A novel endoscopic surgery for dysphagia after stroke

Jian Wang1 · Wuyi Li1 · Yongjin Li1 · Xiaofeng Jin1 · Yanyan Niu1 · Xu Tian1 · Hong Huo1

Abstract
Background Dysphagia is a common complication in stroke patients, which severely affects quality of life. This study aimed to evaluate the effectiveness and safety of temperature-controlled plasma radiofrequency (coblation)-assisted endoscopic cricopharyngeal myotomy (CAECPM) for the treatment sustained (>6 months) dysphagia in stroke patients.

Methods This retrospective case-control study included a total of 24 stroke patients with sustained dysphagia, who were either treated with transcervical cricopharyngeal myotomy (CPM) (n = 16) or CAECPM (n = 12). The patients’ swallowing function was evaluated by the Chinese version of the swallow quality-of-life questionnaire (CSWAL-QOL), and dysphagia and aspiration was evaluated using the videofluoroscopic swallowing study (VFSS) swallowing (VFSS-SWAL) score and VFSS aspiration (VFSS-ASPI) score. In each patient, esophageal pressure and complications were also recorded.

Results The CSWAL-QOL score was increased and the VFSS-SWAL and VFSS-ASPI scores were reduced after CAECPM treatment. The upper esophageal sphincter pressure was significantly reduced after CAECPM. Only 1 of 12 (8.3%) patients had subcutaneous and mediastinal emphysema, and 2 patients had gastric regurgitation.

Conclusion This exploratory study demonstrates that CAECPM is worth further investigation for dysphagia after stroke. CAECPM may be an effective and safe treatment for sustained dysphagia in stroke patients. Larger and prospective studies are required to validate these results.

Keywords Coblation · Dysphagia · Cricopharyngeal myotomy · Stroke · Esophageal pressure

Dysphagia is one of the most common symptoms in patients with cerebral apoplexy. Epidemiological studies have showed that the incidence of dysphagia in stroke patients is 18.7–50% worldwide [1, 2]. Although dysphagia can resolve within a few days or weeks after stroke, sustained dysphagia occurs in approximately 8–13% of stroke patients [3, 4].

The videofluoroscopic swallowing study (VFSS) is often used to detect swallowing dysfunction, and is sensitive to detect dysphagia in stroke patients [3]. Cricopharyngeal muscle contraction with increased esophageal sphincter pressure is a major cause of sustained dysphagia after stroke [5].

Although several conservative treatments have been used to improve swallowing function in stroke patients with sustained dysphagia—including changing food traits, physical rehabilitation, and nasogastric tube or jejunum feeding tube placement—these treatments do not significantly reduce the incidence of aspiration pneumonia and mortality [6]. Moreover, traditional surgical intervention such as transcervical cricopharyngeal myotomy (CPM), endoscopic laser CPM (ELCPM), and botulinum toxin (Botox) injection is often needed for stroke patients with sustained dysphagia [5, 7].

Temperature-controlled plasma radiofrequency (coblation), which can quickly dehydrate and break the target tissues by forming a plasma field via a bipolar wand, has been widely used in throat surgery. Coblation has many...
advantages compared with traditional radiofrequency methods. For examples, coblation causes less damage to the surrounding tissues due to its low working temperature (40–90 °C) [8]. In addition, direct contact with the tissue via the plasma knife provides good tactile feedback for the surgeons. Quick removal of smoke by coblation can reduce burn risk to the airway. However, the safety and effectiveness of coblation-assisted endoscopic cricopharyngeal myotomy (CAECPM) for the treatment of sustained dysphagia in stroke patients have not been investigated to date.

In this study, we compared the effect of CAECPM vs transcervical CPM in stroke patients with sustained dysphagia. The purpose of this study was to investigate the effectiveness and safety of CAECPM in the treatment of dysphagia in stroke patients.

Materials and methods

Patients

This study was approved by the Medical Ethics Committee of Peking Union Medical College Hospital, and all patients gave their informed consent. This retrospective case-control study included 28 stroke patients with sustained dysphagia who underwent CPM at our hospital between January 2015 and August 2016. We retrospectively analyzed the medical records of the 28 patients. Stroke patients with the presence of sustained dysphagia (>6 months) were included in this study. Exclusion criteria were a previous history of dysphasia; cancer including head and neck cancer, neurodegenerative diseases, or neuromuscular disorders; and radiotherapy history of head and neck, and long-term bedridden patients. Of the 28 patients, 12 patients underwent CAECPM. The other 16 control patients underwent transcervical CPM. All the patients had eating difficulties, but had independent self-care ability such as personal hygiene, dressing, defecation, and movement.

Surgical procedure

The surgical field exposure procedure for CAECPM was performed as previously reported [7] (Fig. 1). Briefly, the cricopharyngeal muscle was exposed using a diverticuloscope (Karl Storz, Tuttingen, Germany). Under the view of a 12° or 30° rigid laryngeal endoscope, a type 7070 Coblator® (ArthroCare Corp, Sunnyvale, CA) was introduced to incise the cricopharyngeal muscle longitudinally to separate the mucosa. The Coblator was then used to blunt dissect the tissues posterior to the cricopharyngeal muscle. The muscle was integrally isolated from the buccopharyngeal fascia and removed. Each cricopharyngeal muscle fiber and partial esophageal inner circular layer muscle nearby was removed without damage to the buccopharyngeal fascia. The incision power was set at grade 7, and the coagulation power was set at grade 3–5 in temperature-controlled plasma radiofrequency ablation. Electrocoagulation was assisted when excessive bleeding occurred. The assistant adjusted the endoscope to maintain the Coblator in the center of the view. Since Coblator has the function of ablation and absorption, no other system is needed to remove the smoke.

For control patients, traditional transcervical CPM was performed (Fig. 2). By placing a urinary catheter tube with a balloon sac in the esophagus preoperatively, the integrity of the muscle and mucosa during the operation could be maintained and better identified. A transverse incision was made in the neck. Then the lower thyroid cartilage, cricoid cartilage, trachea, and esophagus were fully exposed by pulling away the lateral thyroid gland. The recurrent laryngeal nerve was carefully dissected and protected. The sac of the urinary catheter tube was then inflated with 5–10 ml air. The urinary catheter tube was gradually pulled up until it was fixed. The air sac location was the cricopharyngeal muscle level. The esophageal sphincter and cricopharyngeal muscle were resected via half circumferential resection rather than transection, using a size-15 bladder. The mucosa of the esophagus and pharynx was kept intact.

Swallowing function evaluation

Clinical information of all patients were recorded, including the patient’s body weight, [Chinese version] swallow quality-of-life questionnaire (CSWAL-QOL) score [9], time of nasogastric tube (NGT) removal, videofluoroscopic swallowing study (VFSS) score, high-resolution measurement (HRM) of upper esophageal sphincter, and post-operation hospitalization time (HT). All the patients were followed up for more than 6 months after surgery.

The SWAL-QOL was established by McHomey et al. [9]. The CSWAL-QOL, which showed relative high reliability and validity in the Chinese population, was revised by Lam et al. [10]. The CSWAL-QOL evaluated swallowing function in this study.

Dysphagia and aspiration was evaluated using VFSS (Fig. 3). The VFSS swallowing (VFSS-SWAL) score was evaluated according to the VFSS scoring system proposed by Frowen et al. [11]. The VFSS aspiration (VFSS-ASPI) score was assessed using Rosenbek’s method [12]. Higher VFSS scores indicate severe dysphagia and aspiration.

Esophageal pressure measurement

Esophageal pressure was measured using high-resolution manometry (HRM) (ManoScan 360™; Given Imaging Inc, Duluth, GA). Each patient swallowed 5 ml of water 10
times, and the changes in the esophageal pressure were recorded by a pressure sensor. The average resting pressure [RestP (A)], minimal resting pressure [RestP (Min)], average residual pressure [ResiP (A)] and average relaxation ratio were calculated using ManoView analysis software (Given Imaging Inc, Duluth, GA).

**Statistical analysis**

Statistical analyses were performed using SPSS v17.0 statistical software (SPSS, Chicago, IL). Quantitative data without normal distribution were expressed as median and interquartile range and compared by Wilcoxon rank sum test. Quantitative data with normal distribution were expressed as mean ± standard deviation and analyzed by Student’s t test. Categorical data were compared by Chi squared ($\chi^2$) test. Probability values less than 0.05 were considered statistically significant.

**Results**

**Baseline characteristics**

Table 1 summarizes the baseline characteristics of patients in the CAECPM and CPM groups. Of the 12 patients in the CAECPM group, 5 were male and 7 were female. The mean age of the patients was 63.33 ± 6.3 years (range,
The mean disease duration was 13.25 ± 7.2 months (range, 6–29 months). The mean postoperative hospitalization stay was 4 ± 0.8 days (range, 3–5 days). The average follow-up period was 7.37 ± 2.2 months (range, 6–11 months).

Of the 16 stroke patients in the control CPM group, 7 were male and 9 were female. The average age of the patients was 58.81 ± 8.8 years (range, 54–75 years). The mean disease duration was 13.87 ± 6.9 months (range, 8–38 months). The mean postoperative hospitalization stay was 6.75 ± 0.8 days (range, 6–9 days). The average follow-up period was 8.25 ± 1.8 months (range, 6–12 months).

There were no statistical differences in age, sex, disease duration, and follow-up period between the two groups (P > 0.05) (Table 1).

### Swallowing function evaluation

Of the 12 patients in the CAECPM group, 10 received NGT nutrition, and the NGT was successfully removed in 9 patients during the postoperative follow-up. Table 2 summarizes the swallowing function evaluation in patients in the CAECPM group before and after surgery. Mean body weight increased from preoperative 53.75 ± 10.8 kg to postoperative 57.92 ± 8.4 kg (t = −4.614, P = 0.001).

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**Table 1** Baseline characteristics of patients *(N = 24)* in the CAECPM and CPM groups

<table>
<thead>
<tr>
<th></th>
<th>CAECPM <em>(n = 12)</em></th>
<th>CPM <em>(n = 16)</em></th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>63.33 ± 6.3</td>
<td>58.81 ± 8.8</td>
<td>0.124</td>
</tr>
<tr>
<td>Disease duration (months)</td>
<td>13.25 ± 7.2</td>
<td>13.87 ± 6.9</td>
<td>0.820</td>
</tr>
<tr>
<td>Gender (male/female)</td>
<td>5/7</td>
<td>7/9</td>
<td>0.609</td>
</tr>
<tr>
<td>Follow-up time (months)</td>
<td>7.37 ± 2.2</td>
<td>8.25 ± 1.8</td>
<td>0.216</td>
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</table>

CAECPM coblation-assisted endoscopic cricopharyngeal myotomy; CPM cricopharyngeal myotomy
The CSWAL-QOL score was significantly elevated from preoperative 26.92 ± 4.8 to postoperative 50.25 ± 14.2 (t = −5.104, P = 0.000). The VFSS-SWAL score was significantly reduced from preoperative 7.08 ± 1.9 to postoperative 3.75 ± 2.7 (t = 6.916, P < 0.001). The VFSS-ASPI score was significantly decreased from preoperative 6.67 ± 1.2 to postoperative 3.33 ± 1.6 (t = 8.864, P = 0.000).

For patients in the CPM group, 11 out of 16 patients received nutrition through the gastric tube before surgery, and the tube was successfully removed in 9 patients. The mean body weight of the 16 patients was elevated from preoperative 56.56 ± 7.7 kg to postoperative 58.31 ± 6.4 kg. The VFSS-SWAL score was significantly reduced from preoperative 6.69 ± 1.3 to postoperative 2.94 ± 1.4. The CSWAL-QOL score was not measured because preoperative SCWAL-QOL was not available in the CPM group. The VFSS-ASPI score was significantly reduced from preoperative 6.68 ± 1.2 to postoperative 2.81 ± 1.0.

Compared with the control group, the body weight gain was significantly greater in the CAECPM group (t = −2.292, P = 0.034). The mean length of hospitalization stay was significantly shorter in the CAECPM group than in the control group (t = 8.780, P = 0.000) (Table 3). There was no significant difference in decannulation rate, VFSS-SWAL improvement, and VFSS-ASPI improvement between the two groups (P > 0.05, Table 3).

**Esophageal pressure**

In the CAECPM group, the RestP (A) value was significantly decreased from preoperative 87.30 ± 25.8 mmHg to postoperative 43.47 ± 19.8 mmHg (t = 4.912, P = 0.000). The RestP (Min) value was significantly reduced from preoperative 68.32 ± 16.6 mmHg to postoperative 30.95 ± 19.3 mmHg (t = 6.426, P = 0.000). The ResiP (A) values were significantly reduced from preoperative 64.68 ± 36.9 mmHg to postoperative 16.39 ± 15.3 mmHg (t = 4.028, P = 0.002) (Fig. 4).

**Complications**

In the CAECPM group, postoperative subcutaneous and mediastinal emphysema occurred in 1 of 12 (8.3%) patients (Fig. 5). The emphysema disappeared within 4 days without severe infection. Gastric regurgitation occurred in 2 patients without any further treatments. No patients suffered from incision infection, mediastinal infection, and severe bleeding. No new vocal disorders occurred after operation. For control patients, no emphysema, deep cervical fascial space infection, or recurrent laryngeal nerve injury occurred.

**Discussion**

Loss of relaxation in the cricopharyngeal muscle is the main cause of dysphagia and aspiration in stroke patients. Effective treatment of dysphagia can reduce the lung infection-associated mortality, improve the nutritional status, and increase the quality of life in stroke patients [1]. Currently, the main treatment options for sustained dysphagia due to cricopharyngeal muscle dysfunction include swallowing training, balloon expansion, botulinum toxin injection, cricopharyngeal muscle or upper esophageal sphincter incision, and laser-assisted endoscopic CPM. The major surgical methods include pharyngeal muscle resection through neck and microscopic laser-assisted pharyngeal muscle resection. There is still lack of reports about the application of endoscopic Coblation-assisted pharyngeal muscle resection.

Endoscopic CPM is preferred by surgeons since it has similar safety and effectiveness compared with traditional open surgery, and is associated with many advantages such as smaller wound, no external scar, shorter operation time, less pharyngeal fistula, and esophageal perforation and, and thus is associated with longer hospitalization stay. Furthermore, peroral CPM can avoid recurrent laryngeal nerve injury, which can reduce the rate of postoperative vocal

**Table 2** Swallowing function evaluated in stroke patients (N = 28) before and after the CAECPM (n = 12) and CPM (n = 16) procedures

<table>
<thead>
<tr>
<th>Patient weight (kg)</th>
<th>VFSS-SWAL</th>
<th>VFSS-ASPI</th>
<th>CSWAL-QOL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CAECPM</td>
<td>CPM</td>
<td>CAECPM</td>
</tr>
<tr>
<td>Pre-operation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>53.75 ± 10.8</td>
<td>7.08 ± 1.9</td>
<td>6.69 ± 1.3</td>
<td>6.67 ± 1.2</td>
</tr>
<tr>
<td>56.56 ± 7.7</td>
<td>3.75 ± 2.7</td>
<td>2.94 ± 1.4</td>
<td>3.33 ± 1.6</td>
</tr>
<tr>
<td>Post-operation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>57.92 ± 8.4</td>
<td>6.916</td>
<td>8.532</td>
<td>8.864</td>
</tr>
<tr>
<td>58.31 ± 6.4</td>
<td>4.614</td>
<td>2.292</td>
<td>0.001</td>
</tr>
</tbody>
</table>

CAECPM coblation-assisted endoscopic cricopharyngeal myotomy; CPM cricopharyngeal myotomy; VFSS-ASPI videofluoroscopic swallowing study-aspiration; VFSS-SWAL videofluoroscopic swallowing study (VFSS)-swallowing; CSWAL-QOL [Chinese version] swallow quality-of-life questionnaire
Cord paralysis [7, 13–16]. Endoscope has some advantages because it can provide a wider angle [17] and reduce the dead zone in operation [18]. In addition, endoscope can change the angle and depth, and thus avoids the repeated focal length regulation and shorten operation time [19]. Endoscope can observe the operating field from different angles, which can provide conditions for learning [18].

Coblation has been widely used in tonsillectomy and adenoidectomy. It has been reported that coblation can shorten the operative time in tonsillectomy, and is associated with lower postoperative pain, but healing was slightly delayed in adults [20, 21]. Paramasivan et al. reported that the application of coblation for adenotonsillectomy had several advantages over standard methods for the treatment of children with obstructive sleep apnea. Coblation is a type of contact-type system that can avoid the drawback of poor tactile feedback. In addition, Coblator can keep surgical structure clear by removing smog, blood, and secretion, thus facilitating the surgical procedure [22].

Meanwhile, CEACPM can combine with endoscope or microscope, which avoids the disadvantage of laser surgery.

This is the first report about the effectiveness of CAECMP in the treatment of dysphagia in stroke patients. In this study, we compared the effectiveness of CAECMP vs CPM in stroke patients with sustained dysphagia. We found that compared with traditional CPM, CAECMP treatment was associated with greater weight gain and shorter hospitalization stay, but has a similar decannulation rate, suggesting that CAECMP may be similar or better than CPM in oral intake and body weight gain. In addition, we found that CAECMP and CPM has a similar effect on the VFSS-SWAL improvement and VFSS-ASPI improvement, suggesting that CAECMP is similar to CPM in improving swallowing function.

Although traditional cricopharyngeal muscle amputation can alleviate dysphagia by reducing muscle tension, recurrent dysphagia occurred after cricopharyngeal muscle amputation due to reconnection of the remnant muscle fiber by scar formation, and complete excision of the muscle during secondary operation achieved good outcome [23].

**Table 3** Patients’ swallowing function in the CPM and CAECMP groups (*N* = 28)

<table>
<thead>
<tr>
<th></th>
<th>CPM (<em>n</em> = 16)</th>
<th>CAECMP (<em>n</em> = 12)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight gain (kg)</td>
<td>1.75 ± 2.2</td>
<td>4.17 ± 3.1</td>
<td>0.034</td>
</tr>
<tr>
<td>Mean length of stay (days)</td>
<td>6.75 ± 0.8</td>
<td>4.00 ± 0.8</td>
<td>0.000</td>
</tr>
<tr>
<td>Decannulation rate</td>
<td>9/11</td>
<td>9/10</td>
<td>0.538</td>
</tr>
<tr>
<td>VFSS-SWAL improvement</td>
<td>3.81 ± 1.3</td>
<td>3.33 ± 1.7</td>
<td>0.422</td>
</tr>
<tr>
<td>VFSS-ASPI improvement</td>
<td>3.62 ± 1.5</td>
<td>3.32 ± 1.3</td>
<td>0.588</td>
</tr>
</tbody>
</table>

CAECMP: coblation-assisted endoscopic cricopharyngeal myotomy; CPM: cricopharyngeal myotomy; VFSS-ASPI: videofluoroscopic swallowing study-aspiration; VFSS-SWAL: videofluoroscopic swallowing study (VFSS-swallowing)

**Fig. 4** Mean upper esophageal sphincter pressure as measured before and after CAECMP. Green bar: preoperative value; blue bar: postoperative value. RestP(A): average residual pressure, RestP(Min): minimal resting pressure

**Fig. 5** CT image showing subcutaneous emphysema

*Surg Endosc*
Therefore, we believed that removal of the cricopharyngeal muscle may reduce the possibility of reconnection of the remnant muscle fiber. Traditional CPM complications include the following: mediastinitis, neck abscess, or fistula, severe bleeding, vocal fold paralysis [7, 24]. The complications in this study were in accordance with previous reports, only 1 of 12 (8.3%) patients had subcutaneous and mediastinal emphysema (which disappeared with 4 days). Gastric regurgitation occurred in 2 of 12 (16.7%) patients. No other complications such as vocal disorders, incision infection, mediastinal infection, and severe bleeding occurred. A key step to reduce complications is to maintain the integrity of buccopharyngeal fascia, which can prevent postoperative deep cervical fascial space infection.

In conclusion, we investigated the effectiveness and safety of CAECPM in the treatment of dysphagia in stroke patients. We found that CAECPM improved swallowing function, decreased upper esophageal sphincter pressure, and was associated with fewer complications in stroke patients with sustained dysphagia. Moreover, CAECPM treatment was associated with greater body weight gain and less hospitalization stay compared with CPM treatment. Our findings suggest that CAECPM (which utilizes the coblation technique) provides a new choice for pharyngolaryngeal endoscopic surgery. However, since our study has a small sample size, future studies with a large sample size are required to confirm our conclusion.

Acknowledgement This study was supported by a grant from the National Natural Science Foundation (No: H1301 81300816).

Compliance with ethical standards

Conflict of interest Jian Wang, Wuyi Li, Yongjin Li, Xiaofeng Jin, Yanyan Niu, Xu Tian, and Hong Huo declare that they have no conflicts of interest or financial ties to disclose.

References