Review

Bowel Injury in Gynecologic Laparoscopy

A Systematic Review

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OBJECTIVE: To evaluate the incidence of bowel injury in gynecologic laparoscopy and determine the presentation, mortality, cause, and location of injury within the gastrointestinal tract.

DATA SOURCES: The PubMed, EMBASE, ClinicalTrials.gov, and Cochrane Library databases were searched. Additional studies were obtained from references of retrieved papers.

METHODS OF STUDY SELECTION: Included retrospective studies and randomized controlled trials reported the incidence of bowel injury in gynecologic laparoscopy. Studies were excluded if they were not in English or duplicated data.

TABULATION, INTEGRATION, AND RESULTS: Two reviewers extracted data in duplicate from each study regarding incidence, cause, and location of bowel injury. Ninety studies published between 1972 and 2014 met eligibility criteria, representing 474,063 gynecologic laparoscopies. Six hundred four bowel injuries were reported for an incidence of 1 in 769 (0.13%, 95% confidence interval [CI] 0.12–0.14%). The rate of bowel injury varied by procedure, ranging from 1 in 3,333 (0.03%, 95% CI 0.01–0.03%) for sterilization to 1 in 256 (0.39%, 95% CI 0.34–0.45%) for hysterectomy. The small intestine was the most frequently damaged region of the gastrointestinal tract, representing 166 of 354 (47%) injuries. The majority of bowel injuries occurred during abdominal access and insufflation obtained using a Veress needle or trocar placement (201/366, 55% of injuries). Although most bowel injuries were recognized intraoperatively, diagnosis was delayed by more than 1 day in 154 of 375 cases (41%, 95% CI 36–46%). Bowel injuries were managed primarily by laparotomy (80%). Mortality occurred after bowel injury in 5 of 604, or 1 of 125 (0.8%, 95% CI 0.36–1.9%) cases. All deaths occurred as a result of delayed recognition of bowel injury (n=154), making the mortality rate for unrecognized bowel injury 5 in 154 or 1 in 31 (3.2%, 95% CI 1–7%). There were no deaths associated with intraoperatively diagnosed bowel injury.

CONCLUSION: The overall incidence of bowel injury in gynecologic laparoscopy is 1 in 769 but increases with surgical complexity. Delayed diagnosis is associated with a mortality rate of 1 in 31.

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During the past four decades, gynecologic laparoscopy has evolved from a limited method of access used for diagnosis and sterilization to an advanced operative approach that frequently serves as a substitute for laparotomy. As of 2009, 20% of the 600,000 hysterectomies performed in the United States were done laparoscopically.[1] The advantages of laparoscopy over laparotomy include less postoperative pain, shorter hospital stays, and reduced blood loss.[2–4] However, complications may arise during initial abdominal access, port placement, dissection, or use of electrosurgery.

Bowel injury is thought to be a rare complication of laparoscopy but carries a high rate of morbidity and mortality, particularly when diagnosed postoperatively.[5] Some studies suggest that the mortality rate associated with delayed diagnosis bowel injury may be as high as 21%.[6,7] Furthermore, laparoscopy-associated bowel injury is a significant cause of litigation in the United States.[8] Despite several decades of experience with laparoscopy, the rate of bowel injury is not well defined with widely varying rates reported.[5,9] We undertook a systematic review to evaluate the incidence, presentation,

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mortality, cause, and location of injury within the gastrointestinal tract associated with gynecologic laparoscopy.

SOURCES

The PubMed Central, EMBASE, Cochrane Library, and ClinicalTrials.gov databases were searched in duplicate by two reviewers (N.C.L. and A.B.S.) to identify studies reporting the incidence of bowel injury in gynecologic laparoscopy. The PubMed Central search was conducted using two sets of MeSH headings: 1) "laparoscopy," "gynecologic surgical procedures," and "intraoperative complications or postoperative complications"; and 2) "laparoscopy," "intestinal perforation," and "gynecologic surgical procedures." A similar search strategy was used for EMBASE. The databases were searched without restriction on date of publication or study design. Additional relevant articles that did not appear in the database searches were garnered from the references of included papers.

STUDY SELECTION

This systematic review was conducted in accordance with Guidelines for Meta-Analyses and Systematic Reviews of Observational Studies.[10] The aim of the review was to evaluate the incidence of bowel injury in gynecologic laparoscopy as well as the clinical presentation, mortality rate, cause, and location of injury within the gastrointestinal tract. Eligibility for inclusion was limited to papers written in English that reported the incidence of laparoscopic bowel injury. Studies were excluded if they were not in English or duplicated data already included in the review. The quality of the enrolled studies was evaluated by two reviewers in duplicate (N.C.L. and A.B.S.) using the Newcastle-Ottawa Quality Assessment Scale (see the Appendix, available online at http://links.lww.com/AOG/A638).

Each abstract obtained through the electronic databases was evaluated for relevance, and the full text of each relevant abstract was obtained and evaluated for inclusion. Data were obtained and extracted by two reviewers in duplicate (N.C.L. and A.B.S.). The definition of bowel injury in these studies varied from serosal abrasion to full enterotomy. Because bowel injury was infrequently defined and serosal injury and enterotomy were rarely distinguished, we do not distinguish between the types of bowel injuries for the purpose of this review.

Comparisons of categorical variables, including rates of bowel injury by year and study type (prospective compared with retrospective), were performed using Fisher's exact test. Additionally, rates of bowel injury in studies that explicitly defined bowel injury to include both serosal injuries and enterotomies were compared with rates in those studies that did not specify the definition of bowel injury using Fisher's exact test. P values $<.05$ were considered significant. Ninety-five percent confidence intervals (CIs) were calculated using the Wilson method for calculating CIs for proportions.[11] Analyses were conducted using Stata 13.

RESULTS

Study selection is outlined in Figure 1. A total of 324 abstracts and 236 full-text articles were reviewed for eligibility. The literature review identified 90 studies meeting inclusion criteria (Table 1).[6,7,9,12–99] The studies were published between 1972 and 2014 and reflect an international pool of experience with gynecologic laparoscopy. Among them were 60 retrospective and 27 prospective studies. A total of 474,063 laparoscopies were reported, including 230,033 sterilizations, 54,181 hysterectomies, 3,885 myomectomies, 496 sacrocolpopexies, and nine cytoreductions for ovarian cancer. An additional 50,437 laparoscopies were classified as "diagnostic" or "minor" without further description, and 52,992 laparoscopies were characterized as "major" or "advanced."

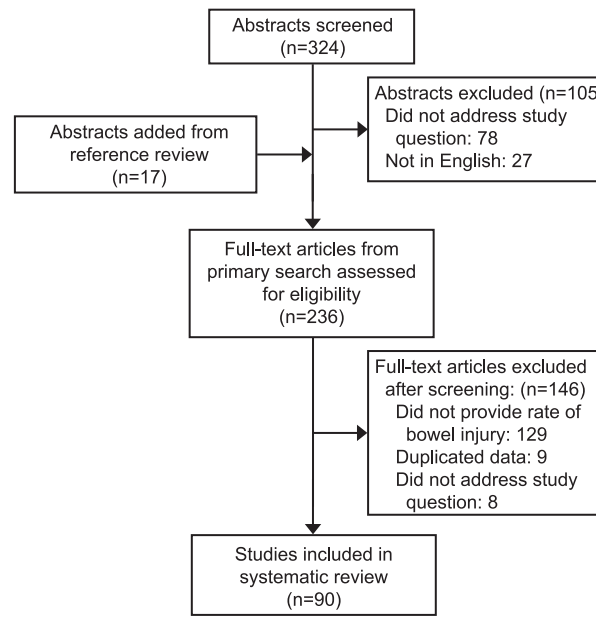

Fig. 1. Flow diagram of study selection. PubMed, Cochrane Library, EMBASE, and ClinicalTrials.gov databases were searched for studies reporting the incidence of bowel injury in gynecologic laparoscopy.

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Table 1. Incidence of Laparoscopic Bowel Injury in Reviewed Studies

Reference	Study Type	Country	Dates of Data Collection	No. of Laparoscopies	No. of Bowel Injuries	% of Bowel Injuries
Abdelmonem et al[12]	Retrospective cohort	U.S.	2001–2003	51	3	5.88
Antosh et al[13]	Retrospective cohort	U.S.	2006–2010	23	0	0.00
Bateman et al[14]	Retrospective cohort	U.S.	1989–1994	2,324	8	0.34
Biojo and Manzi[9]	Retrospective cohort	Colombia	1981–1992	136,627	4	0.00
Brosens[7]	Part prospective and retrospective	Belgium	1997–1998	23,540	45	0.19
Brummer[15]	Prospective cohort	Finland	2006	1,679	7	0.42
Campos[16]	Retrospective cohort	Brazil	1998–2008	29	2	6.90
Casey[17]	Retrospective cohort	U.S.	1989–1994	93	4	4.30
Chapron et al[18]	Retrospective cohort	France	1987–1995	29,966	49	0.16
Cheung et al[19]	Retrospective cohort	Canada	2001–2005	175	0	0.00
Park et al[73]	Retrospective cohort	South Korea	2010–2012	250	0	0.00
Chopin et al[20]	Prospective cohort	France	1993–2007	1,460	1	0.07
Condos[21]	Retrospective cohort	Australia	1968–1969	100	1	1.00
Davis et al[22]	Retrospective cohort	U.S.	1988–1992	40	1	2.50
Decloedt et al[23]	Retrospective cohort	Belgium	1994–1996	90	1	1.11
Donnez et al[24]	Retrospective cohort	Belgium	1990–2006	3,190	3	0.09
Donnez et al[99]	Retrospective cohort	Belgium	1989–2010	3,298	45	1.36
Erian et al[25]	Prospective cohort	U.K.	2003–2006	400	2	0.50
Fagotti et al[26]	Retrospective cohort	Italy	2009–2011	100	1	1.00
Fanfani et al[28]	Prospective cohort	Italy	2009–2010	20	0	0.00
Fanfani et al[27]	RCT	Italy	2011–2012	68	0	0.00
Galen et al[29]	Prospective cohort	U.S.	1994–1998	212	0	0.00
Garcia Padial et al[30]	Retrospective cohort	U.S.	1990–1992	75	0	0.00
Garry et al[31]	Retrospective cohort	Australia	1992–1993	920	1	0.11
Han et al[32]	Prospective cohort	Taiwan	2010	10	0	0.00
Harkki-Siren et al[33]	Retrospective cohort	Finland	1990–1994	70,607	44	0.06
Harkki-Siren et al[34]	Retrospective cohort	Finland	1995–1996	32,205	24	0.07
Harmanli et al[35]	Retrospective cohort	U.S.	1999–2008	970	0	0.00
Heaton et al[36]	Prospective cohort	U.S.	2003–2009	623	4	0.64
Heinberg et al[37]	Retrospective cohort	U.S.	1998–2002	270	3	1.11
Hoffman et al[38]	Retrospective cohort	U.S.	2000–2002	359	0	0.00
Hsu et al[39]	Prospective cohort	Taiwan	2002–2004	512	0	0.00
Hughes et al[40]	Retrospective cohort	U.K.	1970–1973	1,910	2	0.10
Hulka et al[41]	Retrospective cohort	U.S.	1995–1995	14,911	90	0.60
Imran et al[42]	Retrospective cohort	U.S.	1971–1973	1,302	5	0.38
Jamieson et al[43]	Prospective cohort	U.S.	1978–1987	9,475	4	0.04
Jansen et al[6]	Prospective cohort	Netherlands	1994–1994	25,764	29	0.11
Kaali and Barad[44]	Retrospective cohort	U.S.	1983–1990	4,532	4	0.09
Kafy et al[45]	Retrospective cohort	Canada	1997–2004	223	1	0.45
Karaman et al[46]	Prospective cohort	Belgium	1992–2004	1,120	0	0.00
Kavallaris et al[47]	Retrospective cohort	Germany	1998–2009	1,255	2	0.16
Kives et al[49]	Retrospective cohort	U.S.	2000	9,574	25	0.26
Kondo et al[50]	Retrospective cohort	France	1995–2008	2,271	9	0.40
Kongwattanakul et al[51]	RCT	Thailand	2010–2011	25	0	0.00
Kriplani et al[52]	Retrospective cohort	India	Unknown	110	0	0.00
Lee et al[53]	Retrospective cohort	South Korea	2008–2010	500	1	0.20
Lee et al[93]	Prospective cohort	Taiwan	1995–2008	105	1	0.95
Leung et al[55]	Prospective cohort	China	2001	143	0	0.00

(*continued*)

Table 1. Incidence of Laparoscopic Bowel Injury in Reviewed Studies (*continued*)

Reference	Study Type	Country	Dates of Data Collection	No. of Laparoscopies	No. of Bowel Injuries	% of Bowel Injuries
Limpaphayom et al[56]	Retrospective cohort	Thailand	1974–1978	5,000	1	0.02
Liu et al[57]	Retrospective cohort	China	2006–2008	167	0	0.00
Loffer and Pent[58]	Review	U.S.	Unknown	32,719	64	0.20
Mac Cordick et al[59]	Prospective cohort	France	1992–1996	743	1	0.13
Magrina et al[60]	Retrospective cohort	U.S.	2006–2010	9	2	22.22
Martel and Gilliland[61]	Retrospective cohort	Canada	1991–1994	106	0	0.00
Mehta[62]	Retrospective cohort	India	1979–1979	10,100	1	0.01
Miranda[63]	Retrospective cohort	Chile	1994–2000	2,140	3	0.14
Morgan-Ortiz et al[64]	Prospective cohort	Mexico	2009–2011	209	2	0.96
Moss et al[65]	Retrospective cohort	U.K.	2008–2011	58	1	1.72
Mourits et al[66]	RCT	Netherlands	2007–2009	185	4	2.16
Mueller et al[94]	Retrospective cohort	Germany	2005–2009	567	1	0.18
Nazik[67]	Retrospective cohort	Italy	2010–2012	441	7	1.59
Noe et al[68]	RCT	Germany	2010	83	0	0.00
Obermair et al[69]	Retrospective cohort	Australia	2002	55	0	0.00
Pahisa et al[70]	Prospective cohort	Spain	1997–2007	67	1	1.49
Paraiso et al[71]	RCT	U.S.	2007–2011	27	0	0.00
Park et al[72]	Prospective cohort	South Korea	2008–2011	515	1	0.19
Park, Kim et al[73]	Retrospective cohort	South Korea	1997–2011	115	1	0.87
Paul et al[74]	Retrospective cohort	India	1993–2009	1,001	0	0.00
Penfield[75]	Review	U.S.	1984–1984	10,840	6	0.06
Roy et al[76]	RCT	India	2007–2009	60	0	0.00
Sadik et al[77]	Retrospective cohort	Turkey	1992	50	1	2.00
Schwartz[78]	Retrospective cohort	U.S.	1991–1992	45	0	0.00
Seow et al[79]	Retrospective cohort	Taiwan	1994–2001	1,045	2	0.19
Shen et al[80]	Retrospective cohort	Taiwan	1992–2002	2,702	11	0.41
Shiota et al[81]	Retrospective cohort	Japan	1995–2009	629	1	0.16
Siedhoff et al[82]	Retrospective cohort	U.S.	2007–2011	834	9	1.08
Sizzi et al[83]	Prospective cohort	Italy	1998–2004	2,050	1	0.05
Sokol et al[97]	Retrospective cohort	U.S.	1997–2000	482	5	1.04
Song et al[84]	Retrospective cohort	South Korea	2000–2008	2,012	9	0.45
Sutasanasuang[85]	Retrospective cohort	Thailand	2006–2010	30	2	6.67
Tarik et al[86]	Retrospective cohort	Turkey	1996–2003	3,572	15	0.42
Tozzi et al[95]	RCT	Germany	1995–2002	63	1	1.59
Vaisbuch et al[87]	Retrospective cohort	Israel	1998–2005	167	0	0.00
van de Lande et al[88]	Retrospective cohort	Netherlands	1994–2005	63	0	0.00
Wang et al[90]	Retrospective cohort	Taiwan	1994–1999	6,451	11	0.17
Wang et al[89]	Retrospective cohort	Taiwan	2004	21	0	0.00
Warner et al[91]	Retrospective cohort	U.S.	2006–2010	390	5	1.28
Wright et al[92]	Retrospective cohort	U.S.	2000–2010	4,137	8	0.19
Wu et al[98]	Prospective cohort	China	2006–2011	565	0	0.00
Zullo et al[96]	RCT	Italy	2001–2003	42	1	2.38
			Total	474,063	604	0.13

RCT, randomized controlled trial.

A total of 604 bowel injuries were reported for a combined incidence of 1 in 769 (0.13%, 95% CI 0.12–0.14%). Rates of bowel injury varied by procedure, year, study methodology, and by definition of bowel injury. The rate of injury ranged from 1 in 3,333 (0.03%, 95% CI 0.01–0.03%) for laparoscopic sterilization to 1 in 256 (0.39%, 95% CI 0.34–0.45%) for hysterectomy (Table 2). Rates of bowel injury for a single procedure (laparoscopic hysterectomy) were compared before 2000 and after 2000. Rates reported

Table 2. Incidence of Laparoscopic Bowel Injury by Procedure

Procedure	No. of Laparoscopies	No. of Bowel Injuries	% Bowel Injury (95% CI)	% Laparoscopies Complicated by Bowel Injury (95% CI)	No. of Studies	References
Laparoscopic hysterectomy (LAVH, TLH, LSH) for benign indications	48,407	188	0.39 (0.34–0.45)	1:257 (1:222–1:294)	37	12,15,19,20,22,24,25,27,30,31,35,36,39,41,45–52,61,64,71,73,76–82,84,85,87,89,111–113
Laparoscopic hysterectomy for malignant indications	4,934	20	0.41 (0.27–0.63)	1:246 (1:158–1:370)	12	16,26,28,65,66,69,70,72,92
Laparoscopic hysterectomy for mixed (benign and malignant) indications	840	3	0.36 (0.12–1.05)	1:280 (1:95–1:833)	4	27,37,38,55
Laparoscopic sacrocolpopexy	496	5	1.0 (0.43–2.3)	1:99 (1:42–1:232)	3	13,68,91
Laparoscopic sterilization	230,033	48	0.02 (0.01–0.03)	1:4,792 (1:3,333–1:1,000)	9	5,9,34,40,42,43,56,62,114
Adnexal surgery	343	0	0	—	3	39,53,73
Secondary cytoreduction for ovarian cancer	9	2	22.2 (6.3–54.7)	—	1	69
Laparoscopic myomectomy	3,885	1	0.03 (0.01–0.15)	1:3,885 (1:666–1:10,000)	7	32,39,57,73,74,83
Diagnostic or minor procedures not otherwise specified*	53,437	39	0.07 (0.05–0.10)	1:1,370 (1:1,000–1:2,000)	8	6,18,21,33,34,59,86,90
Major procedures not otherwise specified†	52,992	108	0.20 (0.17–0.24)	1:490 (1:416–1:588)	9	18,33,52,59,63,89,90,115
Laparoscopy not otherwise specified	78,687	190	0.24 (0.21–0.28)	1:414 (1:357–1:476)	13	7,14,17,23,29,44,58,67,73,75,93,97,99
Total	474,063	604	0.13 (0.12–0.14)	1:784 (1:714–1:833)		

CI, confidence interval; LAVH, laparoscopic-assisted vaginal hysterectomy; TLH, total laparoscopic hysterectomy; LSH, laparoscopic supracervical hysterectomy.

Data are % (95% confidence interval) unless otherwise specified.

* Diagnostic or minor procedures not otherwise specified includes minimal adhesiolysis, destruction of minimal endometriosis, ovarian biopsies, ovarian punctures, tubal sterilization, and assisted conception.

† Major procedures includes ectopic pregnancy, pelvic inflammatory disease, polycystic ovary syndrome, benign ovarian cysts, tubal plasty, uterine suspension, extended adhesiolysis, moderate or severe endometriosis, hysterectomy, myomectomy, lymphadenectomy, colposuspension, tubal sterilization reversal, genital prolapse, endometrial and cervical cancer, retroperitoneal endometriosis.

before 2000 (1/222 [0.45%]) were higher than those reported after 2000 (1:294, 0.34%) (relative risk [RR] 0.75, 95% CI 0.57–0.98, P=.03). There was also a significant difference in the rate of bowel injury among studies (including all procedure types) that explicitly defined bowel injury to include serosal injuries and enterotomies, 1 in 416 (0.24%), compared with studies that did not clearly define bowel injury (1/833 [0.12%]) (RR 0.47, 95% CI 0.38–0.59, P<.001). Finally, there was a significant difference in the incidence of bowel injury identified by prospective (1/666 [0.15%]) and retrospective (1/909 [0.11%]) studies (RR 0.78, 95% CI 0.63–0.96, P=.02).

Twenty-nine studies describing 354 bowel injuries reported the location of the injury within the gastrointestinal tract (Table 3). The small intestine was the most frequently damaged region with 166 (47%, 95% CI 42–52%) injuries followed by the colon with

Table 3. Location of Laparoscopic Bowel Injuries

Location	No. of Bowel Injuries (n=354)	% of Bowel Injuries (95% CI)	References
Small intestine	166	46.9 (41.2–52.1)	7,9,14,17,18,23,25,26,33,34,37,40,42,43,58,60,63,75,80,86,91,112
Large intestine	106	29.9 (25.4–34.9)	7,14,15,17,18,21,25,33,34,37,43,58,62,80,86,111–113
Rectum	62	17.5 (13.9–21.8)	5–7,14,17,18,43,58,90
Rectum	17	5.6 (3.7–8.6)	16,24,34,53,63,65,70,72,73,91

CI, confidence interval.

106 (30%, 95% CI 25–35%) injuries, the rectum with 62 (18%, 95% CI 14–22%) injuries, and the stomach with 20 injuries (6%, 95% CI 4–9%).

An additional 30 studies evaluating 366 bowel injuries described the laparoscopic instruments responsible for the damage (Table 4). The majority of bowel injuries occurred during initial abdominal access obtained using a Veress needle or trocar placement (201 injuries [55%], 95% CI 50–60%). Electrosurgery was causative factor in 105 (29%, 95% CI 24–34%) bowel injuries. 42 (11%, 95% CI 9–15%) injuries occurred intraoperatively during dissection or lysis of adhesions as a result of an unknown instrument, and 15 (4.1%, 95% CI 3–7%) occurred as a result of the grasping forceps or scissors (Table 4).

Bowel injury was managed primarily by laparotomy (Table 5). The management of laparoscopic bowel injury was described in 40 studies reporting 307 injuries. Among these, 247 (80%, 95% CI 76–84%) injuries were managed with laparotomy, including conversion of the initial laparoscopic procedure. Some injuries discovered intraoperatively were repaired laparoscopically (23 injuries [8%], 95% CI 5–11%), and a remarkably small fraction (seven injuries [2%], 95% CI 1–5%) were managed expectantly. Among the injuries treated laparoscopically, two required reoperation with laparotomy. An additional 30 injuries (10%, 95% CI 7–14%) were managed without laparotomy, but the mode of treatment was not specified.

Among the 375 bowel injuries for which time of injury was reported, the diagnosis was delayed in 154 of 375 cases (41%, 95% CI 36–46%). The median time to diagnosis for delayed injuries was 3 days but varied from 1 to 13 days. The presenting signs and symptoms of bowel injury were described in 19 cases (Fig. 2) and most frequently included peritonitis (9/19), abdominal pain (8/19), fever (8/19), and abdominal distension (6/19). Two patients presented with rectovaginal fistulas, and one had an abdominal abscess. Leukocytosis (2/19) and leukopenia (1/19) were infrequently reported. Two patients were reported to be in septic shock on presentation, one of whom developed acute respiratory distress syndrome.

Among 604 bowel injuries, five deaths were reported for an overall mortality rate of 1 in 125 (0.8%, 95% CI 0.36–1.9%) cases. However, only 42 studies explicitly mentioned mortality as an outcome. Furthermore, all of the deaths reported in these series occurred as a result of delayed recognition of bowel injury (n=154), making the mortality rate for unrecognized bowel injury 5 in 154 or 1 in 31 (3.2%, 95% CI 1–7%). There were no deaths associated with intraoperatively diagnosed bowel injury.

Table 4. Cause of Laparoscopic Bowel Injury

Cause	No. of Bowel Injuries (n=366)	% of Bowel Injuries (95% CI)	References
Veress needle, trocar insertion, or creation of pneumoperitoneum	201	54.9 (49.8–60.0)	6,7,9,14,18,21,25,33,34,41–43,46,49,54,58,59,62,86,91,112
Electrosurgery and laser	105	28.7 (24.3–33.5)	7,22,33,34,40,42,43,58,63,90,111,112
During dissection or lysis of adhesions, unknown instrument	42	11.5 (8.6–15.1)	6,7,14,23,24,86,112
Forceps and scissors	15	4.1 (2.5–6.7)	7,34,75
Clip	1	0.3 (0.27–1.53)	5
Suction-irrigator during retraction	1	0.3 (0.27–1.53)	111
McCartney tube insertion	1	0.3 (0.27–1.53)	65

CI, confidence interval.

Table 5. Management of Laparoscopic Bowel Injury

Management	No. of Bowel Injuries (n=306)	% of Bowel Injuries (95% CI)	References
Laparotomy	247	80.4 (75.7–84.5)	6,7,9,12,14–17,21–25,33,34,36,40,42–45,58–60,62–65,67,75,80,84,91,111–113,47
Laparoscopy	23	7.5 (5.0–10.9)	7,16,24–26,53,60,67,70,83
Expectant	6	2.3 (1.1–4.6)	7,34,77
Unspecified	30	9.8 (6.9–13.6)	6,15,36,42,58,80,84

CI, confidence interval.

DISCUSSION

In this review of 474,063 gynecologic laparoscopies, bowel injury occurred in 1 in 769 cases. The incidence of injury varied across 90 studies, from 0 to 1 in 4.5.[27,32,35,71] Rates of injury differed as a result of inconsistencies in the definition of bowel injury, failure to stratify injury rates by procedure complexity, and differences in study design. We noted a higher rate of bowel injury in prospective as compared with retrospective studies, suggesting that retrospective studies may be underestimating the true incidence of injury.

Because bowel injury was inconsistently defined, some studies report both serosal abrasion and perforation, whereas others describe only enterotomy. A French study of 29,966 laparoscopies, in which the rate of bowel injury was 0.12%, reported bowel injury as a complication only if it required laparotomy and excluded injures repaired intraoperatively.[18] Notably, the rate of injury was higher in studies that defined bowel injury to include both serosal injuries and enterotomies than in studies that did not clearly define bowel injury, suggesting that serosal injuries are underreported. Additionally, injuries repaired intraoperatively may be underreported. Two of the largest retrospective series in the review, the Finnish studies, which together evaluated 102,812 laparoscopies, reported a remarkably low rate of bowel injury at 0.06–0.07% and a high proportion of delayed diagnosis (82%).[33,34] This rate of delayed diagnosis is substantially higher than our rate of 42%, indicating that the rate of intraoperatively repaired injuries may be underestimated.[6,7,33,34,41,100] These findings highlight the need for prospective studies evaluating the incidence of laparoscopic complications that clearly define bowel injury.

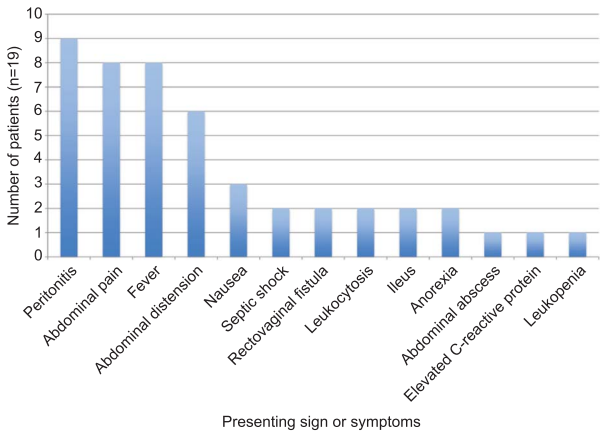

Fig. 2. Presenting signs and symptoms of bowel injury diagnosed postoperatively.

Llarena. Bowel Injury in Gynecologic Laparoscopy. Obstet Gynecol 2015.

Obtaining abdominal access is a high-risk segment of laparoscopic procedures. Approximately 55% of bowel injuries occurred during abdominal access and insufflation, either as a result of the Veress needle or a trocar. The International Society for Gynecologic Endoscopy survey found that although bowel injury occurred less frequently among experienced surgeons, the risk of injury during abdominal access was unrelated to experience.[7,100] In a study of trocar-associated injuries reported to the U.S. Food and Drug Administration, bowel injury was second only to major vascular injury as the leading cause of trocar-associated death after laparoscopy and was more likely than vascular injury to go undetected during surgery.[101] A recent systematic review of 28 randomized controlled trials found no difference in major vascular or visceral complications between the open Hassan technique and the closed Veress needle approach[102]; however, the open-entry technique resulted in fewer failed entries.[103] It has been suggested that the open technique may facilitate intraoperative diagnosis of bowel injury, reducing mortality associated with delayed recognition.[75,104] Unproven strategies for preventing complications associated with abdominal access include evaluating the primary trocar site from a secondary port and inspecting the bowel underneath the primary entry site for damage, particularly in the presence of adhesions.[104] Knowledge of laparoscopic access techniques is critical for

avoiding complications associated with abdominal entry.

Delayed diagnosis of bowel injury results in significant morbidity and mortality and is an important cause of litigation in the United States.[8] We found that 41% of bowel injuries went unrecognized at the time of surgery. Electrosurgery, which accounted for 29% of bowel injuries in our review, has frequently been implicated as the causative factor in late-presenting bowel injuries.[33,105] Limited information is available about the presentation of postoperatively diagnosed laparoscopic bowel injuries; however, the presentation often differs from the classical picture of peritonitis, possibly as a result of minimal stimulation of acute phase reactants by laparoscopy compared with laparotomy.[100,106,107] In this series, leukocytosis, ileus, and septic appearance were infrequently reported, particularly when the small bowel had been injured.

Managing bowel injury frequently requires laparotomy, although several studies support the safety of intraoperative laparoscopic repair.[108–110] Bowel injuries diagnosed postoperatively almost always require laparotomy, because the entire abdomen must be evaluated.[105,106] Approximately 80% of bowel injuries in the reviewed series were managed with laparotomy and 8% were managed laparoscopically. Despite the notion that injuries such as from a Veress needle can be observed expectantly, we would advise caution given that we identified only six cases in 46 years of literature.

In this series, five deaths were reported after a delay in diagnosis of bowel injury, for a mortality rate of 1 in 31. Prior studies have reported the mortality rate after delayed diagnosis to be as high as 21%.[6,7,100,105] There were no deaths associated with intraoperatively diagnosed injuries; however, deaths may be underreported, because only 29 of 90 studies explicitly mentioned mortality as an outcome. These results highlight the need for prospective data regarding mortality rates after laparoscopic bowel injury.

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