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REVIEW

Ambulatory versus conventional laparoscopic appendectomy: a systematic review and meta-analysis

Mario Trejo-Avila[1] · Eduardo Cárdenas-Lailson[1] · Carlos Valenzuela-Salazar[1] · Jose Herrera-Esquivel[1] · Mucio Moreno-Portillo[1]

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Abstract

Purpose Ambulatory laparoscopic appendectomy has gained popularity due to the improved understanding of patient selection criteria, the application of enhanced recovery pathways, and the potential for improving healthcare resource utilization. The aim of the review was to compare the morbidity and readmission rates between ambulatory and conventional laparoscopic appendectomy (LA).

Methods A systematic search was undertaken using PubMed, Embase, Cochrane, and Web of Science. Studies from 2014 to 2018, on adult patients undergoing ambulatory LA, were considered. Meta-analyses were conducted to pool the total number of complications and readmission events in the ambulatory and conventional groups.

Results A total of 5 studies met our inclusion criteria accounting for 7079 total of patients with acute appendicitis treated by ambulatory LA and 6370 patients treated by conventional LA. We included four observational studies (two prospective and two retrospective) and one randomized controlled trial. Length of stay was significantly lower in the ambulatory group (mean difference = − 15.63 h, 95% CI = − 21.78 to − 9.49, $P = < 0.00001$). The relative risk (RR) of reoperation was 0.49 (95% CI = 0.12–1.95, $P = 0.31$). The results demonstrated a pooled RR of overall morbidity of 0.79 (95% CI = 0.65–0.97, $P = 0.02$) and a pooled RR of readmission of 0.72 (95% CI = 0.59–0.88, $P = 0.002$), both results favoring the ambulatory LA group.

Conclusion There is a lack of high-quality comparative studies making conclusive recommendations not possible at this time. Based on current data, ambulatory LA may be safe and feasible as compared with conventional LA.

Keywords Acute appendicitis · Ambulatory appendectomy · Laparoscopic appendectomy · Outpatient · ERAS

Introduction

Ambulatory surgery is defined as an outpatient treatment model in which the length of hospital stay (LOS) is shorter than 12 h without an overnight hospitalization [1–4]. In some countries, ambulatory surgery has become the standard of care for elective gastrointestinal procedures such as inguinal hernia repair, cholecystectomy, fundoplication, laparoscopic gastric banding, and proctologic procedures [5, 6]. In the USA, more than two-thirds of elective surgeries are done on an ambulatory basis [5]. Due to the fact that laparoscopic appendectomy is an emergency surgery and cannot be planned, implementation of "short-stay" protocols (ambulatory appendectomy) requires definition of selection criteria for candidate patients, as well as a perioperative care pathway.

Hospital discharge on the same day of appendectomy for acute appendicitis was described since 1994 [7–9]. Although there was initial concern about increasing complications and hospital readmissions with the practice of ambulatory surgery, recent evidence has supported discharging patients on the same day of surgery [2, 10]. This evidence is true for patients with acute uncomplicated appendicitis (non-perforated) [10, 11]. Only one systematic review has been published about this topic despite the high prevalence of the disease [2]. That systematic review, published in 2014, reviewed studies between 1993 and 2012 and concluded that the few data reported in 13 studies (mainly retrospective) suggest that day-case appendectomy may be feasible. Observational studies have shown that

✉ Mario Trejo-Avila
mario.trejo.avila@gmail.com

[1] Department of General and Endoscopic Surgery, Hospital General Dr. Manuel Gea González, 4800 Calzada de Tlalpan, 14080 Mexico, Mexico

discharging patients on the same day of surgery or treating them with an outpatient/ambulatory procedure is not related with increased readmission, unplanned consultations, overall morbidities, or reoperation [2].

In the cost-effective healthcare environment, ambulatory laparoscopic appendectomy has gained popularity owing to the improved understanding of patient selection criteria, the application of enhanced recovery pathways, and the potential for improving healthcare resource utilization. However, application of these criteria is not easy in the acute care environment. Up to date, no meta-analysis regarding ambulatory treatment of acute appendicitis is available in the surgical literature.

This systematic review and meta-analysis aimed to evaluate the safety and feasibility of ambulatory laparoscopic appendectomy (LA) protocols in comparison to conventional LA for the treatment of adult patients with acute appendicitis. The primary aim of the study was to compare the overall morbidity rates and readmission rates between ambulatory LA (outpatient) and conventional LA (inpatient).

Materials and methods

This systematic review and meta-analysis was conducted and reported according to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines [12]. No previous review protocol was published.

Definitions

The international definition of ambulatory surgery includes surgical procedures with a hospital stay of less than 12 h [1, 2, 6]. Studies reporting day-case, outpatient, or same-day discharge with a stay of less than 12 h were included. Studies of laparoscopic appendectomies with fast-track or Enhanced Recovery After Surgery protocols were included if their LOS was less than 12 h.

Conventional or "traditional" care was defined as the type of care in which the patients usually were admitted to the hospital after the surgical procedure. The length of stay in this group was more than 12 h postoperatively. This systematic review considered studies of laparoscopic appendectomy performed within these definitions.

Search strategy

The online literature was searched using the following combination of medical subject heading (MeSH) terms ["laparoscopic appendectomy" OR "minimally invasive appendectomy"] AND ["ambulatory appendectomy" OR "day-case appendectomy" OR "day stay" OR "same day appendectomy" OR "outpatient" OR "fast-track appendectomy" OR "enhanced recovery after surgery"] AND ["acute appendicitis" OR "uncomplicated appendicitis" OR "complicated appendicitis"]. A MEDLINE (using PubMed as the search engine), Embase database, Cochrane database, and Web of Science search was performed. Searches were limited to publications in English. All studies in the last 5 years (from 2014 to 2018) on adult patients (over 18 years old) undergoing ambulatory/outpatient laparoscopic appendectomy were considered. Titles and abstracts were screened for eligibility and full-text original articles were retrieved. Duplicates were deleted. The latest electronic search was performed on December 20, 2018.

Eligibility criteria

Original clinical studies evaluating ambulatory/outpatient laparoscopic appendectomy for adult patients with acute appendicitis were included. Inclusion criteria included any systematic review, meta-analysis, randomized controlled trial (RCT), prospective comparative study, and retrospective comparative study. Included studies should have compared outpatient/ambulatory laparoscopic appendectomy versus conventional care. We excluded review articles, editorials, case reports, case series, observational non-comparative studies, and studies with no results available. Manuscripts were excluded if an electronic version was unavailable.

Quality assessment

The quality of the articles was assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) guidelines [13]. Each article was rated on a 4-point scale from high to very low, based on the level of confidence in the effect estimate.

Data collection process and synthesis

Two independent authors extracted data from the included studies on a Microsoft Excel database. The following information was recorded: author names, year of publication, journal, type of study, country, number of patients, mean age (years), sex, complicated or uncomplicated appendicitis, total white blood cell count, C-reactive protein mean value, mean operative time, time to resume diet, postoperative pain according to Visual Analogue Scale (VAS), length of stay, overall morbidity rate, failed discharge rate, readmission rate, and reoperation rate. Data was presented using descriptive methods.

Results of the systematic review are divided in patient selection criteria for ambulatory surgery in the included studies, preoperative management employed in the ambulatory group, intraoperative management, postoperative management and discharge criteria, and failure of the ambulatory protocol

expressed as conversion from ambulatory laparoscopic appendectomy (AmbLA) to "conventional" laparoscopic appendectomy (ConvLA).

The primary aim of the study was to compare the overall morbidity rates and readmission rates between ambulatory LA and conventional LA.

Statistical analysis

Statistical analysis was performed with Review Manager version 5.3.5 (RevMan, Cochrane Collaboration, Oxford, UK). Meta-analyses were conducted to pool the total number of complications (overall morbidity) in the AmbLA and ConvLA groups of each study and also the total number of readmission events in the AmbLA and ConvLA groups of each study. The results of the meta-analysis were expressed as the relative risk (RR) for dichotomous data and as mean difference (MD) for continuous data, with 95% confidence intervals (95% CI). Mantel-Haenszel method was used for dichotomous variables. All meta-analyses were completed using random-effects model, which assumes both within-study and between-study variability for a more conservative estimate as compared to a fixed-effects model. The I^2 test statistic was used to quantify heterogeneity. $P < 0.05$ was considered statistically significant. Funnel plots were constructed to assess the risk of publication bias across studies for all outcome measures (morbidity and readmission).

Results

Description of included studies

After the review of abstracts, full original articles, and hand searching references, five articles were identified as eligible for analysis. A flowchart overview of the search is depicted in Fig. 1. A total of five studies met our inclusion criteria accounting for 7079 total of patients with acute appendicitis treated by AmbLA between 2014 and 2018 [11, 14–17]. A total of 6370 patients with acute appendicitis were included in the ConvLA group (control group) [11, 14–17]. The majority of the studies were conducted in the USA and France [14–17], and one study was conducted in Mexico [11] (see Table 1). The primary study designs were observational comparative studies (two prospective and two retrospective) [14–17]. Only one article used a randomized controlled trial to evaluate enhanced recovery protocol as a mean to reduce postoperative length to stay after LA [11]. The aims of these studies were to evaluate ambulatory/outpatient laparoscopic appendectomy versus conventional care in terms of length of stay, morbidity,

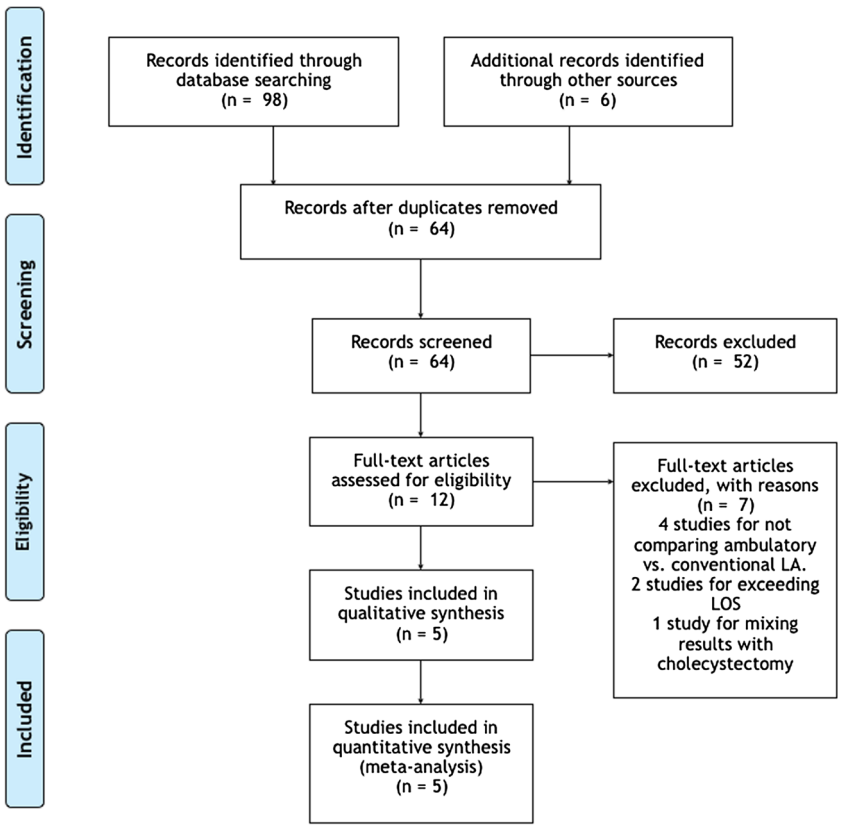

Fig. 1 PRISMA 2009 flow diagram of inclusion and exclusion of studies

and readmissions. No systematic reviews or meta-analyses were found in database searches.

Excluded studies

We excluded four studies reporting "outpatient" or "ambulatory" laparoscopic appendectomy, mainly because they analyzed a cohort of patients without comparing their intervention with a control group (in this case, "conventional or traditional" care): Aubry et al. [3], Frazee et al. [18, 19], and Grelpois et al. [20]. Finally, the study of Trevino et al. [21] was excluded because they included mixed data from ambulatory appendectomies and cholecystectomies.

Patient selection criteria for ambulatory surgery in the included studies

The characteristics of patients included in the meta-analysis are shown in Table 2**.** The mean total white blood cell count [11, 15, 17] as well as the mean C-reactive protein level [11, 15, 17] reported in the studies are presented in Table 2.

Lefrancois et al. [15] developed a predictive score ranging from 0 to 5 (the so-called Saint Antoine score) for discharged patients within the first 24 h from laparoscopic appendectomy. They assigned one point for each of the following factors: body mass index less than 28 kg/m^2, white cell count less than 15,000/mL, C-reactive protein less than 30 mg/L, no radiological signs of perforation, and appendix diameter of 10 mm or smaller. Patients with a score of 4 or superior were considered for AmbLA. They reported a success rate of 97%.

In the only RCT, the inclusion criteria were patients of both sexes, aged between 18 and 70 years, and with an American Society of Anesthesiologist (ASA) grade of I or II [11]. Rosen et al. [14] and Scott et al. [16] included patients older than 18 years who underwent laparoscopic appendectomy for acute uncomplicated appendicitis. Gignoux et al. [17] offered AmbLA to all patients with uncomplicated and complicated appendicitis, excluding patients with the following items: cases that could not be operated before 5 pm and could not be postponed to the next day, home-hospital journey over 1 h, patient living alone, and severe comorbidities which required monitoring. They reported 10.1% of the patients in the AmbLA group having complicated appendicitis and 25% of patients in the ConvLA group.

Patients excluded from AmbLA had the following characteristics in the studies: pregnant women [11, 14, 15], patients taking oral anticoagulants [11], severe comorbidities [11, 15], intraoperative confirmation of gangrene or perforation [11, 14, 16], presence of generalized peritonitis [17], severe sepsis [15], incidental appendectomy [11, 16], appendectomy performed concomitant with another procedure [11, 16], insufficient understanding from the patient [15], home located over 1-h transport [15], and patients who required longer than 48 h of hospital admission [16].

Preoperative management in AmbLA

Trejo-Avila et al. [11] and Gignoux et al. [17] adapted some of the items included in the ERAS guidelines to patients with acute appendicitis. Some of these items were information to patients and caregivers, preoperative treatment with calculated crystalloid isotonic solution, use of antibiotics, standard gastric prophylaxis, opioid-sparing analgesia, preoperative complete evaluation by anesthesiologists, and avoidance of bladder catheter.

Table 1 Summary of original papers used in this review

Author	Year	Study type	Country	Patients, *n* AA versus CA	Quality of the evidence (GRADE)
Trejo-Avila et al. [11]	2018	Randomized controlled trial	Mexico	AA = 50 CA = 58	Moderate ⊕⊕⊕⊖
Rosen et al. [14]	2017	Prospective comparative	USA	OA = 173 CA = 178	Low ⊕⊕⊖⊖
Lefrancois et al. [15]	2015	Prospective comparative	France	AA = 37 CA = 65	Low ⊕⊕⊖⊖
Scott et al. [16]	2017	Retrospective comparative	USA	AA = 6710 CA = 5993	Low ⊕⊕⊖⊖
Gignoux et al. [17]	2018	Retrospective comparative	France	AA = 109 CA = 76	Very low ⊕⊖⊖⊖

GRADE Grading of Recommendations Assessment, Development and Evaluation, *AA* ambulatory appendectomy (AmbLA group), *CA* conventional appendectomy (ConvLA group)

Table 2 Study characteristics

Study	Mean age (years)	Sex (female/male) %	Uncomplicated/ complicated appendicitis	Total WBC, mean (SD)	CRP level, mean (SD)
Trejo-Avila et al. [11]	AA = 32.6 CA = 33.6	AA: F = 41/M = 58 CA: F = 44.8/M = 55.2	Uncomplicated appendicitis	AA = 15.06 CA = 15.3	AA = 3.17 (md/dL) CA = 3.21
Rosen et al. [14]	AA = 36.6[a] CA = 32.4	AA: F = 40.5/M = 59.5 CA: F = 36/M = 64	Uncomplicated appendicitis	AA = NR CA = NR	AA = NR CA = NR
Lefrancois et al. [15]	AA = 32 CA = 35	AA: F = 47/M = 53 CA: F = 40/M = 60	Complicated appendicitis AA = 0 CA = 9%	AA = < 15.0 CA = < 15.0	AA = < 30 (mg/L) CA = < 30
Scott et al. [16]	AA = <50 years = 80% CA = < 50 years = 75%	AA: F = 49/M = 51 CA: F = 49/M = 51	Uncomplicated Appendicitis	AA = NR CA = NR	AA = NR CA = NR
Gignoux et al. [17]	AA = 27.8[a] CA = 43.2	AA: F = 42.2/M = 57.8 CA: F = 46.1/M = 53.9	Complicated AA = 10.1%[a] CA = 25%	AA = 12.8 CA = 14.1	AA = 27.8[a] (mg/L) CA = 63.7

M male, *F* female, *NR* not reported in the study, *AA* ambulatory appendectomy (AmbLA group), *CA* conventional appendectomy (ConvLA group)
[a] Statistically significant ($P < 0.05$)

Rosen et al. [14] mentioned that they informed patients about laparoscopic appendectomy and counseled patients that they would be going home from the post-anesthesia care unit.

Lefrancois et al. [15], after classifying their patients according to their scale (score of 4 or superior), admitted patients to surgery if between 7:00 and 13:00, and after 13:00, the operation was delayed until the next morning. If the surgery was postponed, they sent patients home with oral antibiotics. Gignoux et al. [17] also postponed the surgery to the next day.

There was not a specific preoperative management in patients selected for AmbLA in the majority of the studies [14–16].

Intraoperative management

All patients in the included studies underwent laparoscopic appendectomy [11, 14–17]. General anesthesia was performed according to recommendations of ERAS guidelines [11, 17]. Antibiotic prophylaxis was mentioned in the majority of the studies [11, 15, 17]. Surgical incisions were infiltrated with local anesthetics [11, 15, 17]. No drainage was routinely placed in some studies [11, 15]. Trejo-Avila et al. [11] mentioned that patients in the AmbLA group received strict control of fluid therapy. They also prevented hypothermia and avoided the placement of nasogastric tubes. Lefrancois et al. [15] employed low-pressure pneumoperitoneum (9 mmHg).

There was not a specific protocol reported for patients in the AmbLA group in two studies [14, 16].

Postoperative management

Patients were discharged from the recovery room [11, 15, 16], ambulatory recovery unit [17], or post-anesthesia care unit [14].

Some of the discharge criteria employed for AmbLA were the presence of normal vital signs [11, 14–17], adequate activity and mental status [11, 16, 17], adequate pain control [11, 14, 16, 17], ability to urinate [11, 14], ability to ambulate [11, 14], adequate tolerance of oral intake [11, 14], absence of nausea or vomiting [11, 14, 17], dressings dry without evidence of bleeding [14, 17], and physician approval [11, 14, 16]. Gignoux et al. [17] employed a post-anesthetic discharge scoring system for home readiness after ambulatory surgery. Scott et al. [16] employed a scoring system (Procedural and Anesthesia Scoring System) in order to decide if the patient is safe to go home. Patients with a score of more than 12 were considered safe for discharge. This score evaluates consciousness, activity, circulation, respiration, O_2 saturation, pain, and emesis.

Conversion from AmbLA to ConvLA and readmission rates

The mean failed discharge rate was 13.6% (range 2.6% to 35%) in patients intended to receive ambulatory management [11, 14, 15, 17]. One study reverted from AmbLA to conventional appendectomy in the case of generalized peritonitis or abscess requiring administration of intravenous antibiotics, anaphylaxis, persisting pain that could not be treated by oral analgesic, fever, or vomiting [17]. They reported a failed discharge rate of 6.8% in the AmbLA group (see Table 3) [17].

Trejo-Avila et al. [11] reported a failed discharge rate of 10% from the recovery room in patients randomized to AmbLA, and these patients required admission to the hospital.

The highest rate of conversion from AmbLA to ConvLA was 35% in one study [14]. The reported reasons were no transportation, not passing the discharge criteria,

Table 3 Summary of outcomes

Study	Mean operative time (min)	Mean LOS (h, days)	Failed discharge rate (%)	Overall Morbidity (%)	Readmission (%)
Trejo-Avila et al. [11]	AA = 54.8 CA = 60.4	AA = 9.7 h[a] CA = 23.2 h	AA = 10% CA: −	AA = 4% CA = 5.2%	AA = 4% CA = 5.2%
Rosen et al. [14]	AA = 1.2 (h) CA = 1.4 (h)	AA = 9.3 h[a] CA = 19.3 h	AA = 35% CA: −	AA = 3.4% CA = 2.2%	AA = 1.7% CA = 1.7%
Lefrancois et al. [15]	AA = 41[a] CA = 49	AA = 8.5 h[a] CA = 33.2 h	AA = 2.6% CA: −	AA = 8% CA = 9%	AA = 3% CA = 6%
Scott et al. [16]	AA = NR CA = NR	AA = same-day CA = 1 night	AA = NR CA = NR	AA = 2.2% CA = 2.7%	AA = 2.2%[a] CA = 3.1%
Gignoux et al. [17]	AA = 30.8[a] CA = 37.7	AA = 8.5 h CA = NR	AA = 6.8% CA: −	AA = 11.9%[a] CA = 25%	AA = 4.6% CA = 9.2%

AA ambulatory appendectomy (AmbLA group), *CA* conventional appendectomy (ConvLA group)

[a] Statistically significant ($P < 0.05$)

intraoperative findings, age, medical comorbidity, and homelessness.

Meta-analysis of the outcomes

Three studies were included in the meta-analysis of postoperative length of stay [11, 14, 15]. The length of stay was significantly lower in the ambulatory group (MD = − 15.63 h, 95% CI = − 21.78 to − 9.49, P = <0.00001) (see Fig. 2). The pooled summary was associated with high heterogeneity as indicated by the I^2 value of 92% ($P < 0.0001$).

The five studies were included in the meta-analysis of overall morbidity rates [11, 14–17]. The results demonstrated a pooled RR of overall morbidity of 0.79 (95% CI 0.65–0.97, $P = 0.02$), favoring the ambulatory group. This pooled summary was associated with low heterogeneity as indicated by the I^2 value of 0% ($P = 0.46$) (see Fig. 3a).

Three studies were included in the meta-analysis of reoperation rates [11, 15, 17]. The RR of reoperation was 0.49 (95% CI = 0.12–1.95, $P = 0.31$). This pooled summary was associated with low heterogeneity as indicated by the I^2 value of 0% ($P = 0.69$) (see Fig. 3b).

The five studies were included in the meta-analysis of readmission rates [11, 14–17]. The results demonstrated a pooled RR of readmission of 0.72 (95% CI 0.59–0.88, P = 0.002), favoring the ambulatory group (see Fig. 3c). This pooled summary was associated with low heterogeneity as indicated by the I^2 value of 0% ($P = 0.93$).

Risk of publication bias

Potential publication bias was assessed by visual inspection of the funnel plots (Fig. 4), which suggested no obvious evidence of publication bias. The results need to be interpreted with caution as there are a limited number of studies included in the analysis.

Discussion

This is the first meta-analysis that provides evidence that in selected patients with acute uncomplicated appendicitis, ambulatory laparoscopic appendectomy pathways may be safe and feasible as compared with conventional laparoscopic appendectomy protocols. Although the current available data suggests that AmbLA pathways may be associated with lower rates of postoperative morbidity and readmissions in comparison with ConvLA protocols, further high-quality research is needed. Importantly, we identified some elements that allow patients to recover optimally from laparoscopic appendectomy. These elements are part of the following components: patient eligibility criteria; preoperative, intraoperative, and postoperative care; and hospital discharge criteria. These elements, which combine interventions of the enhanced recovery after surgery protocol, should be delivered for optimal management of the patient undergoing

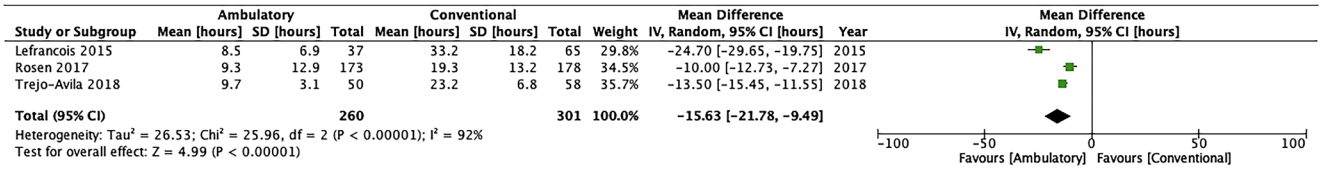

Fig. 2 Meta-analysis forest plot concerning length of stayd>

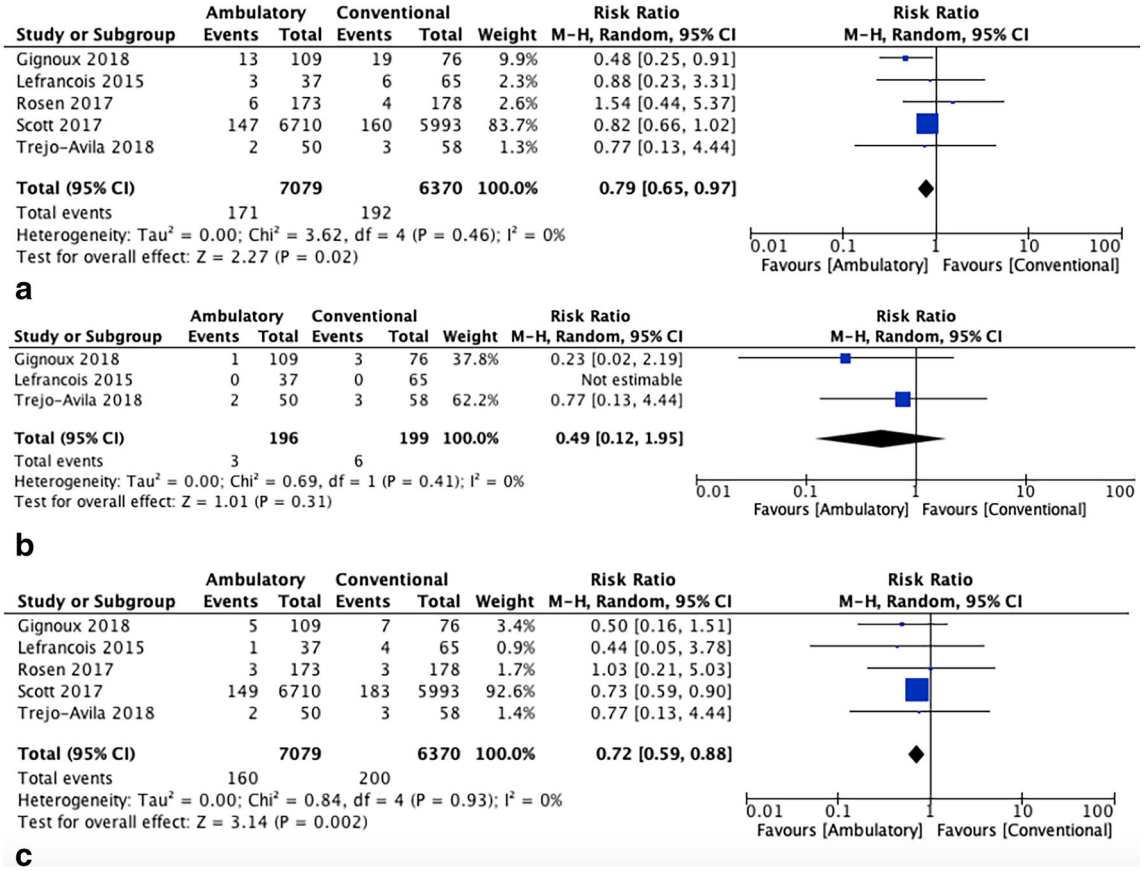

Fig. 3 Meta-analysis forest plots concerning: overall morbidity (**a**), reoperation (**b**), and readmission (**c**)

laparoscopic appendectomy with ambulatory care. All these elements are described in the "Results" section.

Several observational studies, either prospective or retrospective, had debated the safety and feasibility of ambulatory, outpatient, same-day discharge management of acute appendicitis [22, 23, 24, 25, 26, 27].

In the only systematic review available on this topic, the authors examined outcomes after same-day discharge. They found that the mean hospital readmission rate was 2.01% (range 0% to 5.1%) and the mean morbidity rate was 4.2% (range 0% to 13%) [2]. They concluded that readmission and morbidity were low after same-day appendectomy. Nevertheless, they found a low level of evidence and the review included only 77% of patients with laparoscopic appendectomy. They added to their discussion that even if the day-case appendectomy seemed feasible and safe, the results should be considered with some caution, mainly because of the low evidence levels of the retrospective studies included [2]. Although we did not find high-quality studies in recent literature, in the last 5 years, more prospective studies had been published. Unfortunately, we still lack data from high-quality studies in order to recommend ambulatory appendectomy as the treatment of choice in acute uncomplicated appendicitis.

As suggested by Rosen et al. [14], the success of an outpatient appendectomy approach rests on patient education, clear communication of expectations, and reliable follow-up. Patient selection is another major factor in running a successful ambulatory surgery unit with excellent patient outcomes [5]. As a part of this review, we found that some protocols had strict patient selection criteria before enrollment in ambulatory surgery and some other protocols better defined the exclusion criteria. Based on the results of this review, we believe that AmbLA could be offered to low-risk patients (ASA I–II), with uncomplicated acute appendicitis, and those who have Saint Antoine score ≥ 4.

As mentioned in the "Results" section, some studies did not show any special protocol for the management of patients in the ambulatory group. In the majority of the studies, the ambulatory protocol was focused in the postoperative management of the patients. A recent review aimed to assimilate appropriate evidence to support pathway development for the surgical process of acute appendectomy [10]. They divided their analysis in preoperative, intraoperative, and postoperative management. The preoperative protocol components were education and counseling, the use of preoperative antibiotics, initial non-surgical management, venous thromboembolism prophylaxis, and delay of operation 12 to 24 h for uncomplicated appendicitis. The intraoperative components were laparoscopic surgical technique, use of peritoneal drain, urinary catheter, and nasogastric tube. Lastly, the

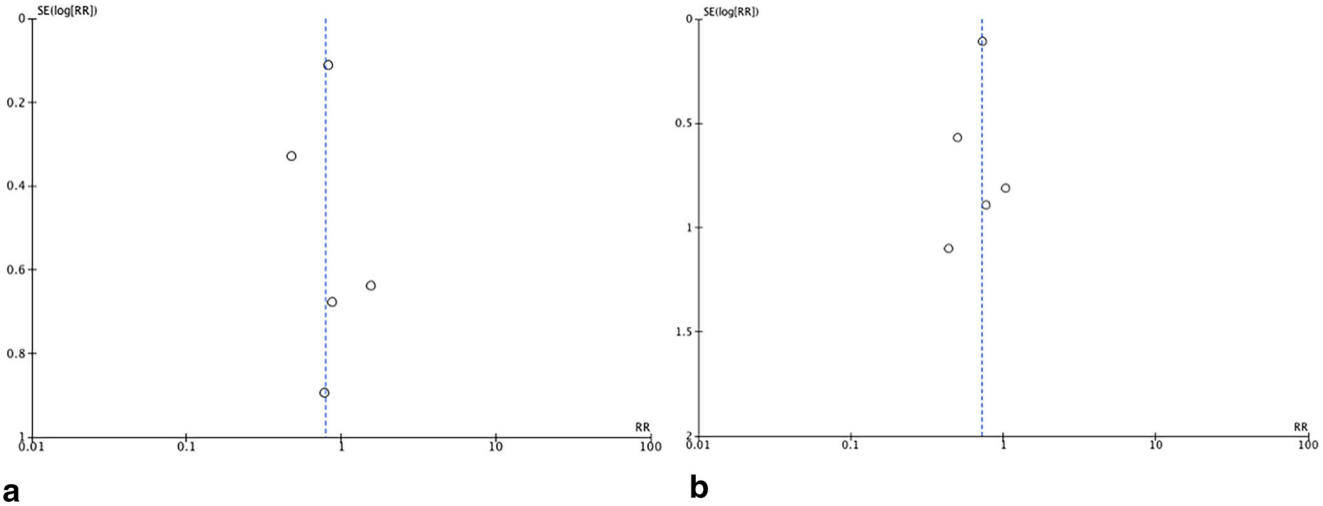

Fig. 4 The funnel plot of overall morbidity rates (**a**) and readmission rates (**b**) between ambulatory LA and conventional LA

postoperative management included use of same-day or fast-track protocols, postoperative antibiotics, early oral alimentation, and early mobilization [10]. As acute appendicitis is a common disease, it seems necessary to develop a standardized protocol that includes all of the above elements and to define common criteria for inclusion, exclusion, perioperative care, discharge, and follow-up to better select patients who may benefit from outpatient/ambulatory laparoscopic appendectomy.

Current trends in surgery suggest that adopting enhanced recovery pathways has reduced surgical and healthcare-acquired infections, decreased length of stay, and reduced postoperative costs [10, 28]. Enhanced recovery pathways are multidisciplinary protocols comprising patient engagement, optimal nutrition, multimodal analgesia, early mobility, and evidence-based practices to avoid preventable harms [10]. ERAS pathways are mostly used in elective surgeries, with a minimal number of publications adapting ERAS programs to emergency surgery [25]. The application of ambulatory and ERAS pathways to acute appendicitis is limited by the acuteness and unplanned nature of the disease.

Although the postoperative care with a recovery room discharge criteria is probably the cornerstone of the management of patients in the setting of ambulatory surgery, we believe that either a preoperative or an intraoperative optimization of patients should also be integrated in the pathway of patients treated by ambulatory laparoscopic appendectomy. As integrated by two of the included studies in this review [11, 17], some recommendations of the Enhanced Recovery After Surgery Society [29] could be adapted to the treatment of patients with acute appendicitis. As previously reported by Hamill et al. [30], employing an optimized recovery pathway, that is to say an Enhanced Recovery After Surgery protocol, could facilitate same-day discharge and help reduce inconvenience, cost, and pressure on hospital beds. They mentioned in their review that no ERAS protocol was published for acute appendicitis at that time. We found two studies that employed an ERAS protocol for laparoscopic appendectomy in our review. In both studies, the length of hospital stay was less than 12 h allowing the management of patients as ambulatory.

Our study has a number of limitations that should be addressed. All included studies in this meta-analysis demonstrated high risk of bias. Only one RCT was found but was graded as moderate evidence. There were no high-quality randomized controlled trials, and the observational studies were not matched cohorts. Due to the nature of observational studies, this review is prone to information bias, and selection bias, among others. Selection bias seems to be an important concern, especially in large retrospective studies [16], since included patients in the ambulatory surgery group might have better condition or less morbidities than those included in the conventional protocol. Also, the rates of readmission could be inaccurate due to the retrospective design of the studies. Also, the inclusion criteria, exclusion criteria, and preoperative and intraoperative management for ambulatory surgery were not fully uniform among the included studies. Another important limitation is the lack of uniformity on the definition of ambulatory surgery. Nevertheless, all of the included studies had less than 12 h of length of stay. It should be important to standardize the current definition for ambulatory, outpatient, or same-day appendectomy [31]. The best available data suggests that ambulatory LA is associated with lower rates of morbidity and readmission as compared with conventional LA. However, this data should be further evaluated in better designed and powered studies. Definitive conclusions and recommendations regarding the real benefits of ambulatory

laparoscopic appendectomy may need to wait until more high-quality studies on the topic are published.

Conclusions

In conclusion, there is a lack of well-designed, high-quality comparative studies making conclusive recommendations not possible at this time. However, the current best available data suggests that in selected patients with acute uncomplicated appendicitis, ambulatory laparoscopic appendectomy pathways may be safe and feasible as compared with conventional laparoscopic appendectomy protocols.

Authors' Contributions Mario Trejo-Avila designed this study, collected and interpreted the data, performed statistical analyses, and drafted the manuscript. Eduardo Cárdenas-Lailson, Carlos Valenzuela-Salazar, Jose Herrera-Esquivel, and Mucio Moreno-Portillo reviewed data, critically revised the manuscript, and performed overall supervision. All authors contributed to the final approval of the manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval As this was a systematic review and meta-analysis of published available studies, ethical approval was not required.

Informed consent For this type of review article, formal informed consent is not required.

References

1. Wodey E, de la Briere F (2013) Ambulatory surgery in France: practical and medicolegal considerations. Ann Fr Anesth Reanim 32:243–246
2. Cosse C, Sabbagh C, Grelpois G, Brehant O, Regimbeau JM (2014) Day case appendectomy in adults: a review. Int J Surg 12: 640–644
3. Aubry A, Saget A, Manceau G, Faron M, Wagner M, Tresallet C, Riou B, Lucidarme O, le Saché F, Karoui M (2017) Outpatient appendectomy in an emergency outpatient surgery unit 24 h a day: an intention-to-treat analysis of 194 patients. World J Surg 41:2471–2479
4. Sabbagh C, Brehant O, Dupont H, Browet F, Pequignot A, Regimbeau JM (2012) The feasibility of short-stay laparoscopic appendectomy for acute appendicitis: a prospective cohort study. Surg Endosc 26:2630–2638
5. Richman DC (2010) Ambulatory surgery: how much testing do we need? Anesthesiol Clin 28:185–197
6. Kraft K, Mariette C, Sauvanet A, Balon JM, Douard R, Fabre A, Guidat A, Huten N, Johanet H, Laurent A, Muscari F, Pessaux P, Pierme JP, Piessen G, Raucoules-Aime M, Rault A, Vons C (2011) Indications for ambulatory gastrointestinal and endocrine surgery in adults. J Visc Surg 148:69–74
7. Jain A, Mercado PD, Grafton KP, Dorazio RA (1995) Outpatient laparoscopic appendectomy. Surg Endosc 9:424–425
8. Schreiber JH (1994) Results of outpatient laparoscopic appendectomy in women. Endoscopy 26:292–298
9. Salam IM, Fallouji MA, el Ashaal YI, Chandran VP, Asham NN, Galala KH, Sim AJ (1995) Early patient discharge following appendicectomy: safety and feasibility. J R Coll Surg Edinb 40:300–302
10. Hornor MA, Liu JY, Hu QL, Ko CY, Wick E, Maggard-Gibbons M (2018) Surgical technical evidence review for acute appendectomy conducted for the Agency for Healthcare Research and Quality safety program for improving surgical care and recovery. J Am Coll Surg 227:605–617
11. Trejo-Ávila ME, Romero-Loera S, Cárdenas-Lailson E, Blas-Franco M, Delano-Alonso R, Valenzuela-Salazar C, Moreno-Portillo M (2019) Enhanced recovery after surgery protocol allows ambulatory laparoscopic appendectomy in uncomplicated acute appendicitis: a prospective, randomized trial. Surg Endosc 33:429–436
12. Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009) Preferred Reporting items for Systematic Reviews and Meta-Analyses: the PRISMA statement. PLoS Med 6:e1000097
13. Balshem H, Helfand M, Schunemann HJ, Oxman AD, Kunz R, Brozek J, Vist GE, Falck-Ytter Y, Meerpohl J, Norris S, Guyatt GH (2011) GRADE guidelines: rating the quality of evidence. J Clin Epidemiol 64:401–406
14. Rosen DR, Inaba K, Oh PJ, Gutierrez AC, Strumwasser AM, Biswas S, Cala M, Ault GT (2017) Outpatient laparoscopic appendectomy: feasible in a public county hospital? J Am Coll Surg 224: 862–867
15. Lefrancois M, Lefevre JH, Chafai N, Pitel S, Kerger L, Agostini J, Canard G, Tiret E (2014) Management of acute appendicitis in ambulatory surgery. Is it possible? How to select patients? Ann Surg 261:1167–1172
16. Scott A, Shekherdimian S, Rouch JD, Sacks GD, Dawes AJ, Lui WY, Bridges L, Heisler T, Crain SR, Cheung MKW, Aboulian A (2017) Same-day discharge in laparoscopic acute non-perforated appendectomy. J Am Coll Surg 224:43–48
17. Gignoux B, Blanchet MC, Lanz T, Vulliez A, Saffarini M, Bothorel H, Robert M, Frering V (2018) Should ambulatory appendectomy become the standard treatment for acute appendicitis? World J Emerg Surg 13:28
18. Frazee RC, Abernathy SW, Isbell CL, Isbell T, Regner JL, Smith RD (2016) Outpatient laparoscopic appendectomy: is it time to end the discussion? J Am Coll Surg 222:473–477
19. Frazee R, Burlew CC, Regner J, McIntyre R, Peltz E, Cribari C, Dunn J, Butler L, Reckard P, Dissanaike S, Karimi K, Behnfield C, Melo N, Margulies D (2017) Outpatient laparoscopic appendectomy can be successfully performed for uncomplicated appendicitis: a Southwestern Surgical Congress Multicenter Trial. Am J Surg 214: 1007–1009
20. Grelpois G, Sabbagh C, Cosse C, Robert B, Chapuis-Roux E, Ntouba A, Lion T, Regimbeau JM (2016) Management of uncomplicated acute appendicitis as day case surgery: feasibility and a critical analysis of exclusion criteria and treatment failure. J Am Coll Surg 223:694–703
21. Trevino CM, Katchko KM, Verhaalen AL, Bruce ML, Webb TP (2015) Cost effectiveness of a fast-track protocol for urgent laparoscopic cholecystectomies and appendectomies. World J Surg 40: 856–862
22. Cash CL, Frazee RC, Smith RW, Davis ML, Hendricks JC, Childs EW, Abernathy SW (2012) Outpatient laparoscopic appendectomy for acute appendicitis. Am Surg 78:213–215
23. Dubois L, Vogt KN, Davies W, Schlachta CM (2010) Impact of an outpatient appendectomy protocol on clinical outcomes and cost: a case-control study. J Am Coll Surg 211:731–737

24. Cross W, Chandru Kowdley G (2013) Laparoscopic appendectomy for acute appendicitis: a safe same-day surgery procedure? Am Surg 79:802–805
25. Cash CL, Frazee RC, Abernathy SW, Childs EW, Davis ML, Hendricks JC, Smith RW (2012) A prospective treatment protocol for outpatient laparoscopic appendectomy for acute appendicitis. J Am Coll Surg 215:101–105
26. Frazee RC, Abernathy SW, Davis M, Hendricks JC, Isbell TV, Regner JL, Smith RW (2014) Outpatient laparoscopic appendectomy should be the standard of care for uncomplicated appendicitis. J Trauma Acute Care Surg 76:79–82
27. Gilliam AD, Anand R, Horgan LF, Attwood SE (2008) Day case emergency laparoscopic appendectomy. Surg Endosc 22:483–486
28. Ljungqvist O, Scott M, Fearon KC (2017) Enhanced recovery after surgery: a review. JAMA Surg 152:292–298
29. Gustafsson UO, Scott MJ, Hubner M, Nygren J, Demartines N, Francis N, Rockall TA, Young-Fadok TM, Hill AG, Soop M, de Boer HD, Urman RD, Chang GJ, Fichera A, Kessler H, Grass F, Whang EE, Fawcett WJ, Carli F, Lobo DN, Rollins KE, Balfour A, Baldini G, Riedel B, Ljungqvist O (2019) Guidelines for perioperative care in elective colorectal surgery: Enhanced Recovery After Surgery (ERAS®) Society Recommendations: 2018. World J Surg 43:659–695
30. Hamill JK, Rahiri JL, Gunaratna G, Hill AG (2016) Interventions to optimize recovery after laparoscopic appendectomy: a scoping review. Surg Endosc 31:2357–2365
31. Trejo-Avila M (2019) Expedited discharge, outpatient, same-day, fast-track, or ambulatory appendectomy in uncomplicated acute appendicitis: are they all the same? Am J Surg. https://doi.org/10.1016/j.amjsurg.2019.05.009