the same unique parameters that are faced when the target of a procedure is elsewhere within the abdominal cavity. Our rational for excluding ectopic pregnancies was due to the fact that the fetus is not viable, and such cases do not share the unique challenges of the other intraabdominal gestational RALS cases; such obstacles include manipulation around the gravid uterus and prioritizing fetal viability. Additionally, multiple ectopic cases managed robotically reported in the literature occur in the first trimester.[21-23] These cases do not entail the same parameters of fetal risk, uteroplacental blood flow, and anesthesia implications.

Despite the paucity of cases within the literature for non-obstetrical RALS, there were commonalities between them. All surgeries were performed within the second trimester. This is expected, as the second trimester is following the completion of organogenesis within the first trimester and is before the third trimester wherein the gravid uterus presents a cumbersome surgical obstacle.[2,24,25] Blood loss was also consistently low with 83.3% having an EBL ≤50. This is in line with other literature often demonstrating lower EBL as a benefit of RALS.[1,14,16] Also consistent with purported benefits of RALS, postoperative stay was generally short, with only 3 (11%) patients enduring hospitalization beyond POD day 1. Of note, all three of these cases had a urologic indication: partial nephrectomy (n=2) and pheochromocytoma (n=1). Therefore, the longer hospital stay in those cases may be due to the intrinsic nature of the operation and need for post-operative monitoring rather than post-operative recovery.

Additionally, with regard to patient positioning, we acknowledge that there is little room for adjustment, as many surgeries require predetermined patient position. In pregnant patients, the gravid uterus places pressure on the IVC, impeding venous return and impacting fetal blood flow.[26,27] Besides obvious anesthetic implications, positioning patients in supine can worsen the hypotension and disrupt placental blood flow. Therefore, favoring positions such as left lateral tilt and avoiding a full supine position can reduce the risk of adverse hemodynamic changes.[12,28,29] As many urologic and gynecologic procedures require Trendelenburg positioning, this may be beneficial for both the patient and the fetus. However, in certain cases, such as a left sided partial nephrectomy, the surgical team may have no choice but to position the patient on the right side. [30] When feasible, modifications such as left lateral decubitus should be implemented to limit IVC compression and improve maternal cardiac output.[29,31]

A modification utilized specifically in 2 of the reported cases was the use of the open-entry Hasson technique for entry into the peritoneum, in lieu of closed-entry Veress access. Three authors utilized a direct vision entry into the abdomen to ensure atraumatic entry.

Specifically, Eichelberger et al., Mendevil et al., and Podolsky et al. used 2-mm trocar and 2-mm laparoscope, 5-mm laparoscope, and 12-mm trocar, respectively.[5,12,32] Under typical conditions, there is no significant difference in major complication rates between these techniques and mode of entry is typically determined by surgeon preference.[33-36] However, in the setting of pregnancy, there was concern in some studies that the Veress needle could injure the uterus on penetration, as it is a blind approach to gaining abdominal access. Yet, as seen in several of the reported studies, Veress access was successful without any major complications. Therefore, we conclude that all modes of peritoneal access are acceptable, so long as there is proper compensation for the size of the gravid uterus. If entry is obtained in the upper abdomen, above the level of the gravid uterus, then the risk of injury to the uterus is minimized and surgeon preference should dictate technique. However, if the entry is planned in the lower abdomen, consideration should be given to an open-entry technique despite a lack of evidence to support its absolute necessity.

With regard to port placement and intra-operative technique, additional modifications may be required. In the majority of the cases identified in this review, there were no significant modifications to port placement (Table 2). In the few cases where modifications were specifically commented on, the inferior ports were shifted slightly cephalad to ensure safe port placement.[13,37] However, per standard guidelines, all ports in all studies were placed under direct vision – and the cephalad ports were placed first to ensure adequate visualization. Of note, there were no major intra-operative modifications to technique for the urologic cases; for the gynecologic cases, there were slight modifications worth noting. First, and somewhat obvious, a uterine manipulator is contraindicated in these cases. In order to displace the uterus for better visualization, Al-Badawi et al. utilized a 10-mm dismantling fan retractor for traction as it was believed this would be the most atraumatic instrument for safely applying some traction on the gravid uterus. In contrast, Chen et al. utilized a grasper via the accessory port to lift and hold the round ligament to create enough working space. None of the other series noted specific modifications to account for the gravid uterus.

Due to the nature of systematic reviews, the findings herein are subject to potential publication bias. It may be that RALS surgeries in pregnancy have been performed but have simply not been reported in the literature. Considering RALS is sometimes performed over traditional laparoscopic surgery secondary to surgeon preference, underreporting may occur due to surgeons not considering this procedure novel, but rather a technique interchangeable with laparoscopy. This could lead to unreported outcomes, complications and surgical modifications that are not accounted for in our review. Additionally, the studies included lack substantial and uniform outcome data, such as the Clavien-Dindo classification[38]. While overall safety cannot be established, no cases in this review showed significant post-operative complications or maternal-fetal complications.

Perhaps owing to the paucity of cases, no current guidelines exist in regard to RALS within this population. Although commonalities clearly exist, the lack of standards is made apparent by the variation in surgical modifications exhibited by the cases in our review. Our review is of particular importance due to the fact that robotic urologic surgeries now exceed laparoscopic surgeries in terms of volume.[1] As robotics become a larger part of the field of urology, a larger number of urology trainees will be increasingly comfortable with robotic surgery rather than laparoscopic procedures. This will continue the trend toward robotics, as it has been established that surgeons trained in certain procedures are more likely to perform these procedures in their future practice.[39] As RALS becomes the de facto intervention due to surgeon's preference, it is important to validate its implementation in the pregnant population. Switching to a laparoscopic approach for the sole indication of pregnancy may present suboptimal conditions if the physician is more comfortable with a robotic approach. Our results highlight the need for further research to address the safety, efficacy and application of RALS in pregnancy.

Conclusion:

Our review demonstrates the rarity of RALS in pregnant patients for non-obstetrical indications. Based on the published literature, our review demonstrates that RALS could be a safe and effective in pregnancy. However, in order to conclusively evaluate the safety, superiority, or inferiority of non-obstetric RALS versus traditional laparoscopic surgery in the pregnant population, further studies are necessary. As robotic surgery becomes more ubiquitous within urologic and gynecologic training, RALS may be implemented on the basis of surgeon preference and comfort. Therefore, we encourage tertiary care centers performing non-obstetrical RALS to publish their pregnancy outcomes and complication rates in order to build an evidence-base to guide future practice.

Figure 1 – Flow diagram of studies identified in the systematic review[4]

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Figure 1

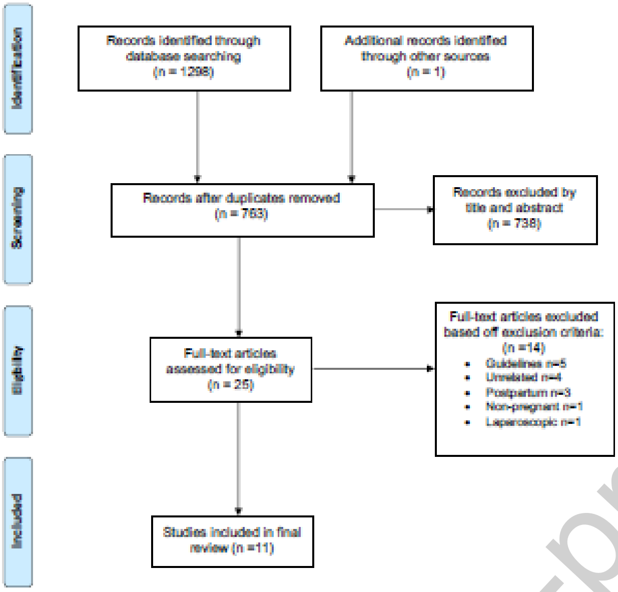
Identification
Screening
Eligibility
Included
Records identified through database searching (n = 1298)
Additional records identified through other sources (n = 1)
Records after duplicates removed (n = 763)
Records excluded by title and abstract (n = 738)
Full-text articles assessed for eligibility (n = 25)
Full-text articles excluded based off exclusion criteria: (n =14)
Guidelines n=5
Unrelated n=4
Postpartum n=3
Non-pregnant n=1
Laparoscopic n=1
Studies included in final review (n =11)

Table 1. Clinical and surgical information of non-obstetrical RALS in pregnancy

#	Author	Age Parity	Indication for surgery	Procedure type/ Management	GA at surgery	Duration, EBL	Complications	Discharge	Final pathology	Maternal-fetal outcomes
Ovarian:										
1	Al-Badawi 2011	29 G3P2	Endometrioid adenocarcinoma grade 1	Right oophorectomy, infracolic omentectomy, multiple peritoneal biopsies	17 wks	78 min <100 cc	None	POD1	No residual disease, stage 1-A	Vaginal delivery, healthy neonate, birth weight 3200 g; CT scan 2 months postpartum showed no evidence of recurrence
2		39 G5P4	Adult type granulosa cell tumor	Left salpingo-oophorectomy, infracolic omentectomy, multiple peritoneal biopsies	17 wks	68 min <100 cc	None	POD1	Residual disease in left ovary, stage 1-A	NR
3	Baldwin	22 G1P	6.8x4.4x6.5 cm left ovary with large	Left salpingo-oophorectomy	14 wks	113 min	None	POD1	Mature teratoma	Vaginal delivery at term, healthy neonate,

	2011	0	solid component	with staging & pelvic washings		NR			with negative pelvic washings	birth weight 3430 g; Apgar score 9'-9'
4	Carter 2011	46 G3P2	14 cm enlarging left adnexal mass	Left ovarian cystectomy	20 wks	95 min 15 cc	None at 2 wks post-op	POD1	Benign mucinous cystadenoma	NR
5		38 G3P2	10x6x13 cm left ovarian enlarging cyst	Left ovarian cystectomy	15 wks	95 min 10 cc	Pain at trocar sight at 2-wks post-op	POD1	Benign mixed epithelial cystadenoma	NR
6		19 G1P0	15 cm right ovarian mass	Right ovarian cystectomy	15 wks	92 min 15 cc	None	NR	Mature cystic teratoma	NR
7		25 G1P0	Painful 16 cm right ovarian cyst	Right ovarian cystectomy	15 wks	86 min minimal	None	NR	Benign serous cystadenoma	NR

8		23 G2P1	Painful 18 cm left ovarian mass	Left ovarian cystectomy	19 wks	153 min 15 cc	None	NR	Benign mucinous epithelial cystadenoma	Term pregnancy
9		21 G1P0	15 cm ovarian mass	Ovarian cystectomy	21 wks	196 min minimal	None at 2 wks post-op	NR	Benign mucinous cystadenoma	PPROM at 30 wks
10	Chen 2015	36 G2P1	Painful 5.2x4.3x7.8 cm left ovarian tumor CA-125: 414 U/ml	Left salpingo-oophorectomy, bilateral PLND, omentectomy, pelvic washings	14 wks	145 min <50 cc	Chemotherapy (5 courses carboplatin and paclitaxel) began at 18 wks	NR	Ovarian endometrioid adenocarcinoma (grade 2) with positive cytology (pT1cN0Mx) stage1C	Cesarean delivery at 37 wks for cancer staging, healthy neonate, birth weight 2888 g; Apgar score 9'-9'; CT scan at 18 months postpartum showed no local recurrence, CA-125 15.56 U/ml
11-2	Eichelberger[a]	28.5 ± 5.2	Adnexal mass with mean diameter of 7.3 ±2.4 cm	Oophorectomy n=2, cystectomy n=17	19.6 wks (range 17-	77 min (range 60-	None	POD0	Mature teratoma n=10, serous	Mean gestational age at delivery 38.6 wks with one preterm at <37 wks; mean birth weight

9	2012 n=19	G2P 0			21.4)	93) 10 cc (rang e 0-20)			cystadeno ma n=3, endometrio ma n=1, mucinous cystadeno ma n=2, benign cyst n=1, tumor of low malignant potential n=3	3009 g[b]
3 0	Mendiv il 2013	32 G1P 1	Painful 10 cm enlarging pelvic mass	Right salpingo-oophorectomy	16 wks	124.2 min 25 cc	None	NR	Immature teratoma, stage 1, grade 3	Vaginal delivery at 37 wks, healthy neonate, birth weight 2892 g; Apgar score 9 at 5 min
3 1		35 G1P 1	Painful 6 cm right ovarian complex mass	Right ovarian cystectomy	16 wks	90 min 25 cc	None	NR	Ovarian endometrio ma	Vaginal delivery at 39 wks, healthy neonate, birth weight 3024 g; Apgar score 9 at 5 min
3 2		31 G5P	Bilateral complex pelvic masses	Left salpingo-oophorectomy & right partial	22 wks	159 min	None	NR	Benign, hemorrhagi	Vaginal delivery at 38 wks, healthy neonate, birth weight 2956 g;

		1		ovarian cystectomy		100 cc			c cyst	Apgar score 8 at 5 min
33		37 G1P1	Painful enlarging right ovarian lesion	Right ovarian cystectomy	23 wks	85.2 min 10 cc	Post-op pneumonia requiring readmission and antibiotics	NR	Mucinous cystadenoma	Vaginal delivery at 39 wks, healthy neonate, birth weight 3030 g; Apgar score 9 at 5 min
Urologic:										
34	Capella 2020	33 G6P3	4.2 cm right adrenal lesion	Right adrenalectomy Perioperative dexamethasone, post-op prednisone, during cesarean hydrocortisone, postpartum prednisone	19 wks	118 min 50 cc	None	POD1	Adrenocortical adenoma	Cesarean delivery for failure to progress at 39 wks, healthy neonate, birth weight 2800 g; Apgar 8-9, POD3 pre-eclampsia with severe features
35	Nassi	26	Cushing syndrome with 3.4x2.8x3.7 cm	Right adrenalectomy	21 wks	NR	None	NR	Benign adrenocorti	Scheduled cesarean delivery at 36 wks,

	2015	NR	right adrenal mass	Intra-op hydrocortisone, post-op and postpartum steroid therapy		NR			cal adenoma	healthy neonate, birth weight 2550 g; normal Apgar; ACTH normal at 6 months postpartum
36	Park 2008	36 G1P0	4.0 cm left renal mass	Left partial nephrectomy	14 wks	165 min (warm ischemia=28 min) 100 cc	None	POD5	Conventional-type RCC with Fuhrman nuclear grade 3, stage T1a	Remainder of pregnancy was uneventful
37	Podolsky 2010	34 G1P0	5 cm right adrenal mass Urine normetanephrine 8776 mcg/24h	Right adrenalectomy via transperitoneal access Pre-op phenoxybenzamine 20 mg QID and labetalol	21 wks	270 min 250 cc	None	POD4	Benign pheochromocytoma	Cesarean delivery after failed induction for oligohydramnios at 39 wks, healthy neonate; blood pressure stable at one month postpartum

				100 mg TID							
38	Ramirez 2015	35 NR	6.5 cm right renal mass	Right partial nephrectomy	20 wks	253 min (warm ischemia 36 min) 120 cc	None	POD6	Chromophobe RCC with negative margins (T1b)	Vaginal delivery at term, healthy neonate	
	Total= 38 patients	30.0 ± 6.3 G1=9 >G1= 27 NR=2	Ovarian=33 Urologic=5		Mean 18.7 wks[c] range: 14-23	Mean 104 min[c] (n=37) EBL: ≤50=30 51-200=5 >200	Pneumonia=1	≤1=25 >1=3 NR=10		Vaginal delivery: n=8 Cesarean: n=4 NR=26	

					=1				

Abbreviations: *GA,* gestational age*, NR*, not reported, *POD*, post-op day, *PPROM*, preterm premature rupture of membranes, *PLND*, pelvic lymph node dissection, *QID*, four times a day, *RCC*, renal cell carcinoma, *TID*, three times a day, *wks*, weeks
[a]Data was reported in aggregate (n=19)
[b]Only 8 of the 19 subjects had maternal-fetal information available
[c]Standard deviation could not be calculated because Eichelberger et al. reported their data as aggregate with 19 patients. They did not report standard deviation for GA at surgery and surgical duration

Table 2. Surgical Modifications for non-obstetrical RALS in pregnancy

Author	Anesthesia	Access	Port Placement	Positioning	Pneumo-peritoneum	Other
Ovarian:						
Al-Badawi 2011	- Avoided use of nitrous oxide - End- tidal CO_2 kept ~33–35 mmHg	NR	- One 12-mm assistant port placed at the left upper quadrant (Palmer's point) - Three robotic port sites placed under direct vision with an endoscopic camera through the assistant port	NR	Limited to 12 mmHg	Utilized a 10-mm dismantling fan retractor for traction for better visualization
Baldwin 2011	NR	Hasson technique	Secondary trocars inserted under direct visualization	- Dorsal lithotomy with a right lateral tilt allowing easier access to the left adnexa -Trendelenburg 15–20°	Limited to 12 mmHg	- Nasogastric tube inserted into the stomach - No instruments applied to the cervix for uterine manipulation
Carter 2011	NR	Hasson technique	NR	NR	Limited to 12 mmHg	NR

Chen 2015	NR	NR	- Trocar setting at a higher position suggested for cases with large uterus or pregnancy >13 weeks - Adopting sites 6 cm above the umbilicus for the scope, & 8–10 cm caudal-lateral to the scope for the side arms	NR	NR	- No uterine manipulator used - Tocolytic agents given before, throughout & after the surgery - Utilized a grasper via the accessory port to lift & hold the round ligament
Eichel-berger 2012	NR	Direct vision port placement: 2-mm trocar & 2-mm laparoscope	Midline 12-mm trocar placed sufficiently above the fundus followed by 2- to 8-mm trocars placed at 10 cm to the right & left of the midline trocar	NR	NR	NR
Mendivil 2013	NR	Direct vision port placement: 5-mm laparoscope	NR	NR	NR	NR
Urologic:						
Capella 2020	NR	Veress needle	Mild cephalad deviation	NR	Limited to 12 mmHg	NR
Nassi 2015	NR	NR	NR	NR	NR	NR
Park 2008	NR	Veress needle	NR	NR	Limited to 10 mmHg	NR
Podolsky 2010	NR	Direct vision port placement: 12-mm	First trocar placed in the left upper quadrant or subxiphoid area under direct visualization	Left lateral decubitus position	Limited to 10-12 mmHg	Continuous monitoring for acidosis

		trocar				
Ramirez 2015	NR	Veress needle	Adjusted superiolaterally	Left lateral decubitus position	Limited to 12 mmHg	Avoided the use of mannitol

Abbreviations: *NR*, not reported