



Transanal ileal pouch anal anastomosis for ulcerative colitis in children and adults: a systematic review and meta-analysis

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Abstract

Purpose The incidence of pediatric onset ulcerative colitis (UC) is increasing, with increasing rate of children eventually requiring surgical treatment. Total proctocolectomy with ileal pouch-anal anastomosis (IPAA) is the preferred surgical treatment. Although transanal IPAA (ta-IPAA) is becoming widely accepted for adult UC patients, data regarding this procedure in children are scarce. Nevertheless, some adult publications also include patients under 18 years old. This systematic review and meta-analysis aimed to summarize surgical and functional outcomes following ta-IPAA, and extract conclusion regarding pediatric UC patients.

Methods PubMed, Cochrane Library databases, Embase, Web of science and Google Scholar databases were searched, using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses [PRISMA] guidelines. The final search was updated in April 2022. Four comparative cohorts ($n = 868$) and 11 non-comparative case series ($n = 241$) were included. Six reports included children. Anastomotic leak, complications, operative time, conversion rate, length of stay and functional outcomes were examined.

Results A total of 1103 patients, ranging 9–79 years were included in this review. We found no difference in risk for anastomotic leak (OR 1.36, 95% CI 0.46–4.06), minor and major complications (OR 0.92, 95% CI 0.48–1.76 and OR 0.78 95% CI 0.36–1.69, respectively) comparing ta-IPAA to transabdominal IPAA. Short- and long-term follow-up showed satisfying functional outcomes and quality of life.

Conclusions Our review suggests that ta-IPAA is not inferior to transabdominal IPAA. Implementation of this method in children is technically feasible due to familiarity with the dissection plane. Long-term functional outcomes and quality of life are paramount in the pediatric population and should be particularly investigated. Multicenter prospective studies are required to investigate pediatric UC patients undergoing ta-IPAA.

Keywords Ulcerative colitis (UC) · Transanal · Ileal pouch anal anastomosis (ta-IPAA) · Laparoscopy · Transanal minimally invasive surgery (TAMIS) · Children

Introduction

Inflammatory bowel diseases (IBDs), including ulcerative colitis (UC) and Crohn's disease (CD), usually begin during adolescence and young adulthood, with almost a quarter of the patients presenting before 20 years old. It is estimated that 15–20% of all UC patients are children, with rising incidence of pediatric-onset UC recently reported as 1–4 per 100,000 children a year. Total procto-colectomy (TPC) with ileal pouch anal anastomosis (IPAA) as a single or multiple staged procedure, is considered the gold standard operation for UC, and is an important therapeutic option for medically refractory disease. Since the majority of pediatric UC patients show severe and extensive disease,

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prevalence of TPC and IPAA is estimated higher in children (30–40%) compared to adults (10–15%) suffering from UC [1–3]. Recently, various minimally invasive IPAA approaches have been developed and are most commonly performed through a hybrid approach with laparoscopic colectomy followed by open proctectomy. The laparoscopic abdominal approach has shown favorable short- and long-term outcomes and improved safety profile compared to open procedures [4, 5].

During the last decade, transanal rectal surgeries such as total mesorectal excision (TME) and natural orifice specimen extraction (NOSE) have been widely accepted in adults for oncological indications [6, 7]. The original objective of these approaches was to overcome difficult anatomic conditions such as narrow pelvis and obesity and to improve dissection planes [8]. The use of transanal approaches in children with a given limited working space, is remarkably advantageous and is also widely accepted for other congenital pediatric etiologies such as in Hirschsprung's disease and anorectal malformations [9, 10]. Endoscopic transanal IPAA (ta-IPAA) for adults with UC has been first described by Liyanage et al. in 2013, and since then has been reported as feasible, safe, and comparable to laparoscopic transabdominal approaches [6, 11]. However, data regarding endoscopic ta-IPAA in children is limited [10]. In our institution, we recently started to use this technique in children with UC. Although UC results in severe inflammation of the rectal mucosa, we did not experience any technical problems during transanal phase in these patients.

The original purpose of this study was to systematically review all published literature on pediatric ta-IPAA for UC patients. However, due to the extremely restricted data published for this group of patients, a systematic review and meta-analysis were conducted with inclusion of all UC patients and compared operative and post-operative course, complications and functional performance following ta-IPAA. Although several non-systematic reviews have been published in this domain, this is the first systematic review and a meta-analysis conducted to date.

Materials and methods

Analysis of the literature and writing of the manuscript were performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [12].

Eligibility criteria

All publications in which surgical outcomes of ta-IPAA performed for the treatment of UC were considered for inclusion in this review. Studies which included patients with IBD

unclassified (IBDu) as part of the cohort were considered for inclusion if the IBDu group constituted less than 10% of the cohort. Exclusions criteria were studies reporting outcomes of patients undergoing ta-IPAA for indications other than UC or IBDu, studies reporting outcomes of ta-IPAA as a redo procedure following previous anal-anastomosis of any type and studies reporting outcomes of UC patients as part of a heterogeneous group without discrete reporting of UC patients characteristics and outcomes. There were no restrictions on age, gender, or ethnic group. To note, the primary search was conducted specifically on pediatric population (< 19 years old) with hardly any result, hence the investigators decided to broaden the search strategy with no age restrictions. All randomized or non-randomized studies, and prospective or retrospective case series of reasonable size ($n > 5$), were eligible for inclusion. Small case series, reviews, published conference abstracts, and animal or cadaveric-based studies were excluded from this review.

Data items

The main outcome measure was postoperative anastomotic leak rate. Secondary outcome measures were length of hospital stay (LOS), operative time, conversion of operative technique, intra-operative and post-operative complications, readmission and functional outcomes. Other variables extracted from each record included surgical technique, age, gender, dates of data collection and follow-up time. Complications were recorded according to the Clavien–Dindo classification and divided into minor complications (grade I–II) or major complications (grade III or higher) [13]. Anastomotic leak was recorded as a separate variable as well as part of the complication variables. Data were collected from both manuscripts content and provided tables.

Search strategy, data selection and collection processes

We conducted a literature search in multiple electronic databases, including Cochrane Library databases, PubMed, Embase, Web of Science, ClinicalTrials.gov (www.clinicaltrials.gov), and Google Scholar. We did not find any reported randomized controlled trial with published results of this topic. The search strategy included the terms and keywords (also using MeSH headings): “colitis” or “ulcerative colitis” added with any of the following combinations: “transanal” and “proctectomy”; “transanal endoscopic proctectomy”; “transanal” and “IPAA” or “ileal pouch anal anastomosis”; “TAMIS” or “transanal minimally invasive surgery” and “total mesorectal excision”; “NOTES” or “natural orifice transluminal endoscopic surgery” and “proctectomy”; and “transanal endoscopic microsurgery” and “total mesorectal excision”. The final search was updated on 30th

April 2022. Endnote 20 was used to manage and screen the records identified. Duplicate and unrelated studies were eliminated before the reviewers' screening process. The reviewers (E.F.A and S.I) independently screened the titles and abstracts to decide whether inclusion criteria were met, with no disagreement in this stage between the reviewers. The reviewers (E.F.A and S.I) then collected independently the data from the full text, English language articles using a MS-Excel sheet. Retrieved data included: authors, publication date, study time period, sample size, age, gender distribution, intervention, outcomes as previously described, follow-up time and data for quality assessment. This process was followed with a secondary manual search of references lists from eligible articles reviewed, by each reviewer independently. Following completion of the Excel sheets, any disagreement between the reviewers was resolved by discussion with a third investigator (K.H) if required. No automation tool was used in these processes.

Risk of bias assessment

Risk-of-bias assessment was completed by two independent reviewers (A.E.F and H.J). The Newcastle–Ottawa Quality Assessment Scale (NOS) was used for cohort studies and the Joanna Briggs Institute Critical Appraisal Checklist (JBI) was used for case-series. The NOS is scored by awarding a point for each answer that is marked with an asterisk below. Possible total points are four points for Selection, two points for Comparability, and three points for Outcomes. The JBI uses ten criteria to evaluate the overall methodological quality of a study. The criteria include participants inclusion criteria; description of subjects and settings; valid and reliable measure of exposure; objective and standard measure of condition; valid and reliable measure of outcome; consecutive and complete patients inclusion, reliable clinical information, reporting of demographics and results and appropriate statistical analysis [14, 15] (Appendix 1).

Data synthesis and analysis

A meta-analysis was performed if there were sufficient similarities in the reporting of outcome measures in different studies. Meta-analyses were done separately for comparative and non-comparative studies due to difference in reporting measures. For cohort studies risk ratios and mean differences were pooled to extrapolate point estimates and 95% confidence intervals. The meta-analysis was performed using Open Meta-Analyst software [OpenMetaAnalyst for Windows 8 (64-bit) (built 04/06/2015) by Brown University]. Heterogeneity was assessed using the I^2 statistic. Heterogeneity was considered significant when I^2 value was higher than 50%. Meta-analyses were performed using a random-effects model. Funnel plots were analysed to evaluate

publication bias and small-study effects. Results were considered statistically significant at $p < 0.05$.

Results

Search results

The electronic search strategy described above yielded a total of 1348 records (Fig. 1). Manual hand searching of references and reviews identified five additional citations. After eliminating duplicates and irrelevant topics, a total of 84 studies remained. 56 studies were excluded following title and abstract screening. 28 studies underwent full-text review, of which 15 studies met inclusion criteria and had extractable data. The other 13 studies were excluded for the following reasons: small size case reports (8), review articles (3), mixed group of predisposing disease (2). Of the 15 included studies, 11 are descriptive case studies ($n = 241$ patients) and four are comparative studies ($n = 868$ patients). (Fig. 1 displays the PRISMA flow diagram.)

Surgical technique

Surgical procedures described in the studies were substantially similar, with some variations within and between the studies. A detailed step-by-step report of the ta-IPAA procedure has been recently published by Park et al. [16]. Generally, dissection of the rectum was performed through a transanal port device, enabling the introduction of laparoscopic instruments, an angled scope and an insufflation device. A purse-string suture was placed 3–4 cm proximal to the dentate line, and the proctectomy was started 1 cm distally, leaving a 1–2 cm rectal cuff. Dissection was performed both by monopolar cautery and by an energy device. A complimentary abdominal approach was usually performed to complete the colectomy or mobilize the mesenteric root of the small bowel to gain length and to build the pouch. In all patients a J-pouch was created. The abdominal phase was conducted with an open or laparoscopic approach (single incision platform or traditional multiport). Variations in surgical techniques were noticed in several aspects:

1. Number of procedural stages: two staged (initial IPAA with diverting ileostomy followed by ileostomy closure) VS. three staged (initial sub-total colectomy with end ileostomy, followed by completion proctectomy with IPAA and diverting ileostomy and finally ileostomy closure),
2. Complete transanal proctectomy VS. abdominal dissection of the proximal part of the rectum,
3. Dissection plane: intramesorectal/close rectal dissection (CRD) VS. TME,

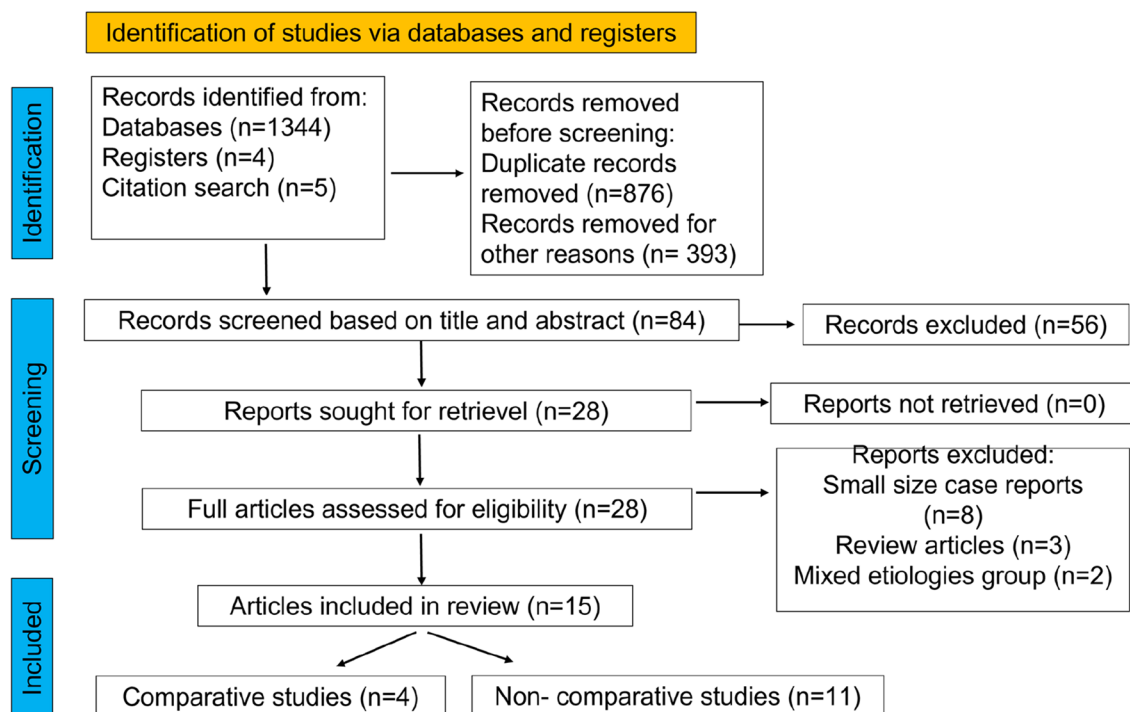


Fig. 1 PRISMA diagram of the selection process of included studies. The search strategy identified a total of 1353 studies. After elimination, a total of 84 studies remained. 56 studies were excluded following title and abstract screening. 28 studies underwent full-text review, of which 15 studies met inclusion criteria and had extractable data.

The other 13 studies were excluded for the following reasons: small size case reports (8), review articles (3), mixed group of predisposing disease (2). Of the 15 included studies, 11 are descriptive case studies ($n = 241$ patients) and four are comparative studies ($n = 868$ patients)

4. Anastomosis technique: hand-sewn VS. double purse-string single stapled,
5. Site of specimen extraction (transanal vs stoma site),
6. Performing a diverting ileostomy as part of the procedure.

To note that some of these variations existed also within the studies.

Characteristics of included studies

Overall data included records of surgeries conducted in Europe, UK and USA, during 2007–2019. Data were published between 2013 and 2021. Patients' age ranged between 9 and 79, with 45% male. Four case series, and one cohort study included children. One case series was exclusively pediatric. Case series included 241 patients undergoing ta-IPAA and cohorts included 868 patients, which compared 338 patients undergoing ta-IPAA to 530 patients undergoing transabdominal IPAA (tabd-IPAA). Length of follow-up varied between 3 weeks to 4 years. The summary of non-comparative and comparative studies included in this review is provided in Tables 1 and 2, respectively.

Outcomes

Anastomotic leak

Anastomotic leaks were diagnosed endoscopically, clinically during examination under anesthesia or by imaging (CT or contrast enema). All comparative studies ($n = 868$), which included 338 patients undergoing ta-IPAA, reported the rate of anastomotic leak. The meta-analysis demonstrated no statistical difference in anastomotic leak rate between ta-IPAA and tabd-IPAA (OR 1.36; 95% CI 0.46–4.06; $I^2 = 68%$; $p = 0.024$; Fig. 2a). Based on the findings of non-comparative studies, the overall leak rate following ta-IPAA was estimated at 7.1% (95% CI 3.9–10.3, $n = 241$; Fig. 2b).

Intraoperative factors (operative time and conversion rate)

IPAA duration of operation were reported in three comparative studies ($n = 594$), which included 238 ta-IPAA patients. The meta-analysis demonstrated no statistical difference in operative time between ta-IPAA and tabd-IPAA (MD -5.68 min; 95% CI -19.21 to 7.85 ; $I^2 = 26%$; $p = 0.258$). Based on the findings of non-comparative studies, the mean ta-IPAA operative time was estimated at 243 min (95% CI

Table 1 Summary of non-comparative studies reporting outcomes of endoscopic ta-IPAA in UC patients

Authors, publication year	Location	Time period	Study type	Sample size	Male/Female	Age (years)	Follow-up time
Liyanage et al. 2013 [11]	UK	2007–2011	Single institution case series	n = 6	4/2	41–77	NA
Tasende et al. 2015 [19]	Spain	2011–2014	Single arm prospective study	n = 16	13/5	40.5 ± 15.7	724 ± 387 days
Leo et al. 2016 [33]	UK	2013–2015	International registry case series	n = 16	10+/6	26–70	NA
de Buck et al. 2016 [22]	Belgium	NA	Single institution case series	n = 11	3/8	22–66	NA
Al Furajji et al. 2017 [34]	Ireland	2013–2015	Single institution case series	n = 10	5/5	40–62	13–34 months
Zaghiyan et al. 2018 [5]	USA, UK, Italy	2015–2017	Three institutions case series	n = 62	43/19	16–68	NA
Souzani et al. 2019 [35]	Denmark	2017–2018	Single institution case series	n = 11	7/4	13–51	49–196 days
Bislenghi et al. 2020 [36]	Belgium	2015–2019	Single institution case series	n = 75	33/42	16–70	10–50 months
Traynor et al. 2021 [10]	USA	2018–2019	Single institution case series	n = 6	1/5	13–18	21–208 days
Capolupo et al. 2021 [37]	Italy	2018–2019	Single institution case series	n = 8	5/3	28–79	NA
Lask et al. 2021 [18]	Germany	2015–2019	Single arm prospective study	n = 20	14/6	14–54	1–4 years

IPAA ileal pouch anal anastomosis, UC ulcerative colitis, ta transanal

Table 2 Summary of comparative studies reporting outcomes of endoscopic ta-IPAA in UC patients

Authors, publication year	Location	Study design	Time period	Total cohort	ta-IPAA	abd-IPAA	Age (years)	Male/Female
de Buck et al. 2017 [23]	Belgium, Denmark, Netherlands	Multicenter retrospective cohort	2011–2016	N = 216	n = 97	n = 119	37 (IQR 28–50)	113/103
Chandrasinghe et al. 2019 [17]	UK, Italy, Netherlands	Multicenter prospective cohort	2002–2017	N = 374	n = 100	n = 274	9–71	107/167
Park et al. 2021 [24]	USA	Single center prospective cohort	2016–2020	N = 113	n = 76	n = 37	36 ± 17	58/56
Truong et al. 2021 [25]	USA	Single center prospective cohort (with consecutive assignment)	2012–2019	N = 165	n = 65	n = 100	37.5 ± 17	78/87

IPAA ileal pouch anal anastomosis, UC ulcerative colitis, ta transanal, abd abdominal

192–294, n = 215 from nine studies). Conversion rate was reported in two comparative studies, and well documented in all case series (n = 414) and was estimated to be 2.8% (95% CI 1.2–4.3).

Minor and major complications

Overall complications were consistently reported in comparative studies (n = 868, ta-IPAA = 338). Minor complications (Clavien–Dindo class I–II) included ileus, small bowel obstruction, wound infection, fever, pneumonia, urinary tract

infection, urinary retention and diarrhea. The meta-analysis demonstrated no statistical difference in minor complications rate between ta-IPAA and tabd-IPAA (OR 0.92; 95% CI 0.48–1.76; I² = 75%; p = 0.007; Fig. 3a). Based on ten non-comparative studies (n = 221), the estimated minor complication rate was 20% (95% CI 11.8–28.8; Fig. 3b). Major complications (Clavien–Dindo class III or higher) included uncontrolled infection, re-operation, anastomotic leak, incarcerated parastomal hernia and bleeding. The meta-analysis demonstrated no statistical difference in major complications rate between ta-IPAA and tabd-IPAA (OR 0.78; 95%

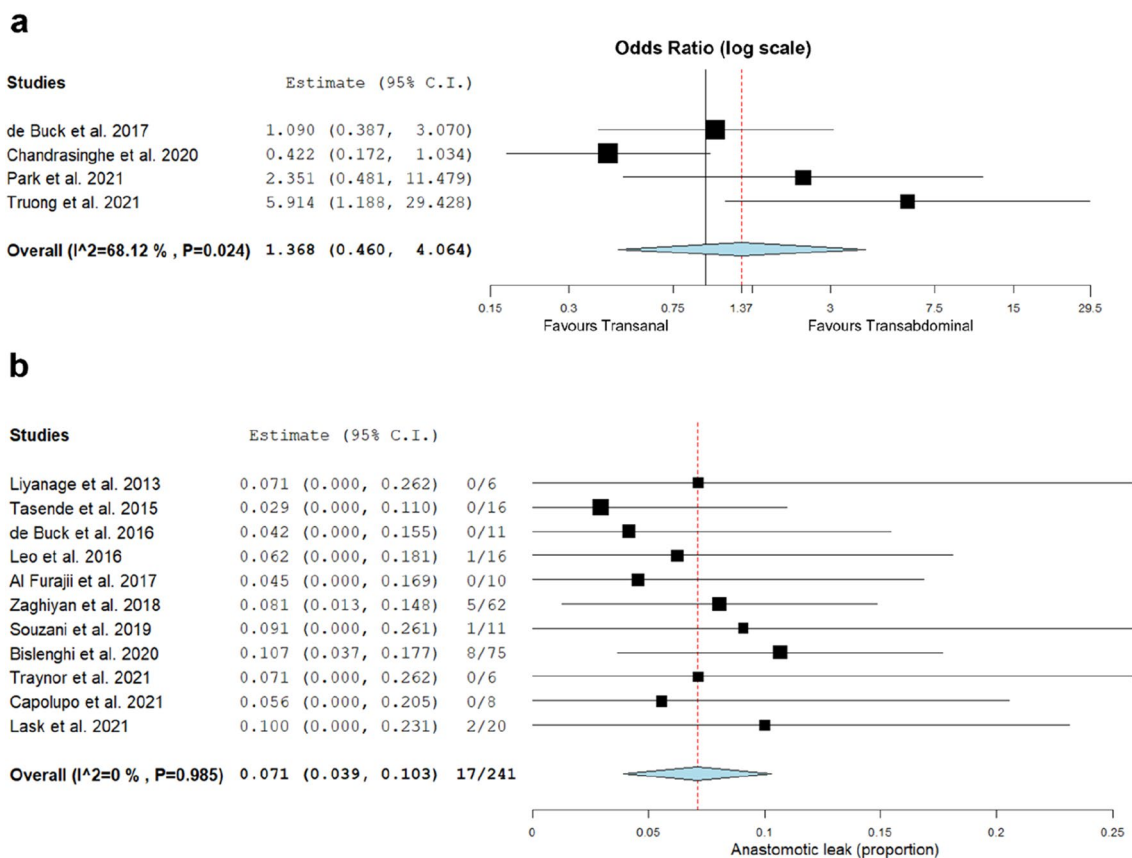


Fig. 2 Forest plots of pooled anastomotic leak rates for comparative (a) and non-comparative (b) studies

CI 0.36–1.69; $I^2=61\%$; $p=0.05$; Fig. 3c). The estimated major complications rate was 8.7% (95% CI 5.2–12.2, $n=221$; Fig. 3d).

Length of hospital stay (LOS)

LOS was reported in three comparative studies ($n=594$, ta-IPAA = 238), wherein two of them a significantly shorter LOS for ta-IPAA patients was found. However, the meta-analysis demonstrated no statistical difference in LOS comparing the groups (OR -0.61 days; 95% CI -2.39 to 1.17 ; $I^2=91\%$; $p<0.001$). Based on the findings of non-comparative studies, estimated mean LOS was 7.4 days (95% CI 6–8.8, $n=221$). Readmission rates were not directly addressed in most studies and hence could not be pooled.

Functional outcomes

Chandrasinghe et al. have explored functional outcomes in their comparative study. They conducted a questionnaire regarding quality of life, quality of health, energy score, bowel function and sexual function. Their results showed a significantly better quality of health and energy level in ta-IPAA patients comparing tabd-IPAA (quality of

health: 7.73 ± 1.19 vs. 7.30 ± 1.53 , $p=0.04$; energy level: 7.17 ± 1.54 vs. 6.68 ± 1.74 , $p=0.03$). The other measures did not differ between the groups [17]. Lask et al. reported short- and long-term functional outcomes in their case-series. In the short-term 0/14 patients displayed any signs of pouchitis, fistula or stenosis. In the long-term follow-up of 1–5 years, 11/19 patients developed pouchitis, and 3 developed a fistula [18]. Tasende et al.'s case series collected data regarding fecal continence and pouch-specific function, 3 months after ileostomy closure. Within 12 patients, 24 h defecation frequency was 5.5 (SD 1.7), with a mean episode of 0.5 per night. Function score was 4.7 (SD 3.7) (0 = perfect, 15 = bad), and continence score was 1.4 (SD 2.9) (0 = perfect, 20 = incontinent). Pouchitis was diagnosed in one patient, 5 months after pouch creation [19]. In all studies exploring functional outcomes, no bladder dysfunction, ejaculation or erectile disturbances were reported.

ta-IPAA in children

We found only one study that described initial experience with ta-IPAA in children with UC. Traynor and Potter have recently described their experience in ta-IPAA conducted as a three-staged procedure for six children with UC [10]. The

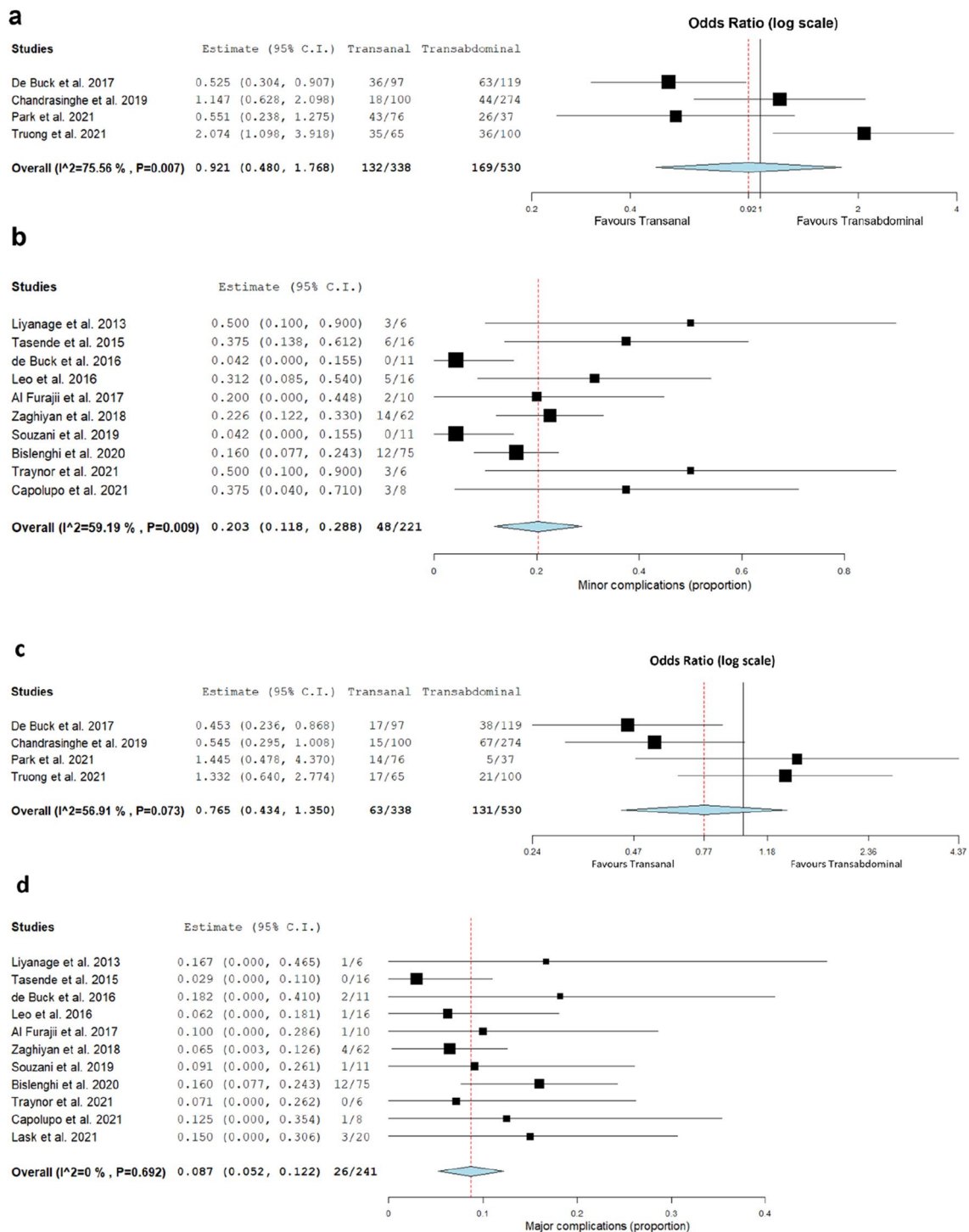


Fig. 3 Forest plots of pooled minor and major complication rates for comparative (a, c) and non-comparative (b, d) studies

abdominal part was conducted with single incision laparoscopy and the transanal resection included a mucosectomy 1 cm proximal to the dentate line with full thickness resection after 4–5 cm. A hand-sewn ileal J-pouch anal anastomosis was conducted. Median operative time was 226 min, with no conversions. Median hospital LOS was 5 days.

In-hospital complications occurred in two patients who had watery diarrhea that prolonged LOS but resolved post discharge. One patient was readmitted for bowel obstruction that resolved with placement of red rubber catheter at the ileostomy site. No patients reported soiling or leakage, though one patient had a single episode of incontinence.

The authors concluded that ta-IPAA is effective and safe and future work is required to compare traditional minimally invasive completion proctectomy to ta-IPAA for applications in pediatric IBD.

Discussion

Surgical treatment for UC patients has dramatically evolved over the last 2 decades, with currently applicable state-of-the-art minimally invasive transanal procedure. The ta-IPAA approach facilitates distal rectal visualization, dissection, and excision due to improved exposure of the distal rectum and usage of a ‘virgin’ operating field. As a result, theoretically, the risk of unintended nervous injury during proctectomy is reduced and better long term functional outcomes can be achieved. The ta-IPAA technique was developed following experience with TAMIS for rectal cancer; however, contrary to oncologic patients, UC patients are younger and expected to have high post-operative quality of life and longevity. Data published regarding ta-TME oncologic patients showed preserved urinary and sexual function and reduced incidence and severity of low anterior resection syndrome. Moreover, quality of life evaluations reported comparable results to abdominal approach, and even slightly higher urinary function satisfaction [20, 21]. Another advantage of ta-IPAA lies in the ability to control the length of the rectal cuff, found as a factor affecting functional outcomes [22]. Our review, summarizing all available data on UC patients undergoing ta-IPAA, collected only three studies directly aimed to investigate functional outcomes, with only one of them containing a comparison group. This data could not be pooled to a meta-analysis but also did not identify any sexual or urinary dysfunction complaints and did not show significant differences compared to tabd-IPAA. The sole comparative study even found better self-reported quality of health and energy level for ta-IPAA patients [17].

This review was consistent in supporting the declaration that ta-IPAA is feasible and safe with acceptable complication rate, as our meta-analysis showed comparable estimates of operative time, LOS, minor and major complications. However, we did not find any specific feature that showed better performance for ta-IPAA group, although separate comparative studies did find shorter hospital stay, lower overall complications and lower postoperative morbidity [23–25].

As a technique currently being developed, intra-operative variations exist even within specialized centers as described in the studies presented. Transanal endoscopic approach requires adequate laparoscopic experience and is challenging due to loss of triangulation and limited view, and a steep learning curve is reported to require a minimum of 50 cases in order to reach acceptable proficiency

[10, 26]. Truong et al. found significantly higher rates of anastomotic leak in ta-IPAA patients, along with a 50% improvement in risk of leak after the 50th procedure [25].

The first among surgical parameters that varied between and within experimental groups was the decision whether to include a diverting ileostomy. There is contradicting data regarding tabd-IPAA and ileostomy, stating on the one hand that non-diversion is associated with higher risk of pouch failure, and on the other hand that diverting stomas do not prevent anastomotic leak [27, 28]. Our extracted data did not find precise reporting in order to draw conclusions regarding the role of ileostomy in the post-operative course, and variability was high.

The second surgical decision is whether to conduct a single-stapled anastomosis with preservation of a distal rectal segment, or mucosectomy and hand sewn anastomosis with complete removal of the rectum. The ability to perform a single-stapled anastomosis and avoiding multiple-staple firings, resulting from limited exposure in abdominal technique, carry the potential to reduce anastomotic leaks. Ishii et al. compared stapled to hand-sewn anastomosis in tabd-IPAA and found greater incidence of postoperative anal fistula in the stapled group and higher frequency of bowel movements and soiling in the hand-sewn group in early postoperative course. However, in a follow-up over more than three years both groups showed similar quality of life [29]. In the studies of this review, there was no specific discriminations between those groups in terms of functional outcomes, so conclusions regarding the effect of anastomotic type were impossible.

The third technical element is defining the plane of rectal dissection to be extensive with TME or limited with CRD. Derivation of the ta-IPAA procedure from the oncological field, and the possibility of dysplasia in chronically ill tissue are in favor for conducting a TME. However, possible consequence of this dissection is the increased risk of iatrogenic urinary and sexual dysfunction due to autonomic nerve lesion. Although the risk of developing rectal cancer in UC patients is related to early onset of UC, it has also been found to increase with disease duration, making an overall low risk within the pediatric population [30]. Chandrasinghe directly compared TME to CRD in ta-IPAA and found comparable quality scores and major incontinence rates, as well as higher stool frequency (> 10/24 h) in the CRD group [17]. Son et al. compared TME to CRD in ovarian cancer requiring rectal dissection and found higher postoperative incidences of anastomotic leak and prolonged ileus in the TME group. Since there were no differences in oncological outcomes, the authors concluded that CRD may be an alternative technique for rectal dissection with less perioperative morbidity and equivalent oncologic outcomes [31]. This finding may resolve the debate regarding preferred dissection plane; however, yet to be proved in relevant ta-IPAA population.

A large-scale randomized trial can help to formulate precise conclusions regarding the preferred and recommended technical considerations of every step of the ta-IPAA procedure.

This review included a wide age range, with patients as young as 9 years old. This information suggests that children are a natural part of UC population eligible for ta-IPAA. Due to data restrictions, we could not conduct separate analyses exclusively for children. However, the single pediatric exclusive report provided promising results [10]. In accordance with the general surgeons' trend, NOTES is also gradually emerging within pediatric surgery community, for example in Duhamel pull-through [32]. Long-term functional outcomes and quality of life are paramount in the pediatric population and should be particularly investigated.

Although this comprehensive systematic review ascertained that all published data were retrieved, the total body of evidence is still limited. Formal meta-analyses could only include four studies of which none was a randomized trial with inherent high level of evidence. Case-series are considered a priori as data of low level, although the grading of the non-comparative studies according to the JBI and NOS scales provided satisfactory results. Variability in the population characteristics and the operative techniques were also possible source of bias.

Conclusion

Ta-IPAA is a safe and feasible method for patients with medically refractory UC. Peri-operative factors as operative time, post-operative complications, LOS and anastomotic leak are comparable to transabdominal IPAA with possible better long-term functional outcomes. Implementation of this method requires a steep learning curve but is also technically feasible in children due to familiarity with the dissection plane. Long-term functional outcomes and quality of life are paramount in the pediatric population and should be particularly investigated. Specific recommendations regarding intraoperative specifications (following a controlled randomized trial) will help standardize the technique to enable reproducible outcomes.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s00383-022-05222-y>.

Author contributions All the authors agreed with the content and gave explicit consent to submit this work.1) All authors whose names appear on the submission made substantial contributions to the conception and design of the work; the acquisition (E.F.A, K.H, H.J, S.I), analysis (E.F.A, K.H), and interpretation of data (E.F.A, K.H, H.J, S.I).2) E.F.A, S.I and H.J drafted the work and revised it critically for important intellectual content3) All authors approved the version to be published.4) All authors agree to be accountable for all aspects of

the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Declarations

Competing interests The authors declare no competing interests.

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