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Carbon Dioxide Laser Versus Stapler-Assisted Endoscopic Zenker's Diverticulotomy: A Systematic Review and Meta-Analysis

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Abstract

To evaluate outcomes following endoscopic management of Zenker's diverticula using a carbon dioxide laser (CO₂) or stapler-assisted technique, a systematic review and meta-analysis were conducted. Seven retrospective, uncontrolled case series including 391 procedures met selection criteria. No higher quality studies were identified. Outcomes favoring the stapler technique included a shorter duration of nil per os (NPO) status (2 studies), length of hospitalization (LOH, 2 studies), and fewer postoperative fevers and abnormal chest x-rays (1 study). Outcomes favoring the CO₂ technique included greater improvement in postoperative dysphagia and regurgitation scores (2 studies) and a lower revision rate (1 study). Meta-analysis demonstrated increased nondental complications in the CO₂ group (odds ratio 3.81; 95% confidence interval, 1.37–10.59; $P = .01$) but no difference in duration of NPO ($P = .06$), LOH ($P = .07$), overall complications ($P = .08$), dental complications ($P = .57$), major complications ($P = .38$), or revision surgery ($P = .82$). Implications are limited by the quality of studies identified.

Keywords

Zenker's; diverticula; carbon dioxide laser; stapler

Since the first endoscopic treatment of Zenker's diverticula in 1917 using cold instruments,¹ significant advances have included the introduction of diathermy in 1960,² the CO₂ laser (CO₂) in 1984, and the stapler in 1993 for party wall transection.^{4,5} The latter two are now

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Author Contributions

Noah P. Parker, (1) conception and design, acquisition of data, and analysis and interpretation of data; (2) drafting the article, revising it critically, and (3) final approval of the version to be published; **Stephanie Misono**, (1) substantial contributions to conception and design, acquisition of data, and analysis and interpretation of data; (2) revising the article; and (3) final approval of the version to be published.

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mainstays of endoscopic management.⁶ While the stapler may reduce pharyngeal/esophageal rupture, mediastinitis, bleeding, and collateral-thermal damage,⁶ the laser may transect more thoroughly and reduce revisions.⁷ This study seeks to systematically review published outcomes of CO₂ and stapler-assisted techniques and to highlight strengths and weaknesses of each.

Methods

World literature (PubMed, Scopus/Embase, ClinicalTrials.gov) from January 1980 through August 2013 was systematically and independently reviewed by each author with a priori selection criteria. Studies were included if CO₂ and stapler groups compared at least 1 primary outcome measure: duration of nil per os (NPO), length of hospitalization (LOH), symptom resolution, complications, and/or revisions. Discrepancies were resolved by discussion and consensus. Data were independently extracted by each author. Corresponding authors were contacted to maximize results.

NPO and LOH were compared if protocols did not predetermine length and if authors did not describe a systematic change to practice patterns. Data were extracted into Microsoft Excel (Microsoft, Redmond, Washington). Means and standard deviations were used for statistical analysis and were derived from median and range when necessary.⁸ Unpaired *t* tests were used where appropriate using QuickCalcs (GraphPad Software, La Jolla, California). Data were transferred to Review Manager for analysis and estimate pooling (RevMan version 5.2, Copenhagen, The Nordic Cochrane Centre, The Cochrane Collaboration, 2012). Funnel plots to assess publication bias were not formally interpreted due to the small number of studies and due to limitations of subjective visual interpretation.⁹ Heterogeneity was interpreted using the *I*² statistic, and a random effects model was used to calculate weighted mean difference (WMD) or Mantel-Haenszel odds ratio (OR).¹⁰ Risk of bias was evaluated using the Newcastle-Ottawa Quality Assessment Scale,¹¹ as recommended for non-randomized studies.¹²

Results

Figure 1 illustrates the review process. Review studies (*n* = 14), single-arm studies (*n* = 11), non-English studies without English abstracts (*n* = 4), letters/commentaries (*n* = 3), and a survey study (*n* = 1) were excluded. The 7 included articles (Table 1)^{7,13–18} were retrospective and nonrandomized. Three articles^{2,5,7} included consecutive patients; the others were unclear. One author provided additional information.¹⁸ Risk of bias,¹¹ including evaluation of selection, comparability, and outcome assessment, rated studies 4–5 stars out of 9, indicating fair quality.

Table 2 displays outcome measures reported. Five studies used the same diverticuloscope in both groups.^{7,14–17} Because of similarities in diverticulosopes and approaches, dental and nondental complications were recorded separately. There were 5 reported dental complications in the CO₂ group and 7 in the stapler group.^{7,13,14,17} Nondental complications were reported in all studies. For CO₂ cases, these included subcutaneous emphysema without mediastinitis (*n* = 28), mediastinitis (*n* = 2), hypopharyngeal injury (*n* = 1), bleeding

(n = 1), pharyngoesophageal stenosis (n = 1), and death (hemolytic anemia causing liver/renal failure, n = 1); 7 were “major” (defined as requiring operative intervention and/or mediastinitis and/or pharyngoesophageal stenosis). For stapler cases, nondental complications included subcutaneous emphysema without mediastinitis (n = 4); none were major. Two studies reported conversion rates to an open approach of 3 of 19 (15.8%)¹⁸ and 4 of 40 (10%)⁷ but did not distinguish between groups.

Study outcomes favoring the stapler included shorter NPO (2 studies)^{13,18} and LOH (2 studies)^{13,18} as well as fewer postoperative fevers and abnormal chest x-rays (1 study).¹⁶ Two studies^{14,16} had protocols or perceived biases in NPO/LOH and so were excluded from this analysis. Study outcomes favoring the laser included lower postoperative dysphagia and regurgitation scores (2 studies)^{7,17} and fewer revisions (1 study).⁷ In this latter study,⁷ all revisions were performed subsequent to stapler-assisted procedures.

Meta-analysis demonstrated an increased risk of nondental complications for the CO₂ technique (OR 3.81; 95% confidence interval [CI], 1.37 to 10.59; *P* = .01) but no difference in NPO (WMD 1.99; 95% CI, -0.12 to 4.11; *P* = .06), LOH (WMD 2.14; 95% CI, -0.20 to 4.49; *P* = .07), overall complications (OR 2.68; 95% CI, 0.88 to 8.17; *P* = 0.08), dental complications (OR 0.71; 95% CI, 0.2 to 2.36; *P* = .57), major complications (OR 2.22; 95% CI, 0.37 to 13.13; *P* = .38), or rate of revision surgery (OR 0.79; 95% CI, 0.10 to 6.39; *P* = .82).

Discussion

While individual study results suggest that use of the stapler hastens patient recovery, pooled analysis of NPO and LOH was limited by potential biases in the data and meta-analysis did not reveal differences between groups. Advocates of the stapler suggest greater safety,⁶ but, while there was a significant reduction in nondental complications, there was no difference in dental or major complications. Advocates of the CO₂ technique suggest more thorough party wall division and fewer revisions.⁷ While results from one group reported fewer revisions for the CO₂ technique,^{7,17} these differences were not substantiated by meta-analysis. Perhaps complication and revision rates depend more on either amount of residual party wall or expertise of the surgeon than the instruments used.

Our study is limited by the quality of literature available. The best evidence was Oxford Level 4,¹⁹ or nonrandomized, retrospective case series. Not all measures sought were available in each study. Also, there is likely variability in techniques used across practices in terms of extent of party wall division, laser settings, and so on, which we were unable to assess. Future controlled, randomized, multi-institutional studies are necessary to make definitive statements regarding the superiority of one technique over the other.

Conclusions

Few studies compare endoscopic CO₂ to stapler-assisted Zenker's diverticulotomy, and all are nonrandomized, retrospective case series. The stapler-assisted technique was associated with fewer nondental complications, but results should be taken in light of the quality of evidence. Higher quality studies comparing these techniques are necessary.

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Figure 1.
Systematic review flow chart.

Table 1

Included Studies.

Study No. Author (year)	Total Cases, N CO ₂ , Stapler, n	Mean Age, y (SD) CO ₂	Mean Age, y (SD) Stapler	Bivalve Diverticuloscope: Laser	Bivalve Diverticuloscope: CO ₂	Bivalve Diverticuloscope: Stapler	Mean Follow-up (SD), mo CO ₂	Mean Follow-up (SD), mo Stapler
Gutschow et al ¹³ (2002)	86 55, 31	71 (7.67)	75 (7.8) ^a	Holinger-Benjamin	Weerdia-Collard	Weerdia	61 (31.3)	35 (29.8) ^a
Miller et al ¹⁴ (2006)	35 16, 19	75 (NR)	74 (NR)	Weerdia	Weerdia	Weerdia	NR	NR
Luna-Ortiz et al ¹⁵ (2009)	4 2, 2	54 (8.5)	67.5 (9.2)	Weerdia	Weerdia	Weerdia	NR	NR
Verhaegen et al ¹⁶ (2011)	107 72, 35	64.9 (NR)	64.9 (NR)	Weerdia	Weerdia or Van Overbeek	Weerdia	82.3 (35.83)	20.9 (10.3) ^a
Adam et al ¹⁷ (2012)	128 61, 67	69.9 (15.1)	70.1 (13.6)	Weerdia	Weerdia	Weerdia	>6 for both groups	>6 for both groups
Herrero-Egea et al ¹⁸ (2012)	19 13, 6	62 (11.6)	74.8 (7.2)	Unspecified	Unspecified	Unspecified	20.4 (27.1)	10.17 (7.15)
Adam et al ⁷ (2013)	12 8, 4	73.9 (17.9)	80.3 (7.3)	Weerdia	Weerdia	Weerdia	>6 for both groups	>6 for both groups

Abbreviations: CO₂, carbon dioxide laser; NR, not reported; SD, standard deviation.^aValues calculated from median and range as previously described.⁸

Table 2

Reported Outcome Measures.

Study No.	Author (year)	Pre/Postsurgical	Symptom Score	Duration	NPO	LOH	Complications	Revisions
1.	Gutschow et al ¹³ (2002)	X		X		X	X	
2.	Miller et al ¹⁴ (2006)	X				X ^a	X	X
3.	Luna-Ortiz et al ¹⁵ (2009)			X ^b		X ^b	X	X
4.	Verhaegen et al ¹⁶ (2011)			X ^b		X ^b	X	X
5.	Adam et al ¹⁷ (2012)	X		X ^b		X ^b	X	X
6.	Herrero-Egea et al ¹⁸ (2012)			X		X	X	
7.	Adam et al ⁷ (2013)	X		X ^b		X ^b	X	X

Abbreviations: LOH, length of hospitalization; NPO, nil per os status. X denotes that outcomes were included in the individual study.

^aStudy 2 did not provide variance and so could not be included in analyses.

^bStudies 3, 4, 5, and 7 had protocols dictating duration of NPO and LOH.