



# Laparoscopic versus open surgery: a systematic review evaluating Cochrane systematic reviews

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## Abstract

**Background** Laparoscopic surgical procedures (LSP) have grown in popularity due to their purported benefits of improved effectiveness and efficiency. This study summarizes the Cochrane systematic reviews' (CSRs') evidence comparing the use of LSP versus open procedures used for surgical patient management and comparing the CSRs' quality and consistency of LSP evidence reported across time and different surgical specialties.

**Methods** The Cochrane Database was searched to identify CSRs comparing LSP versus open procedures; 36 CSRs and 15 CSR protocols were found as of February 16, 2016. Each CSR's clinical outcomes and major conclusions were evaluated; CSR's quality and completeness were assessed using PRISMA and AMSTAR criteria. Overall, CSRs' reporting variations across specialties and trends over time were summarized.

**Results** A weighted analysis across all 36 CSRs found improved outcomes with LSP (odds ratio 0.90; 95% confidence interval 0.88, 0.92). Substantial CSR variation was found in the patient inclusion/exclusion criteria and clinical endpoints used. Individually, most CSR analyses showed no significant difference (65.4%) between LSP versus open procedures; 25.8% showed a LSP benefit versus 8.9% an open benefit. As a major conclusion, a positive LSP impact was documented by 8/36 (22.2%) CSRs; but only half of these CSRs decisively concluded that there was a LSP advantage. Undeclared conflicts of interest were identified in 9/36 CSRs (25.0%), raising the potential for a reporting bias. Both CSR variabilities (i.e., missing population, intervention, comparison, outcome, study design statements) and PRISMA-related deficiencies were documented.

**Conclusions** Overall, CSR evidence supports a LSP advantage; however, clinical decisions must be driven by CSR procedure-specific evidence. Variations and inconsistencies in CSR design and reporting identified future opportunities to improve CSR quality by increasing the methodological transparency, standardizing CSR reporting, and documenting comprehensively any non-financial conflicts of interest (i.e., ongoing research and historical publications) for all CSR team members.

**Keywords** Review · Peer-review · Research · Epidemiologic study characteristics · Research design · Laparoscopy · Surgical procedures · Operative

Over the past 30 years, minimally-invasive surgical procedures have become increasingly popular across nearly all surgical disciplines. Laparoscopic surgery procedures

(LSP) represent one of the earliest and most widely-used minimally-invasive techniques. Initially used only as a diagnostic tool, LSP was eventually adopted as an operative procedure; the first LSP was reported in the literature in 1962 by a gynecologist [1]. About 20 years later, the pivotal description of a laparoscopic appendectomy was published;

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firmly establishing LSP as a mainstream option for the management of surgical conditions [2, 3].

New LSP innovations continue to be developed, typically with the goals of improving patient clinical outcomes and/or lowering costs. A laparoscopic approach is not without disadvantages, however, such as decreasing the operative visual field and limiting tactile sensations; thus making LSPs inherently more technically challenging. Additionally, LSP complications (e.g., damage to major vessels or other structures) may be inadvertently missed intra-operatively by the surgeon.

Although in widespread use today, the evidence basis supporting the LSP approach has not been well established for many applications. Across all specialties, this review of Cochrane systematic reviews (CSR) publications summarized the evidence comparing laparoscopic versus open surgical approaches. In addition to identifying any overall or specialty-specific LSP benefits documented, a secondary aim was to identify any gaps or variations in reporting in order to guide future CSR-based LSP versus open surgical publications. Therefore, the specific objectives of this review of CSRs project included:

1. To summarize the laparoscopic versus open surgical procedural evidence relating to outcomes and costs in all CSRs published for all patient populations studied; and
2. To evaluate the completeness and quality of the CSRs evidence using the PRISMA and AMSTAR guidelines and to identify any potential reporting challenges (e.g., CSR team members' conflicts of interest) [4–6].

The data-driven evidence for each CSR's conclusions (e.g., documentation for the benefits of LSP versus open surgical procedures) was assessed; each CSR's objectives were reviewed carefully to determine if all of the population, intervention, comparison, outcome, and study design (i.e., PICOS) components were documented to clarify the CSR's question(s) raised. As a second priority, the consistency across the data-driven study findings for each CSR was evaluated. Importantly, each CSR was assessed to identify if clinically relevant, definitive recommendations were published; because without clear and definitive CSR recommendations, future advancements in clinical practice may be less likely to occur.

## Materials and methods

### Search strategy and selection of studies

As of 2016, PubMed contained over 50,000 articles with the word "laparoscopic" in their title, including about 1600

indexed as a systematic review or meta-analysis. Due to the large number of search results, the great variation in quality, and the high likelihood of double-counting individual patients' data that would occur if multiple systematic reviews on the same subject were considered, that search strategy was narrowed. As the Cochrane Collaboration's work was highly esteemed among many in the medical community and was self-described to be "recognized as representing an international gold standard for high quality, trusted information", only systematic reviews published by the Cochrane Collaboration were evaluated [7].

The *Cochrane Database of Systematic Reviews* was searched on November 24, 2014 to identify all complete CSR publications and/or CSR protocols published therein on the topic of LSPs. The search was updated on February 16, 2016 to include the most current CSR literature published as of that date. See Online Appendix 1 for the full search strategy. Two team members independently screened all search results by title and abstract. Disagreements were then discussed, including review of the full text when necessary, and ultimately resolved by consensus of the entire co-author team.

### Inclusion/exclusion criteria

To be included, CSRs must have (1) been published in the *Cochrane Database of Systematic Reviews* and (2) compared outcomes and/or resource utilization for patients undergoing a laparoscopic procedure (defined to include any surgical procedures performed entirely under direct visualization through an incision in the abdominal wall [e.g., laparotomy]) versus a comparable open procedure. Robotic-assisted procedures were excluded.

### Data extraction and management

All outcome and resource utilization data related to the comparisons of interest were extracted from the included CSRs "Data and analyses" section or "Results" section. In the sub-group of CSR studies reporting multiple comparisons for any given endpoint (e.g., multiple, related procedures analyzed separately and together such as transabdominal pre-peritoneal versus totally extraperitoneal inguinal hernia repair), the entire population analyses were used. For this summary of CSRs, it would have been preferable to include only CSRs' that included only studies with a low risk of bias. Such a breakdown of data, however, was not readily available for all included CSR studies; using the sub-group of studies with a low risk of bias, therefore, has led to a further biasing of the results presented herein or, alternatively,

a very limited number of CSRs eligible for this summary CSR study's inclusion.

Representing the Cochrane authors' most concise summary of the study's implications for practice, each CSR abstracts' "Authors' conclusions" section was reviewed—as this is where a busy clinician might examine the CSR findings first to answer their clinical question. To summarize each CSR's overall conclusions, therefore, the "Authors' conclusions" section of each CSR's abstract was independently reviewed by all co-authors and classified based upon team consensus into the following three categories: "supports laparoscopic procedure", "supports open procedure", or "other".

For each included CSR, the study designs, participant demographics, and interventions eligible for inclusion in the CSR were documented. The details of study design(s), patient gender(s), and patient age groups eligible for inclusion were assessed separately by two authors (BC and JL); the presence or absence of PRISMA requirements and AMSTAR criteria were also assessed. Only those CSRs published since January 2010 were assessed with the PRISMA checklist, because the PRISMA recommendations were published in 2009 [4–6].

### Quantitative outcomes

Primary endpoints included mortality (i.e., any mortality measure including in-hospital mortality or 30-day operative mortality), any post-operative infection, reoperation, and hospital length of stay. All patient-reported outcomes (e.g., quality of life, satisfaction with cosmetic outcome) were initially evaluated. However, patient self-reported outcomes were ultimately excluded from the primary analysis due to heterogeneity of measures utilized and the subjectivity of interpretation for measures used. Morbidity outcomes not classified elsewhere were considered within "other morbidity", with all remaining endpoints classified as "other". This classification was mainly performed by one team member, but a large sub-group of CSRs was independently categorized by a second team member to assure the reliability of categorization. When multiple outcomes were reported that fell into a similar category (e.g., 30-day mortality and one-year mortality), each of these outcomes was included in the analysis. For those endpoints that were analyzed by the Cochrane authors both as an overall category and in subcategories, only the outcome for the group as a whole was considered to avoid double-counting individual patient outcomes.

The total number of CSRs reporting each endpoint in a given year was tallied. The results were examined qualitatively (% endpoints favoring lap, % favoring open, % with no difference between lap versus open) for trends over time using Spearman's correlation. For each CSR, the odds ratios

(OR), 95% confidence intervals (CI), number of events, and total number of patients were analyzed. Representing an overall "weighted" estimate that considered the individual sample sizes and associated outcome incidences in each CSR reporting a particular outcome, a weighted odds ratio was calculated for each outcome category's findings and across all outcome categories. Any CSR without a reported hazard ratio or mean difference reported was excluded from this "weighted" calculation. Statistical significance was identified with  $p < 0.05$ .

## Results

### Description of included CSRs

There were 36 completed CSR publications (Table 1) and 15 CSR protocols (Table 2) included in this summary review, representing the work of 11 different Cochrane Working Groups. A listing of CSRs identified by the initial search but ultimately excluded from this analysis can be found in Online Appendix 2. One CSR protocol was excluded after the initial screening, because it had subsequently been retracted. Figure 1 reports the flow diagram for the identification of CSRs. After completing the screening protocol defined a priori and described above, there was 100% agreement among screening team members for the CSRs identified for inclusion. Of the included CSRs, 30 reported primary study data, including 25 CSRs that reported data from more than one study-based publication. Two CSRs did not fully report the statistical analyses used (e.g., population size or exact  $p$ -value), so this information was separately gleaned from the primary study publications. Half (18/36) of the included CSRs reviewed gynecologic procedures, three reviewed urologic procedures, and the remaining 15 CSRs reviewed procedures typically performed by general surgeons or surgical subspecialists.

There was variability observed among the study designs included in the CSRs (Table 1): 22/36 (61.1%) included only randomized controlled trials (RCTs), 11/36 (30.6%) included RCTs and non-RCT interventional designs, and 3/36 (8.3%) included all study designs. Among included CSR protocols: 11/15 (73.3%) included only RCTs, 2/15 (13.3%) included intervention-only designs, and 2/15 (13.3%) included all study designs (Table 2). The inter-rater reliability was high ( $\kappa = 0.944$ ) for the inclusion of these different study designs.

Also, CSRs varied in the patient demographics considered for inclusion/exclusion (Table 1). Six CSRs explicitly included patients regardless of age (including one that analyzed adults and children separately), one CSR included only children, another 16 included only adults

Table 1 Included Cochrane systematic reviews

Authors	Issue, year published	Title	Content up-to-date	Types of studies considered	Age/gender inclusion criteria
JWM Aarts, TE Nieboer, N Johnson, E Tavender, R Garry, BWJ Mol, KB Kluivers	Issue 8, 2015	Surgical approach to hysterectomy for benign gynaecological disease	14-Aug-14	RCTs	All women
G Ahmad, A Watson, P Vanderkerchove, R Lilford	Issue 2, 2006	Techniques for pelvic surgery in subfertility	21-Feb-06	RCTs	All women
U Ahmed Ali, F Keus, JT Heikens, WA Bemelman, SV Berdah, HG Gooszen, CJHM. van Laarhoven	Issue 1, 2009	Open versus laparoscopic (assisted) ileo pouch anal anastomosis for ulcerative colitis and familial adenomatous polyposis	3-Nov-08	RCTs, pro-/retrospective non-RCTs	All
P Bhav Chittawar, S Framik, AW Pouwer, C Farquhar	Issue 10, 2014	Minimally invasive surgical techniques versus open myomectomy for uterine fibroids	9-Jul-14	RCTs	Premenopausal women
E Brockbank, F Kokka, A Bryant, C Pomet, K Reynolds	Issue 3, 2013	Pre-treatment surgical para-aortic lymph node assessment in locally advanced cervical cancer	12-Feb-13	RCTs	All women
S Bunyavejchevin, V Phupong	Issue 1, 2013	Laparoscopic surgery for presumed benign ovarian tumor during pregnancy	11-Nov-12	RCTs	Pregnant women
R Cirocchi, I Abraha, E Farinella, A Montedori, F Sciannoneo	Issue 2, 2010	Laparoscopic versus open surgery in small bowel obstruction	8-Oct-09	RCTs, prospective non-RCTs	Adults 16 and over
BVM Dasari, D McKay, K Gardner	Issue 1, 2011	Laparoscopic versus Open surgery for small bowel Crohn's disease	14-Aug-10	RCTs	Adults 16 and over
N Dean, G Ellis, GP Herbison, D Wilson	Issue 3, 2006	Laparoscopic colposuspension for urinary incontinence in women	15-Dec-09	RCTs, qRCTs	Adult women (no age definition)
O Faluyi, M Macean, C Gourley, A Bryant, HO Dickinson	Issue 9, 2010	Interventions for the treatment of borderline ovarian tumours	27-Jul-10	RCTs	All women
K Galaal, A Bryant, AD Fisher, M Al-Khaduri, F Kew, AD Lopes	Issue 9, 2012	Laparoscopy versus laparotomy for the management of early stage endometrial cancer	9-Aug-12	RCTs	Adult women (no age definition)
K George, MS Kamath, P Tharyan	Issue 2, 2013	Minimally invasive versus open surgery for reversal of tubal sterilization	23-Oct-12	RCTs	Premenopausal women
M Gurusurthy, A Bryant, S Shanbhag	Issue 4, 2014	Effectiveness of different treatment modalities for the management of adult-onset granulosa cell tumours of the ovary (primary and recurrent)	31-Jan-14	RCTs, qRCTs, non-RCTs, cohort studies, case series of 10+	Adult women (adult = $\geq 16$ or if study described participants as "adults")
PJ Hajenius, F Mol, BWJ Mol, PMM Bossuyt, WM Ankum, F Van der Veen	Issue 1, 2007	Interventions for tubal ectopic pregnancy	15-Nov-06	RCTs	All women
F Keus, J de Jong, HG Gooszen, CHJM van Laarhoven	Issue 4, 2006	Laparoscopic versus small-incision cholecystectomy for patients with symptomatic cholelithiasis	10-Aug-06	RCTs	All

Table 1 (continued)

Authors	Issue, year published	Title	Content up-to-date	Types of studies considered	Age/gender inclusion criteria
F Keus, J de Jong, HG Gooszen, CHJM Laarhoven	Issue 3, 2006	Laparoscopic versus open cholecystectomy for patients with symptomatic cholecystolithiasis	7-Aug-06	RCTs	All
A Kucukmetin, I Biliatis, R Naik, A Bryant	Issue 10, 2013	Laparoscopically assisted radical vaginal hysterectomy versus radical abdominal hysterectomy for the treatment of early cervical cancer	29-Jul-13	RCTs	Adult women (no age definition)
E Kuhry, W Schwenk, R Gaupset, U Romild, HJ Bonjer	Issue 2, 2008	Long-term results of laparoscopic colorectal cancer resection	2-Jan-08	RCTs	All
R Kulier, M Boulvain, DM Walker, G De Candolle, A Campana	Issue 3, 2004	Mimilaparotomy and endoscopic techniques for tubal sterilisation	1-Sep-08	RCTs	All women
MCM Lapitan, JD Cody	Issue 2, 2016	Open retroperic colposuspension for urinary incontinence in women	5-May-15	RCTs, qRCTs	All women
TA Lawrie, LRF Medeiros, DD Rosa, MI da Rosa, MI Edelweiss, AT Stein, A Zelmanowicz, AB Moraes, RR Zanini	Issue 2 2013	Laparoscopy versus laparotomy for FIGO stage I ovarian cancer	23-Nov-12	RCTs, qRCTs, case-control	All women
C Maher, B Feiner, K Baessler, C Schmid	Issue 4, 2013	Surgical management of pelvic organ prolapse in women	20-Aug-12	RCTs, qRCTs	Adult women (no age definition)
K McCormack, N Scott, PM Go, SJ Ross, A Grant, EU Hernia Trialists Collaboration	Issue 1, 2003	Laparoscopic techniques versus open techniques for inguinal hernia repair	5-Nov-02	RCTs, qRCTs	All
LRF Medeiros, DD Rosa, MC Bozzetti, JMG Fachel, S Furness, R Garry, MINES Rosa, AT Stein	Issue 2, 2009	Laparoscopy versus laparotomy for benign ovarian tumour	9-Nov-07	RCTs	All women
M Metwally, YC Cheong, AW Horne	Issue 11, 2012	Surgical treatment of fibroids for subfertility	21-Jun-12	RCTs	All women
G Nabi, A Cleves, M Shelley	Issue 3, 2010	Surgical management of localised renal cell carcinoma	13-Oct-09	RCTs, qRCTs	Adults (no age definition)
BP Rai, M Shelley, B Coles, CS Biyani, I El-Mokadem, G Nabi	Issue 4, 2011	Surgical management for upper urinary tract transitional cell carcinoma	5-Sep-10	RCTs, qRCTs	Adults (no age definition)
AM Rao, I Ahmed	Issue 5, 2013	Laparoscopic versus open liver resection for benign and malignant hepatic lesions in adults	30-Aug-12	RCTs, qRCTs	Adults 16 and over
A Sanabria, MI Villegas, CH Morales Uribe	Issue 2, 2013	Laparoscopic repair for perforated peptic ulcer disease	3-Jul-12	RCTs	Adults over 18
S Sauerland, T Jaszinski, EAM Neugebauer	Issue 10, 2010	Laparoscopic versus open surgery for suspected appendicitis	25-Aug-10	RCTs	Adults/children considered separately
S Sauerland, M Walgenbach, B Habermalz, CM Seiler, M Miserez	Issue 3, 2011	Laparoscopic versus open surgical techniques for ventral or incisional hernia repair	22-Jul-10	RCTs	Adults (no age definition)

Table 1 (continued)

Authors	Issue, year published	Title	Content up-to-date	Types of studies considered	Age/gender inclusion criteria
W Schwenk, O Haase, JJ Neudecker, JM Müller	Issue 2, 2005	Short term benefits for laparoscopic colorectal resection	30-Jan-05	RCTs	All
S Tou, SR Brown, RL Nelson	Issue 11, 2015	Surgery for complete rectal prolapse in adults	3-Feb-15	RCTs, qRCTs	Adults (no age definition)
EC van Dalen, MS de Lijster, LGJ Leijssen, EMC Michiels, LCM Kremer, HN Caron, DC Aronson	Issue 1, 2015	Minimally invasive surgery versus open surgery for the treatment of solid abdominal and thoracic neoplasms in children	18-Feb-14	RCTs, CCTs	Children $\geq$ 18 at diagnosis
S Vennix, L Pelzers, N Bouvy, GL Beets, JP Pierre, T Wiggers, S Breukink	Issue 4, 2014	Laparoscopic versus open total mesorectal excision for rectal cancer	2-Feb-13	RCTs	All
CH Wilson, A Sammi, DA Rix, NA Soomro	Issue 11, 2011	Laparoscopic versus open nephrectomy for live kidney donors	21-May-10	RCTs, qRCTs	All

RCT randomized controlled trial

CCT controlled clinical trial

qRCT quasi-randomized controlled trial

(but only 6/16 included a definitive, age-based definition of the term “adult”), and 4 had inclusion criteria indirectly related to age (e.g., including only premenopausal women or women of childbearing years). Among CSR protocols, 6 included patients of any age, 2 included only children, and 7 included only adults (with three that explicitly defined the group “adult”) (Table 2). The inter-rater reliability for the age-related inclusion criteria was high ( $\kappa = 0.762$ ).

Two CSRs specifically included all patients regardless of gender, while 16 did not mention gender as part of their inclusion/exclusion criteria. All CSRs reviewing gynecologic procedures included only women, while four CSR gender-specific protocols considered procedures specific to male or female genitourinary systems. The remainder implicitly included patients irrespective of gender, and no CSRs or protocols explicitly excluded patients based on race or ethnicity. The inter-rater agreement was 100% for the CSR identification of gender-related study inclusion criteria.

### Effects of interventions

An overview of the meta-analyses presented by CSRs is displayed in Table 3. In total, 361 different analyses were performed by 30 CSRs. Of those, 236/361 (65.4%) reported no significant difference between the laparoscopic and open outcomes, 93/361 (25.8%) favored the laparoscopic procedure, and 32/361 (8.9%) favored the open procedure. With very high inter-rater reliability demonstrated ( $\kappa = 0.962$ ), data from the five largest CSRs (representing about 40% of all CSR endpoints) were used to assess the inter-rater reliability of co-author team’s outcome classifications.

Evaluating individual clinical outcomes across CSRs, no mortality or reoperation endpoint reached statistical significance. Also, the findings for the CSRs’ patient-reported outcome measures (such as pain scores or quality of life, provided in the supplementary analysis only) were either not statistically significant or favored the laparoscopic procedure. Although one CSR favored using an open procedure based on infection findings, the overall findings for the infection-related outcomes were generally mixed—ranging from not significant to favoring the laparoscopic procedure.

As all but one CSR’s length of stay findings favored the laparoscopic procedure; generally a positive LSP impact upon length of stay was reported. Though comparing LSP versus open surgical procedural cost had been identified as an important study outcome identified a priori, only five CSRs reported cost data. Consequently, a cost analysis comparing LSP versus open procedural costs could not be further pursued.

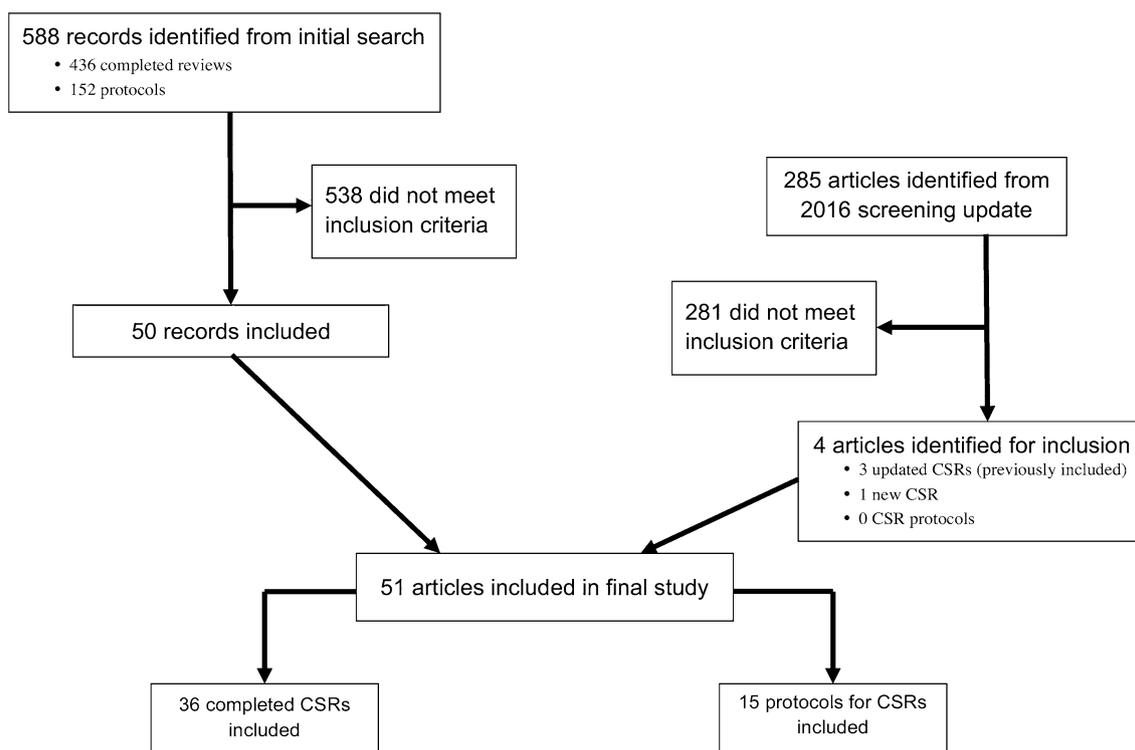
Based upon year of publication, CSRs’ results were examined to evaluate for potential trends in key findings over time.

**Table 2** Included Cochrane systematic review protocols

Authors	Issue, year published	Title	Types of studies	Patient demographics
YC Cheong, S Singh, W Stones	Issue 1, 2010	Surgical interventions for the management of chronic pelvic pain in women	RCTs	All women
YC Cheong, M Metwally, N Shreeve, K Sadek, C Farquhar	Issue 12, 2011	Ovarian surgery for symptom relief in women with polycystic ovary syndrome	RCTs	All women
R Cirocchi, E Farinella, S Trastulli, C Boselli, A Montedori, N Gullà, G Noya, F Sciannameo, I Abraha	Issue 8, 2011	Laparoscopic versus open surgery for colonic diverticulitis	RCTs	All
AV Deshpande, P Michail, GH Smith	Issue 2, 2014	Interventions for undescended testes in children	RCTs, qRCTs	Male children $\leq 16$
M Easow Mathew, A Sharma, S Fahad, R Aravindakshan	Issue 5, 2013	Splenectomy for people with thalassaemia major and intermedia	RCTs, qRCTs	All
F Gao, J Liu, S Zhang	Issue 3, 2011	Quality of life after laparoscopic versus open resection in colorectal cancer	RCTs	All
KS Gurusamy	Issue 11, 2014	Laparoscopic versus open distal pancreatectomy for pancreatic cancer	RCTs; if no RCTs then observational studies	Adults (no age definition)
KS Gurusamy	Issue 11, 2014	Laparoscopic versus open gastrectomy for gastric cancer	RCTs	Adults (no age definition)
KS Gurusamy	Issue 11, 2014	Laparoscopic versus open transhiatal oesophagectomy for oesophageal cancer	RCTs	Adults (no age definition)
KS Gurusamy	Issue 11, 2014	Management strategies for pancreatic pseudocysts: a network meta-analysis	RCTs	Adults (no age definition)
D Ilic, S Evans, D Murphy, M Frydenberg	Issue 2, 2012	Laparoscopic versus open prostatectomy for the treatment of localised prostate cancer	RCTs	Adult men $> 18$
N Montero, L Sans, AC Webster, J Pascual	Issue 1, 2014	Interventions for infected cysts in people with autosomal dominant polycystic kidney disease	RCTs, qRCTs; observational studies analyzed separately	All
M Roqué i Figuls, L Martínez García, MJ Martínez-Zapata, R Pacheco, D Mauricio, X Bonfill Cosp	Issue 8, 2013	Interventions for treating overweight or obesity in adults: an overview of systematic reviews	RCTs	Adults $\geq 18$
T Sasse, U Moehrlen, M Meuli, RN Vuille-dit-Bille	Issue 10, 2011	Exploration of the contralateral side when operating for inguinal hernia in children for detection of bilateral hernation	Prospective and retrospective observational studies	Children age $\leq 20$
AE Vallance, CH Wilson, RM Charnley	Issue 6, 2014	Minimal access drainage procedures for patients with necrotising pancreatitis	RCTs	Adults $\geq 18$

*RCT* randomized controlled trial

*qRCT* quasi-randomized controlled trial



**Fig. 1** Flow diagram of included and excluded Cochrane systematic reviews

Based on weighted outcomes, no trends over time were found for the CSRs that documented no difference between LSP versus open procedures ( $p=0.17$ ), CSRs that favored laparoscopic surgery ( $p=0.41$ ), or CSRs that favored open surgery ( $p=0.72$ ). For unweighted outcome findings, the CSRs' results were similar—that is, the trends over time were not statistically significant ( $p$ -values = 0.63, 0.52, and 0.86, respectively).

The major endpoint categories were evaluated using the calculated unweighted and weighted odds ratios as described in the methods section above. This is reported in Table 4 and shown graphically in Online Appendix 3. In general, the findings across different surgical specialties for clinical outcomes favored the laparoscopic approach (except for the reoperation endpoint, which reported no statistically significant differences). Similarly, the analyses combining all clinical outcome endpoints favored the laparoscopic procedures (i.e., OR 0.90, 95% CI 0.88, 0.92). To ensure these findings were robust in spite of the heterogeneity inherent in the various procedures considered, these weighted analyses were also performed for the subgroups of studies reporting (1) gynecologic versus non-gynecologic procedures and (2) procedures intended to treat malignant or potential malignant conditions versus those for non-cancer or benign neoplastic conditions. These analyses all supported the finding of a slight advantage for the laparoscopic approach or found

no statistically significant difference. These results are presented in Online Appendices 4 and 5.

As key clinically relevant endpoints, analyses were separately performed comparing mortality, infection, and reoperation endpoints. Across all CSRs reporting a mortality endpoint, there appeared to be a LSP mortality benefit (OR 0.85 based on 9 CSRs with mortality endpoints, 95% CI 0.75, 0.97). Using this same endpoint-specific comparison approach, the infection and reoperation outcomes were not statistically significant different between LSP and open surgical management approaches (Online Appendix 6).

Two CSR publications (Lapitan and Cody 2016; and Dean et al. 2006) overlapped in subject matter, reporting data in two CSRs from the same primary studies. As it was not possible to separate out the repeated data to avoid overweighting, a sensitivity analysis was performed for this study's weighted results—running this study's analyses both with and without the most recent CSR by Lapitan and Cody. Excluding these more recent data, the weighted analysis findings were not altered.

A qualitative review of each CSR's abstract conclusions is summarized in Table 5. Across the CSRs evaluated, 8/36 (22.2%) presented the laparoscopic procedures' results as more favorable, but only half of these CSRs did so decisively or made a firm recommendation for future changes in

**Table 3** Number of CSRs reporting each endpoint by statistical significance

	Not significant	Favors laparoscopic	Favors open	Total
Mortality	16/16 (100.0%)	0/16 (0.0%)	0/16 (0.0%)	16
Infection	21/32 (65.6%)	10/32 (31.3%)	1/32 (3.1%)	32
Reoperation	17/17 (100.0%)	0/17 (0.0%)	0/17 (0.0%)	17
Length of stay	1/21 (4.8%)	20/21 (95.2%)	0/21 (0.0%)	21
Other morbidity	116/147 (78.9%)	22/147 (15.0%)	9/147 (6.1%)	147
Other	65/128 (50.8%)	41/128 (32.0%)	22/128 (17.2%)	128
Overall	236/361 (65.4%)	93/361 (25.8%)	32/361 (8.9%)	361

**Table 4** Weighted outcomes

	Conclusion	Odds ratio <sup>a</sup>	95% Confidence interval	Included end-points	Total subjects	Weight
Mortality	Lap	0.88	[0.81, 0.94]	13/16	20,739	0.078
Infection	Lap	0.67	[0.61, 0.74]	29/32	45,717	0.171
Reoperation	NS	0.95	[0.75, 1.20]	11/17	7453	0.028
Length of stay	Lap	0.68	[0.49, 0.94]	2/21	616	0.002
Other morbidity	Lap	0.92	[0.88, 0.95]	115/147	145,259	0.544
Other	Lap	0.91	[0.86, 0.95]	43/128	47,226	0.177
Overall	Lap	0.90	[0.88, 0.92]	213/361	267,010	1.000

<sup>a</sup>Odds ratio for negative outcomes in the laparoscopic group versus the open group

clinical practice; as the opposing viewpoint presented, one CSR concluded that an open procedure was better, albeit had marginal improvement over a LSP approach.

### Conflicts of interest

Potential conflicts of interest (COI) identified are presented in Online Appendix 7. PRISMA and AMSTAR assessments can be found in Tables 6 and 7. The authors of 10/36 (27.8%) CSRs declared a potential COI, while the remaining 26 declared none. Two of those 10 declared COI were related to financial support or industry affiliation. Of the CSRs reporting data from one or more study, 9/30 (30.0%) included studies were co-authored by at least one CSR co-author. Only half (5/9) of CSRs with these potential COI related to co-authorship were declared in the COI section of the CSR manuscript. It was also observed that 4/25 CSRs assessed using PRISMA did not report a funding source (Table 6). The inter-rater agreement was 100% for the COI categorization.

## Discussion

### Laparoscopic versus open surgery

This present study was undertaken to evaluate what is often cited as the highest quality evidence available on any

subject; that is, to summarize the reports from the Cochrane Library's systematic literature reviews and to identify overarching trends over time or CSR patterns reported across surgical specialties for the effect of laparoscopic versus open surgical procedures. Based on this study's results, it appears generally that laparoscopic surgical procedures as a whole have had a positive effect on patient outcomes compared to open procedures. Given the inherent nature of this study's CSR summary comparisons performed, however, no conclusions can be drawn as to the LSP benefit for any specific surgical procedure—beyond what was originally reported by each CSR's findings.

For this study, each CSR's conclusions were carefully reviewed to identify the data-driven basis for the summary statements. When directly assessing the data-basis for the conclusions made, interestingly the CSRs' conclusions were much more equivocal. In general, CSRs' author teams tended to avoid making statements that explicitly supported or refuted the future use of a specific surgical treatment (i.e., LSP vs. open procedure) within their CSR's conclusion statements. Among those who did make explicit data-driven statements, only 4 of 9 CSR co-author teams chose language that clearly supported either the LSP or open approach, while the remainder of CSR co-authors simply restated their major analytical findings without making any recommendation for future changes in clinical practice. For appendectomy and cholecystectomy, however, the CSRs

**Table 5** Authors' conclusions

Authors	Title	Favors
Aarts et al. (2015)	Surgical approach to hysterectomy for benign gynaecological disease	Lap
Ahmad et al. (2006)	Techniques for pelvic surgery in subfertility	–
Ahmed Ali et al. (2009)	Open versus laparoscopic (assisted) ileo pouch anal anastomosis for ulcerative colitis and familial adenomatous polyposis	–
Bhave Chittawar et al. (2014)	Minimally invasive surgical techniques versus open myomectomy for uterine fibroids	Lap
Brockbank et al. (2013)	Pre-treatment surgical para-aortic lymph node assessment in locally advanced cervical cancer	–
Bunyavejchevin and Phupong (2013)	Laparoscopic surgery for presumed benign ovarian tumor during pregnancy	–
Cirocchi et al. (2010)	Laparoscopic versus open surgery in small bowel obstruction	–
Dasari et al. (2011)	Laparoscopic versus Open surgery for small bowel Crohn's disease	–
Dean et al. (2006)	Laparoscopic colposuspension for urinary incontinence in women	–
Faluyi et al. (2010)	Interventions for the treatment of borderline ovarian tumours	–
Galaal et al. (2012)	Laparoscopy versus laparotomy for the management of early stage endometrial cancer	Lap*
George et al. (2013)	Minimally invasive versus open surgery for reversal of tubal sterilization	–
Gurumurthy et al. (2014)	Effectiveness of different treatment modalities for the management of adult-onset granulosa cell tumours of the ovary (primary and recurrent)	–
Hajenius et al. (2007)	Interventions for tubal ectopic pregnancy	–
Keus et al. (2006)	Laparoscopic versus small-incision cholecystectomy for patients with symptomatic cholecystolithiasis	–
Keus et al. (2006)	Laparoscopic versus open cholecystectomy for patients with symptomatic cholecystolithiasis	Lap*
Kucukmetin et al. (2013)	Laparoscopically assisted radical vaginal hysterectomy versus radical abdominal hysterectomy for the treatment of early cervical cancer	–
Kuhry et al. (2008)	Long-term results of laparoscopic colorectal cancer resection	–
Kulier et al. (2004)	Minilaparotomy and endoscopic techniques for tubal sterilisation	–
Lapitan and Cody (2016)	Open retropubic colposuspension for urinary incontinence in women	Open
Lawrie et al. (2013)	Laparoscopy versus laparotomy for FIGO stage I ovarian cancer	–
Maher et al. (2013)	Surgical management of pelvic organ prolapse in women	–
McCormack et al. (2003)	Laparoscopic techniques versus open techniques for inguinal hernia repair	–
Medeiros et al. (2009)	Laparoscopy versus laparotomy for benign ovarian tumour	Lap
Metwally et al. (2012)	Surgical treatment of fibroids for subfertility	–
Nabi et al. (2010)	Surgical management of localised renal cell carcinoma	–
Rai et al. (2011)	Surgical management for upper urinary tract transitional cell carcinoma	Lap
Rao and Ahmed (2013)	Laparoscopic versus open liver resection for benign and malignant hepatic lesions in adults	–
Sanabria et al. (2013)	Laparoscopic repair for perforated peptic ulcer disease	–
Sauerland et al. (2010)	Laparoscopic versus open surgery for suspected appendicitis	Lap*
Sauerland et al. (2011)	Laparoscopic versus open surgical techniques for ventral or incisional hernia repair	–
Schwenk et al. (2005)	Short term benefits for laparoscopic colorectal resection	Lap*
Tou et al. (2015)	Surgery for complete rectal prolapse in adults	–
van Dalen et al. (2015)	Minimally invasive surgery versus open surgery for the treatment of solid abdominal and thoracic neoplasms in children	–
Vennix et al. (2014)	Laparoscopic versus open total mesorectal excision for rectal cancer	–
Wilson et al. (2011)	Laparoscopic versus open nephrectomy for live kidney donors	–

Lap = 8 favored the laparoscopic procedure

Lap\* = 4 strongly favored or recommended the laparoscopic procedure

– = does not clearly favor either procedure

No CSR's abstract conclusion statements clearly favored the open procedure

evaluating these two very common laparoscopic general surgical procedures did clearly denote that the laparoscopic approach was favored over an open procedure. Importantly,

the benefits of laparoscopic surgical management appear to be procedure-specific; a surgical field's experience with a given laparoscopic procedure may be an important factor

in the LSP benefits that have been observed. In summary, LSP benefits must be evaluated on a procedure-by-procedure basis, as potential patient benefits for open versus LSP procedures may otherwise be overlooked.

As the future Cochrane Library's planned direction evaluating laparoscopic surgical procedures, 15 CSR protocols were identified to evaluate the most recent advances in laparoscopic surgical techniques. Other, even more novel innovations, such as NOTES (natural orifice transluminal endoscopic surgery) procedures, have not yet made their way into the Cochrane literature, but may warrant consideration in the coming years.

## Methodological quality

All of Cochrane Library's CSRs evaluated were expected to follow guidelines and standards set forth in the *Methodological Expectations of Cochrane Intervention Reviews* (MECIR) and the Cochrane Handbook [8, 9]. The CSRs included in this study, therefore, all tended to follow similar formats and were generally of high quality. Nonetheless, methodological variability and the need for improvement in certain areas were identified.

One notable inconsistency involved the precise definitions of CSR population's inclusion/exclusion criteria. As age was a relatively common inclusion criterion, MECIR standard R30 states "any notable restrictions on the eligibility criteria of the review should be given and explained" [9]. For the 36 CSRs reviewed, however, the age criterion was defined only vaguely in several studies, however (e.g., including "adults" without an age-based definition). To ensure transparency and appropriate generalization of the findings of CSRs, future CSR authors should more clearly define their age-related inclusion/exclusion criteria. Further, though age may affect the decision to elect to perform a procedure laparoscopically versus with an open approach, only one included review (Sauerland et al. 2010) considered a potential differential effect of laparoscopic versus open surgery on various age groups. Future research may be helpful to elucidate the impact of laparoscopic surgical procedures on patient subpopulations of different ages.

Another area of concern was the transparency and accountability for conflicts of interest by CSR co-author teams. Of the included CSRs published since 2010 (the first full year after the publication of the PRISMA guidelines), 4/25 CSRs (16.0%) did not clearly report their funding sources. MECIR standard R108 mandates authors to "list sources of financial and non-financial support for the review and the role of the funder, if any" [9]. Whether or not funding is utilized, moreover, all CSR co-author team members should be required to complete a disclosure statement and plainly state funding sources (or lack thereof) within the manuscript.

Also, academic and professional conflicts represent a major cause for concern. The Cochrane Handbook, Section 2.6, states that whenever "a review author is also an author of a potentially eligible study" ... "this should be disclosed in the review and, where possible, there should be an independent assessment of eligibility and risk of bias by a second author with no conflict of interest." [8] Among the included CSRs that identified data to report, nearly one-third (9/30) included at least one study that was co-authored by one or more CSR authors. Further, half (5/9) of these conflicts went undisclosed in the "Disclosures" section of the manuscript. This can be a difficult issue to deal with in academia, where the individuals most qualified to conduct a CSR often have gained expertise in that field through conducting the important studies and, consequently, authoring the publications that are to be reviewed. The appropriateness of this is a subject for debate and is beyond the scope of this manuscript; however transparency is not. It is imperative that future authors and editorial teams, for both Cochrane and non-Cochrane systematic reviews, consider the potential (or, at minimum, the appearance) of bias that this situation creates, and both declare and attempt to minimize it in whatever means appropriate. At the same time, consumers of the literature should be careful to interpret CSRs with the knowledge that such a bias may exist.

"The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions" (2009), presents a method for judging the quality and completeness of systematic reviews, and represents an update of the 1999 QUOROM statement [4, 10]. PRISMA included a 27-item checklist of "items deemed essential for transparent reporting of a systematic review" and a template for a flow diagram (to present the number of studies considered at various points throughout the screening process) [4]. Cochrane's MECIR references the PRISMA checklist, and the Cochrane website states the MECIR standards are "compliant with the PRISMA standards", with the exception of one item (Title) [11]. The CSRs included here met an average of about 25/27 PRISMA checklist items for the 25 CSRs assessed (assuming credit is given for "Title").

More important than overall PRISMA completeness scores, specific deficiencies were consistently identified. First, only 10/25 (40%) of CSRs included a flow diagram. Though not required by PRISMA or MECIR, the inclusion of a flow diagram is recommended by both because it enables readers to quickly assess the scope and validity of the data summarized in a given CSR [4, 11]. Interestingly, flow diagrams were reported more commonly in the more recent CSR publications.

Second, there was also concern regarding the clarity of the reviewed CSR's "statement of objectives". Both PRISMA item 4 and MECIR standard R23 require that CSR objectives be stated concisely using the PICOS or PICO

**Table 6** PRISMA checklist item and flow diagram inclusion

Systematic review	Title	Structured summary	Rationale	Objectives	Protocol registration and criteria	Eligibility criteria	Information sources	Search	Study selection	Data collection process	Data items	Risk of bias in individual studies	Summary measures	Synthesis of results across studies	Risk of bias of synthesis across studies	Results of individual studies	Characteristics of studies	Study selection	Additional analyses	Risk of bias of synthesis across studies	Additional analyses	Summary of evidence	Limitations	Conclusions	Funding	Total	Flow diagram*
Aarts et al. (2015)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	26	✓
Bhave Chittawar et al. (2014)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	26	✓
Brockbank et al. (2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	26	✓
Bunyavejhevin and Phupong (2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	25	✓
Cirocchi et al. (2010)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	21	✓
Dasari et al. (2011)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	25	✓
Faluyi et al. (2010)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	26	✓
Galaal et al. (2012)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	25	✓
George et al. (2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	26	✓
Gurumurthy et al. (2014)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	25	✓
Kucukmetin et al. (2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	25	✓
Lapitan and Cody (2016)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	26	✓
Lawrie et al. (2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	26	✓
Maher et al. (2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	24	✓
Metwally et al. (2012)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	26	✓

**Table 6** (continued)

Systematic review	Title	Structured summary	Rationale	Objectives	Protocol and registration	Eligibility criteria	Information sources	Search	Data collection	Data processing	Risk of bias in individual studies	Summary measures	Synthesis of results across studies	Additional analyses	Risk of bias across studies	Synthesis of results across studies	Results of individual studies	Characteristics of studies	Study Risk	Results of bias within studies	Additional analyses	Summary of evidence	Limitations	Conclusions	Funding	Total	Flow diagram*
Nabi et al. (2010)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	25	
Rai et al. (2011)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	25	
Rao and Ahmed (2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	25	
Sanabria et al. (2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	26	
Sauerland et al. (2010)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	25	
Sauerland et al. (2011)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	26	
Tou et al. (2015)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	25	
van Dalen et al. (2015)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	22	
Vennix et al. (2014)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	26	
Wilson et al. (2011)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	25	
Total (n=25**)																										25.1	10

✓ = item was found in CSR

No ✓ = item was not found in CSR

\*A flow diagram is recommended by not required by the PRISMA statement, so it's presence or absence was assessed separately from the 27 items of the PRISMA checklist

\*\*Inclusion of PRISMA checklist items was only assessed for those CSR's published since 2010 to coincide with the publication of the PRISMA recommendations

Table 7 AMSTAR checklist item inclusion

	'A priori' design?	Duplicate study selection and data extraction?	Comprehensive literature search?	Publication (i.e., grey literature) used as an inclusion criterion?	Included and excluded studies provided?	Characteristics of included studies provided?	Quality of included studies assessed and documented?	Quality of included studies used appropriately in formulating conclusions?	Methods used to combine the findings of studies appropriate?	Likelihood of publication bias assessed?	Conflict of interest included?
Aarts et al. (2015)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Ahmad et al. (2006)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
Ahmed Ali et al. (2009)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
Bhave Chittawar et al. (2014)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N/A	Y
Brockbank et al. (2013)	Y	Y	Y	Y	Y	Y	Y	Y	N/A	N/A	N
Bunyavejhevin and Phupong (2013)	Y	Y	Y	Y	N	N/A	N/A	N/A	N/A	N/A	Y
Cirocchi et al. (2010)	Y	Y	Y	N	Y	N/A	N/A	N/A	N/A	N/A	Y
Dasari et al. (2011)	Y	Y	N	N	Y	Y	Y	Y	Y	N	N
Dean et al. (2006)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
Faluyi et al. (2010)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N/A	N
Galaal et al. (2012)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N/A	N
George et al. (2013)	Y	Y	Y	Y	Y	N/A	N/A	N/A	N/A	N/A	Y
Gurumurthy et al. (2014)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N/A	N
Hajenius et al. (2007)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
Keus et al. (2006)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
Keus et al. (2006)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
Kucukmetin et al. (2013)	Y	Y	Y	Y	N	Y	Y	Y	N/A	N/A	N

Table 7 (continued)

	'A priori' design?	Duplicate study selection and data extraction?	Comprehensive literature search?	Publication (i.e., grey literature) used as an inclusion criterion?	Included and excluded studies provided?	Characteristics of included studies provided?	Quality of included studies assessed and documented?	Quality of included studies used appropriately in formulating conclusions?	Methods used to combine the findings of studies appropriate?	Likelihood of publication bias assessed?	Conflict of interest included?
Kuhry et al. (2008)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
Kulier et al. (2004)	Y	Y	N	N	Y	Y	Y	Y	Y	N	N
Lapitan and Cody (2016)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
Lawrie et al. (2013)	Y	Y	Y	Y	Y	N/A	N/A	N/A	N/A	N/A	Y
Maher et al. (2013)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
McCormack et al. (2003)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
Medeiros et al. (2009)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
Metwally et al. (2012)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N/A	N
Nabi et al. (2010)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N/A	N
Rai et al. (2011)	Y	Y	Y	N	Y	Y	Y	Y	N/A	N	N
Rao and Ahmed (2013)	Y	Y	Y	Y	Y	N/A	N/A	N/A	N/A	N/A	Y
Sanabria et al. (2013)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N/A	N
Sauerland et al. (2010)	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	N
Sauerland et al. (2011)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
Schwenk et al. (2005)	Y	Y	N	Y	Y	Y	Y	Y	Y	N	N
Tou et al. (2015)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N/A	N
van Dalen et al. (2015)	Y	Y	Y	Y	Y	N/A	N/A	N/A	N/A	N/A	Y

**Table 7** (continued)

	'A priori' design?	Duplicate study selection and data extraction?	Comprehensive literature search?	Publication (i.e., grey literature) used as an inclusion criterion?	Included and excluded studies provided?	Characteristics of included studies provided?	Quality of included studies assessed and documented?	Quality of included studies used appropriately in formulating conclusions?	Methods used to combine the findings of studies appropriate?	Likelihood of publication bias assessed?	Conflict of interest included?
Vennix et al. (2014)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
Wilson et al. (2011)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N/A	Y
Total	36	36	32	32	34	30	30	30	27	5	12
Percent*	100.0%	100.0%	88.9%	88.9%	94.4%	100.0%	100.0%	100.0%	100.0%	26.3%	33.3%

Y yes (item found in CSR), N no (item not found in CSR), N/A not applicable

\*Percentages are calculated as the total number of "Yes" results out of the total number of results for that question, excluding answers of "N/A"

form, respectively, yet none of the 25 CSRs assessed for compliance with the PRISMA statement presented a concise statement of objectives in the PICO(S) format [4, 11]. While this information could often be pieced together from elsewhere in CSR documentation, the succinct yet thorough PICO(S) statement, as required by these guidelines, was not uniformly or consistently identified. This is an active area for improvement, through the Cochrane Collaboration's Linked Data Project, which aims to annotate already-published CSRs with PICO elements in a more explicit manner [12].

To date, there have been very few external assessments performed examining the adherence of Cochrane publications with the PRISMA statement or even with the Cochrane Collaboration's own guidelines. One study did investigate the quality of CSRs published between 1993 and 1996 and found them to be of "low" quality. At that time, the use of the QUOROM statement was recommended as a tool that might help improve the quality of systematic reviews [13]. Based on the evidence presented herein, however, it appears that the Cochrane literature has begun to reflect this recommendation with an improvement in their CSR quality. Nonetheless, opportunities for improvement with PRISMA-based compliance persist.

AMSTAR is another widely-used instrument for assessing the methodological quality of systematic reviews [5, 6]. The CSRs included here met an average of 87.2% of AMSTAR required items (when questions "not applicable" to a given CSR were excluded from this calculation), and most deficiencies identified were related to reporting the COI's of included studies along with an assessment of publication bias. Additionally, there was notable variability among the reviews' reporting of search methodology including selection of databases and gray literature resources; location and precision of reporting search strategies; and use of journal hand-searching, reference list tracking, and author contacts. Based on the AMSTAR criteria, 4/36 (11.1%) reviews failed to include at least one complete search strategy and the same number failed to report any use of gray literature. Some working groups, such as the Incontinence Working Group, [14] keep comprehensive special registries based on internal Trial Search Coordinator-conducted searches, from which they provide all literature to review authors; while other working groups do not. One CSR (Bunyavejchevin and Phupong 2013) did not disclose any details of its search strategy. Though no studies were identified for inclusion in that CSR, the lack of a complete protocol precludes independent verification of the published results. Increased consistency in search methodology and reporting across the Cochrane Collaboration is strongly recommended.

In conclusion, future CSRs should be careful to include a clear statement of objectives, improve the consistency of reporting search methodology, and be entirely transparent in their disclosure of financial and non-financial COIs. A

more uniform or standardized approach to defining patient demographics, study design-related inclusion/exclusion criteria, search strategies, and outcome definitions would promote the internal consistency and validity of the CSR process. Though Cochrane's editorial guidelines appear to be thorough and aligned with external recommendation (e.g., PRISMA), editors and Cochrane working group staff must ensure these guidelines are fully implemented for every future CSR published, perhaps through an enhanced internal quality control mechanism.

## Limitations

This study was a systematic review of 36 Cochrane systematic reviews (CSRs) that covered several hundred studies representing dozens of different surgical procedures. Given the retrospective nature of this work and its reliance on secondary data, there was wide variability in study populations and endpoint definitions. Further, there may have been variability in the exact nature of the procedures or training of the surgeons considered within the CSRs included here, because all included CSRs reported a procedure inclusion criterion that was limited to the name or a brief description of the procedure under consideration.

Heterogeneity also existed within the outcome categories (e.g., short-term and long-term mortality were grouped together under mortality endpoints). Variation in the statistical analyses used in the included CSRs meant that only 59% of the available meta-analyses could be included in the current study's weighted analyses presented.

While no conclusion can be made about specific procedures or individual patients, the evidence in aggregate suggests that the adoption of operative laparoscopy has had an overall positive effect on patient outcomes, although CSR authors appear hesitant to fully endorse LSP. While surgical patient management may not be altered immediately, these findings should reinforce laparoscopic surgery's role in the surgical management of disease and spur further research and guide improvements in the quality and consistency of future Cochrane and non-Cochrane systematic reviews.

## Compliance with ethical standards

**Disclosures** Since March 2013, Ms. Jennifer Lyon has volunteered for the Cochrane Collaboration as an Assistant Information Specialist for

the Cochrane Urology Group (formerly the Cochrane Prostatic Diseases and Urological Cancers Group). Moreover, she was not involved in any of the Cochrane Library's CSRs included. Dr. Mark Talamini is a surgeon with expertise in laparoscopic surgery. He has published numerous articles on the subject and is the current editor-in-chief of the journal *Surgical Endoscopy*. He did not participate in the screening or selection of Cochrane Library CSR systematic reviews for this study. Moreover, he was not involved in any of the included Cochrane CSR publications. Dr. Brendan Carr, Dr. Laurie Shroyer, and Ms. Jamie Romeiser reported no conflicts of interest or financial ties to disclose.

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