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Systematic Review

Cricopharyngeal Dysfunction: A Systematic Review Comparing Outcomes of Dilatation, Botulinum Toxin Injection, and Myotomy

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Objectives: Cricopharyngeal dysfunction may lead to severe dysphagia and aspiration. The objective of this systematic review was to evaluate the existing studies on the effectiveness of myotomy, dilatation, and botulinum toxin (BoT) injection in the management of cricopharyngeal dysphagia.

Methods: PubMed and Web of Science databases were searched to identify eligible studies by using the terms "cricopharyngeal dysfunction," "cricopharyngeal myotomy," "cricopharyngeal botox," "cricopharyngeal dilation," and their combinations from 1990 to 2013. This was supplemented by hand-searching relevant articles. Eligible articles were independently assessed for quality by two authors. Statistical analysis was performed.

Results: The database search revealed 567 articles. Thirty-two articles met eligibility criteria and were further evaluated. The reported success rates of BoT injections was between 43% and 100% (mean = 76%), dilation 58% and 100% (mean = 81%), and myotomy 25% and 100% (mean = 75%). In logistic regression analysis of the patient-weighted averages, the 78% success rate with myotomy was significantly higher than the 69% success rate with BoT injections ($P = .042$), whereas the intermediate success rate of 73% with dilation was not significantly different from that of either myotomy ($P = .37$) or BoT ($P = .42$). There was a statistically significant difference between endoscopic and open myotomy success rates ($P = .0025$). Endoscopic myotomy had a higher success rate, with a 2.2 odds ratio.

Conclusions: The success rate of myotomy is significantly higher than the success rate of BoT injections in cricopharyngeal dysfunction. Moreover, endoscopic myotomy was found to have a higher success rate compared to open myotomy.

Key Words: Cricopharyngeal dysfunction, cricopharyngeal myotomy, cricopharyngeal botox, cricopharyngeal dilation.

Level of Evidence: NA

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INTRODUCTION

Cricopharyngeal (CP) muscle dysfunction can lead to dysphagia, aspiration, and weight loss, causing significant morbidity and reduced quality of life.[1] Etiologies are numerous and include the general categories of anatomic (cricopharyngeal bar), neuromuscular (central, peripheral, or myogenic), iatrogenic, inflammatory, neoplastic, and idiopathic (Table I).[2] The role of the CP muscle in swallowing has been well established. In 1717, Valsalva first described the anatomy of the cricopharyngeus muscle, which was further clarified by Killian in 1907.[3] CP dysfunction has been attributed mainly to the disordered opening of the CP muscle, which is the main component of the upper esophageal sphincter (UES). The opening of the UES necessitates three factors: neural inhibition of tonic intrinsic sphincter muscle contraction, anterior-superior laryngeal elevation that leads to the mechanical distraction of the UES, and passive stretching of the intrinsic sphincter muscles as the bolus passes.[4,5] A heterogeneous spectrum of disorders can lead to CP dysfunction, including failure of neural inhibition of tonic CP contraction, weakness of pharyngeal muscles with reduced laryngeal elevation and UES opening, as well as decreased compliance of the CP muscle, such as due to radiation fibrosis.

Various preoperative techniques can be used for diagnosis (Table II). The most important component has been a thorough history. In most centers this is followed by a videofluoroscopic swallowing study (VFSS) and manometry. These not only demonstrate the dysfunctional UES, but also demonstrate laryngeal elevation, the strength of the pharyngeal muscles, and laryngeal penetration or aspiration. Although some authors find manometry cumbersome and of limited value,[6,7] others strongly advocate the use of it, especially if coupled with fluoroscopy.[8–11] Manofluoroscopy, which ensures improved sensor placement, also allows assessment of pressures at known sensor locations during swallowing.[10,12,13] It is still

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TABLE I.
Causes of Cricopharyngeal Dysfunction.

Central nervous system
Cerebellar infarct
Brain stem infarct
Parkinsonism
Amyotrophic lateral sclerosis
Base of skull neoplasm
Peripheral nervous system
Peripheral neuropathy
Diabetic neuropathy
Bulbar poliomyelitis
Myasthenia gravis
Neoplasm
Cricopharyngeal muscle
Polymyositis
Oculopharyngeal muscular dystrophy
Hyperthyroidism
Hypothyroidism
Cricopharyngeal disruption
Laryngectomy
Supraglottic laryngectomy
Radical oropharyngeal resections
Pulmonary resections
Cricopharyngeal spasm
Hiatal hernia
Gastroesophageal reflux
Idiopathic cricopharyngeal achalasia

Adapted from Halvorson DJ.[30]

not available and not a part of the workup in many institutions. Poirier et al. advocate the use of manometry to assess the physiological abnormalities at the pharyngoesophageal junction, but do not use it as an indication for surgical treatment.[14] Electromyography has been used by some authors to diagnose swallowing disorders.[15,16]

Numerous treatments exist for CP dysfunction, including swallowing therapy, CP dilation, injection of botulinum toxin, and CP myotomy. The traditional surgical treatment for CP dysfunction has been CP myotomy through a transcervical approach. To minimize the complications of an open approach, endoscopic CP myotomy was introduced using the potassium-titanyl-phosphate laser (wavelength, 532 nm) by Halvorson and Kuhn in 1994.[17] Subsequently, carbon dioxide laser (wavelength, 10,600 nm) gained favor because of its ability to coagulate small vessels and minimize thermal damage.[1]

Blitzer and Brin first presented on the use of in-office botulinum toxin (BoT) injections in 1993 as an alternative to surgery for the treatment of UES dysfunction.[18] In most cases, BoT has been injected under endoscopic visualization and general anesthesia, whereas less has been reported on percutaneous BoT injections under electromyographic guidance and local cutaneous anesthesia.[19] The range of BoT doses reported per injection varies from 10 U to 100 U.[20] Bougienage has been used in the treatment of anatomic esophageal strictures for decades.[21] The commonly used approaches are bougies, wire-guided polyvinyl dilators, air-filled pneumatic dilatation, and water-filled balloon dilatation with or without endoscopy guidance.[22]

CP dysfunction can be challenging diagnostically and in regard to the identification of the best treatment modality for a given patient. The scope of this article was to systematically review the literature regarding CP muscle interventions, specifically myotomy, injection of BoT, and dilation of the CP muscle for the treatment of CP dysfunction in adult patients.

MATERIALS AND METHODS

The literature search was performed according to the guidelines of the Cochrane Collaboration for systematic reviews in PubMed and Web of Science using a time frame from January 1990 until March 2013. Only literature published in English was considered. The search included the following keywords: "cricopharyngeal dysfunction," "cricopharyngeal myotomy," "cricopharyngeal botox," "cricopharyngeal dilation," and their combinations. The inclusion criterion for the studies was for the main focus of the article to be on the success rate and complications of the treatment modality. Bibliographies were manually reviewed to obtain additional articles of relevance. Reviews, editorials, case reports with less than four patients, articles with nonhuman data, duplicate publications, and articles on the pediatric patient population were excluded. Articles describing CP dysfunction attributed directly to Zenker's diverticulum and/or requiring diverticulectomy were also excluded. Articles with one specific etiology (except CP achalasia) as the reason for cricopharyngeal dysfunction were excluded; articles with heterogeneous etiology were included in the study.

The eligible articles were assessed for quality using the modified Downs and Black scale,[23] which is a validated checklist for randomized and nonrandomized studies. Any data extraction or assessment disagreements or inconsistencies were resolved through discussion and consensus.

Statistical Analysis

The average success rate of each procedure was calculated two ways: 1) as the crude (unweighted) average of reported success rates across articles and 2) as the patient-weighted average calculated as the total number of reported successes divided by the total number of treated patients. For logistic regression, the events/trials syntax was used, in which "events" and "trials" respectively represented the number of successes and number of patients in each article; this means that the logistic regression was effectively comparing patient-weighted averages between procedures. Additionally, the procedures were scored for invasiveness as botulinum toxin = low, dilation = medium, and myotomy = high, and the trend in success rate with invasiveness was assessed via the Cochran-Armitage trend test. These analyses assessing success rates were also used for complication rates. SAS version 9.3 (SAS Institute, Cary, NC) was employed for all analyses, and a $P < .05$ significance level was employed for all comparisons.

RESULTS

Study selection identified 567 reference articles; of these 42 met eligibility criteria. An additional five potential relevant reports were identified through scanning reference lists. Ultimately, 32 articles were included in the analysis. Thirteen articles were excluded for the

TABLE II.
Selected Studies of Cricopharyngeal Muscle Intervention for Cricopharyngeal Dysfunction

Author	Year	Study (Level of Evidence)	No. of Patients	Outcome Measures	Type of Treatment	Follow-up	Success Rate (%)	Complication
Schneider[24]	1994	PCS (IV)	7	SR, VFSS, M	BoT-A	4.5–5 months	71	None
Blitzer[18]	1997	RCS (IV)	6	C	BoT-A	Not mentioned	100	Not mentioned
Alberty[4]	2000	PCS (IV)	10	SR, VFSS	BoT-A	1–1.5 months	100	Pharyngeal diffusion
Haapaniemi[34]	2001	RCS (IV)	4	C	BoT-A	2–24 months	75	Urine retention
Shaw[35]	2001	RCS (IV)	12	C	BoT-A	1–14 months	83	Pharyngeal diffusion, pharyngeal tear
Parameswaran[33]	2002	RCS (IV)	12	C, VFSS	BoT-A	3–6 months	92	Neck cellulitis
Zaninotto[25]	2004	PCS (IV)	21	SR, VFSS	BoT-A	12–38 months	43	Death through aspiration
Murry[26]	2005	PCS (IV)	13	C, VFSS	BoT-A	1–9 months	92	Not mentioned
Terre[27]	2008	PCS (IV)	10	C, VFSS, M	BoT-A	12 months	80	None
Lee[36]	2009	RCS (IV)	8	VFSS	BoT-A	0.2–1 month	75	Not mentioned
Alfonsi[28]	2010	PCS (IV)	34	SR	BoT-A	2 months	50	None
Woisard-Bassols[29]	2013	PCS (IV)	11	SR, VFSS	BoT-A	12–48 months	45	None
St. Guily[37]	1994	RCS (IV)	11	C	Myotomy (open)	5–53 months	72	None
Herberhold[38]	1995	RCS (IV)	32	C, VFSS	Myotomy (endoscopic)	Up to 7 years	97	Supraglottic edema, imminent mediastinitis
Poirier[14]	1997	RCS (IV)	40	C, VFSS, M	Myotomy (open)	1–255 months	72.5	Retropharyngeal hematoma
Ali[31]	1997	Cohort study (IIb)	8	C	Myotomy (open)	6 weeks	75	Not mentioned
Halvorson[30]	1998	PCS (IV)	18	C	Myotomy (endoscopic)	Not mentioned	78	Not mentioned
Mason[39]	1998	RCS (IV)	31	C, M	Myotomy (open)	2–48 months	77	Neck hematoma, pulmonary edema, pneumonia
Lawson[40]	2003	RCS (IV)	29	C, VFSS, FEES	Myotomy (endoscopic)	1–36 months	88	None
Zaninotto[25]	2004	PCS (IV)	11	SR, VFSS	Myotomy (open)	6–31 months	73	None
Takes[41]	2005	RCS (IV)	10	SR	Myotomy (endoscopic)	2–24 months	60	None
Dauer[2]	2006	RCS (IV)	22	SR	Myotomy (endoscopic + open)	Not mentioned	58	Fever of unknown etiology, chest pain, pharyngocutaneous fistula, tracheotomy
Munoz[5]	2007	RCS (IV)	14	SR, VFSS	Myotomy (open)	6–10 months	25	Not mentioned
Lawson[42]	2008	RCS (IV)	31	SR, VFSS, FEES	Myotomy (endoscopic)	12–23 months	64.5	None
Kos[9]	2010	RCS (IV)	28	VFSS, M	Myotomy (open)	2.5–203 months	79	Fever, aspiration pneumonia, mucosal perforation
Ozgursoy[10]	2010	RCS (IV)	14	SR, VFSS, MF	Myotomy (endoscopic)	6 months	100	Not mentioned
Bachy[32]	2013	PCS (IV	32	SR	Myotomy (endoscopic)	6–99 months	84	Severe bleeding
Lim[6]	1995	RCS (IV)	40	C, VFSS	Myotomy (endoscopic)	2–22 months	90	Esophageal perforation
Ali[31]	1997	Cohort study (IIb)	12	C	Dilatation (Savary)	6 weeks	58	Not mentioned
Hatlebakk[8]	1998	PCS (IV)	10	SR, M	Dilatation (Savary)	6–20 months	90	Not mentioned
Solt[43]	2001	RCS (IV)	5	C, VFSS, M	Dilatation (balloon)	7–33 months	100	Superficial mucosal splitting
Wang[44]	2005	RCS (IV)	6	SR	Dilatation (balloon + French)	8–27 months	100	None
Clary[21]	2011	RCS (IV)	42	SR	Dilatation (French)	Up to 72 months	64	Partial mucosal tears, laryngospasm
Dou[22]	2012	PCS (IV)	38	SR, VFSS	Dilatation (water-inflated balloon)	3–5 months	76.3	None

BoT-A = botulinum toxin serotype A; C = clinical; FEES = flexible endoscopic evaluation of swallowing; M = manometry; MF = manofluorography; PCS = prospective case series; RCS = retrospective case series; SR = self-rating; VFSS = videofluoroscopic swallowing study.

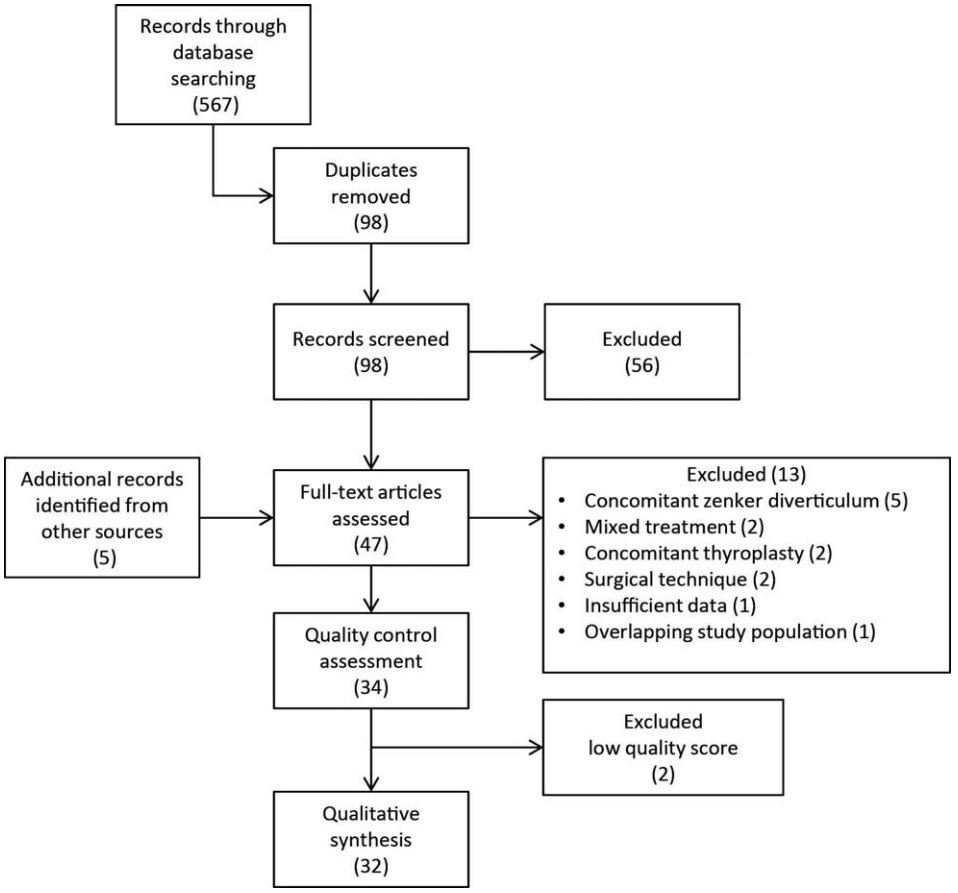

Fig. 1. Flow diagram of the search strategy.

following reasons: 1) surgical technique descriptions (two articles); 2) duplicate and overlapping study populations (one article); 3) insufficient data available to calculate the success rate of the procedure (one article); 4) patients with CP dysfunction besides Zenker's diverticulum over 1.5 cm and/or requiring diverticulectomy (five articles); 5) patients underwent concomitant thyroplasty with BoT injection or myotomy (two articles); 6) patients underwent BoT injection at the same time with myotomy or dilatation (two articles). Studies ranged from 10 to 20 of 25 points on the Downs and Black scale. Two articles receiving a score below 13 were also excluded from the evaluation (Fig. 1).

Twelve studies[4,8,22,24–32] were prospective and 20 [2,5,6,9,10,14,18,21,33–44] were retrospective. All of the publications were observational studies, with a level of evidence of IV; with the exception of one prospective cohort study (IIb) (Table II). All articles except for two dealt with one type of therapeutic procedure; the two exceptions each assessed two procedure types. In these two articles, the authors used one type of procedure for each patient and reported on the success rates and complications of the procedures separately.

Assessment of Success Rates and Complications Between BoT, Dilation, and Myotomy

Of the 32 articles, 12 articles reported on the success rates and complications of BoT injections, six articles on dilation, and 16 articles on myotomy. The range of reported success rates were between 43% and 100% for BoT injections (crude average =76%, patient-weighted average = 69%), between 58% and 100% for dilation (crude average = 81%, patient-weighted average = 73%), and between 25% and 100% for myotomy (crude average = 75%, patient-weighted average = 78%) (Table III).

Patient questionnaires, type of diet tolerated, clinical score of swallowing impairment, and flexible endoscopy had been used for the measurement of success rate in the majority of the articles. In some of the articles, a retrospective review of VFSS had been the choice as an objective tool.

The reported complication rates were between 0% and 25% for BoT injections (crude average = 5%, patient-weighted average = 4%), between 0% and 20% for dilation (crude average = 5%, patient-weighted average = 5%), and between 0% and 39% for myotomy (crude average = 6%, patient-weighted average = 7%) (Table IV). These included pharyngocutaneous fistula, pharyngeal tear, supraglottic edema, imminent mediastinitis, neck cellulitis, retropharyngeal hematoma, neck hematoma, esophageal perforation, laryngospasm, severe bleeding, and death through aspiration.

In logistic regression analysis of the patient-weighted averages, the 78% success rate with myotomy was significantly higher than the 69% success rate with BoT injections ($P = .042$), whereas the success rate of

TABLE III.
Distribution of Success Rates of BoT Injection, Dilation, and Myotomy.

	No. of Articles	Range of Success Rates (Crude Average)	No. of Patients (Sum)	No. of Successes (Sum)	Patient-Weighted Average Success Rate
BoT Injection	12	43%–100% (76%)	148	102	69%
Dilation	6	58%–100% (81%)	113	83	73%
Myotomy	16	25%–100% (75%)	369	286	78%

73% with dilation was not significantly different from that of either myotomy ($P = .37$) or BoT ($P = .42$).

Upon scoring the procedures for invasiveness as BoT injection = low, dilation = medium, and myotomy = high, there was a positive and statistically significant trend favoring increased success rate with increased invasiveness ($P = .039$). In contrast, we found no significant difference in complication rates between procedures via logistic regression, and no significant trend in complication rate with invasiveness via trend analysis.

Subgroup Analysis of Myotomy Procedures

A subgroup analysis was performed to assess the success and complication rates of open versus endoscopic myotomy. For this purpose, one study that used both methods was excluded. There were eight articles reporting outcomes of endoscopic myotomy, whereas seven evaluated open myotomy. Success rates ranged between 60% and 100% with endoscopic myotomy (crude average = 83%, patient-weighted average = 84%) compared to 73% and 79% with open myotomy (crude average = 68%, patient-weighted average = 71%). Comparison of success rates via logistic regression analysis revealed a significant increase in odds of success with the endoscopic procedure (ratio = 2.24, $P = .0025$). Complication rates were reported between 0% and 6% for endoscopic myotomy (crude average = 2%, patient-weighted average = 2%) versus 0% and 39% for open myotomy (crude average = 8%, patient-weighted average = 11%). Comparison of complication rates via logistic regression showed a significant increase in odds of complication with the open procedure (odds ratio = 5.01; $P = .0021$). Brief details of complications were mentioned in Table I.

Subgroup Analysis of BoT Injections

Botulinum toxin units were often reported as a range. We used the midpoint of the BoT unit range in analyzing success and complications rates. Logistic regression analysis indicated that a 20-unit increase in the midpoint BoT dose significantly increased the odds of success (odds ratio = 1.26, $P = .033$) without significantly changing the odds of complication (odds ratio = 0.74, $P = .33$).

DISCUSSION

CP dysfunction can present with various symptoms, often not fitting a common pattern. Patient complaints vary in severity from a lump sensation to complete inability to swallow and life-threatening aspiration. The workup varies among institutions, and there is no agreed on, uniform preoperative or postoperative evaluation technique. Similarly, because outcomes are generally not reported through objective measures, there is continued debate on the best surgical technique and the selection of suitable patients. The aim of this systematic review was to assess the success rates of myotomy, CP dilatation, and botulinum toxin injection in the management of CP dysfunction.

Kaplan is credited for performing the first CP myotomy in 1951 on a patient with bulbar poliomyositis.[45] Varying methods of transcervical myotomy have been described since then as can be seen in Table II. It can be noted that the majority of the articles were on the effectiveness of myotomy (seven papers on open myotomy, eight on endoscopic, and one comparing the two methods) in the management of CP dysfunction. We found the average success rate of myotomy to be 75%, and it was significantly higher than BoT injections ($P = .042$) but not statistically different than dilatation ($P = .37$). The average complication rate of 6% (range = 0%–39%) was not significantly higher than the other methods. Interestingly, myotomy outcomes were significantly better with the endoscopic technique (odds ratio = 2.24), supplemented with the advantage of decreased complication rates ($P = .0021$). Although the risk of mediastinitis and fistula could not be completely excluded by endoscopic laser myotomy, limiting the procedure to the fibers of the cricopharyngeus muscle considerably reduced it.[2,6,10,30,32,38,40–42] Also, any injury to the

TABLE IV.
Distribution of Complications of BoT Injection, Dilation, and Myotomy

	No. of Articles	Range of Complication Rates (Crude Average)	No. of Patients (Sum)	No. of Complications (Sum)	Patient-Weighted Average Complication Rate
BoT Injection	12	0%–25% (5%)	148	6	4%
Dilation	6	0%–20% (5%)	113	6	5%
Myotomy	16	0%–39% (6%)	369	27	7%

recurrent laryngeal nerve is avoided, and the postoperative course is significantly shortened with minimal pain and quick return to swallowing when endoscopic technique can be employed.[30]

The reported articles include patients with various etiologies. Mason et al. reported that the results of myotomy were excellent or good in patients with no discernible (idiopathic) underlying disease, but were not as good in patients with neuropathic or myopathic disease. They also evaluated the role of preoperative manometry and noted that the only factor predicting the success of the procedure, other than the etiology of the disorder, was impaired sphincter opening during manometry (odds ratio = 8.4). They went on to suggest that the most important manometric marker was the absence of the subatmospheric intrasphincteric pressure drop. They concluded that, when combined with an increased intrabolus pressure, the mechanical indicators that the procedure should work are present. Mason et al. also modified the procedure where they divide the sternohyoid and omohyoid muscles (depressors of the hyoid) to improve laryngeal elevation.[39] On the other hand, Poirier et al., in their 40-patient series with a neurogenic origin, reported success if the following criteria were fulfilled: 1) normal voluntary deglutition, 2) adequate tongue movement, 3) intact laryngeal function and phonation, and 4) absence of dysarthria.[14] Kos et al. also report the etiology of the dysphagia to be the most important prognostic factor. The patients with no apparent cause of dysphagia or with non–cancer-related iatrogenic oropharyngeal dysphagia showed 100% improvement. The outcomes in patients with central nervous system damage and extensive head and neck cancer therapy were not as rewarding (25% success rates). Their group also challenged the absence of hypopharyngeal contractions as a contraindication to surgery. In their series, although 71% of the patients with normal constrictor activity showed improvement, 79% with reduced and 71% with absent activity also showed successful outcomes following myotomy.[9] This was also advocated by Ozgursoy and Salassa, and Bammer et al., who reported improved swallowing in patients with weak pharyngeal driving forces.[10,46]

Botulinum toxin injections have been used as a test to determine whether myotomy would be effective.[18] On the other hand, Zaninotto et al. reported success with myotomy even in patients who failed BoT injections, and suggest it should not be used to discriminate between patients who may or may not benefit from surgery.[25]

There is also disagreement between authors on the necessary postoperative studies. Most outcomes are reported on subjective patient improvement. This limits our ability to uniformly compare studies and reported outcomes.

There were fewer studies reporting on the efficacy of CP dilatation. The main advantages include being less invasive and ability to be performed under sedation. This makes it a suitable alternative in patients who cannot undergo general anesthesia along with electromyography-(EMG)-guided in-office BoT injections. Ali et al. performed the only study comparing myotomy and dilatation outcomes. They operated on 20 patients, 12 of whom underwent dilatation and eight myotomy. The patient selection was dictated by clinical circumstances and patient preference, with the exception of patients demonstrating manometric failure of UES relaxations. All of these patients underwent myotomy. They clinically evaluated the patients 6 weeks postoperatively. They had an overall response rate of 65%; 75% of the patients undergoing myotomy and 58% of the patients undergoing dilatation had responded. Unfortunately, when reporting outcomes, they did not differentiate between the two groups.[31] Hatlebakk et al. reported that nine out of the 10 patients remained on an oral diet at 13 months, following dilatation with 18 to 20 mm Savary dilators. On manometry, UES pressures were significantly reduced, and/or the duration and completeness of relaxation increased following dilatation.[8] Solt et al. reported similar improvement in patients without organic stenosis of the UES, with redilatation needed in one patient (out of five) at 21 months.[43] Wang et al. also used dilatation for patients with CP dysfunction that could only be attributed to a CP bar and reported complete response.[44] Clary et al. suggested CP bougie dilatation as a first surgical step. They advocate this two-step approach for two reasons: 1) if dysphagia resolves, the patient can avoid a more morbid myotomy, and 2) if patient experiences no relief, it can suggest a need for further workup to evaluate other causes of dysphagia.[21]

Since the first report of BoT injections for CP dysfunction by Schneider, many have advocated the use of it due to the minimal invasiveness of the procedure, ability to perform in the clinic with EMG guidance, and minimal morbidity.[24] The effective duration varies on the injected site, dosag, and type of disease.[27] Most studies have reported doses between 5 and 50 units[4,18,34] up to 100 units.[20] The maximum duration of the beneficial effects continues to be studied. Terre et al. reported improvement up to a year with a single 100-U injection. They attributed this to the reduction of basal UES pressure, with a subsequent increase in pharyngeal pressure that permitted improvement in sphincter relaxation, as well as the achieved oral diet permitting the strengthening of swallowing musculature.[27] Although Terre et al. recommended BoT injections for patients who had incomplete relaxation of the CP muscle with a certain degree of pharyngeal propulsion, Woisard-Bassols et al. reported good outcomes in patients with CP dysfunction and pharyngolaryngeal weakness.[29] Our review found that BoT injections are not as successful as myotomy, and as the invasiveness of the procedure increased (BoT = low, dilatation = medium, myotomy = high), there was a statistically significant trend favoring increased success rates.

This systematic review has several limitations. Primarily, retrospective chart review studies and prospective cohort studies are subject to selection bias; therefore, the level of evidence provided by this review relies on the strength of the individual articles. The surgeons may select a patient to undergo a particular procedure based on CP dysfunction etiology, patient comorbidities, and surgeon experience. Patients are also allowed to choose the treatment based on recommendations. In CP dysfunction, there is also no universally

agreed on algorithm for management, including preoperative diagnostic testing and patient selection criteria for surgical approach. Due to this, we aimed to only evaluate surgical outcomes. This study is also limited in regard to making recommendations on patient selection for a particular surgical method. Furthermore, the studies reviewed reported outcomes with various methods, relying heavily on self-rating and clinical improvement. Similarly, due to the nature of the disease and infrequency, the largest series in this review included 42 patients. Nevertheless, we believe our data improves our understanding of the surgical management techniques for CP dysfunction and can serve as a starting point for future, well-designed, multicenter prospective trials.

CONCLUSION

In the current systematic review, logistic regression analysis of patient-weighted averages revealed significantly higher success rates with myotomy compared to BoT injections. Although the success rates of dilatation were not found to be significantly different from BoT injections or myotomy, there were also fewer studies assessing myotomy. There was no significant difference in regard to complication rates, and the effectiveness of the procedures improved as the invasiveness increased. As a result, in the well-selected patient, all of these procedures can be employed with good outcomes and minimal morbidity.

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