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Buteyko breathing technique for obstructive Eustachian tube dysfunction: Preliminary results from a randomized controlled trial

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ABSTRACT

Purpose: To assess the effectiveness of Buteyko breathing technique in patients with obstructive Eustachian tube dysfunction (ETD).

Materials and methods: Fifty-one patients (77 ears) aged between 21 and 62 years were randomized to Buteyko breathing in conjunction with medical management (nasal steroid) group or medical management alone group. The Eustachian Tube Dysfunction Questionnaire (ETDQ-7) symptom scores, tympanogram, positive Valsalva maneuver were evaluated at baseline, 6-week and 12-week follow-up.

Results: Normalization of ETDQ-7 symptom scores at 6-week follow-up was observed in 30.0% (12/40) of the Buteyko breathing group versus 16.2% (6/37) of the controls ($P > 0.05$). At 12-week follow-up, the ratio rose to 50.0% (20/40) in the Buteyko breathing group and 24.3% (9/37) in the controls ($P < 0.05$). Tympanogram normalization at 12-week follow-up was observed in 53.6% (15/28) of the Buteyko breathing group versus 26.9% (7/26) of the controls ($P < 0.05$). The Buteyko breathing group showed slight improvement in positive Valsalva maneuver at 6- and 12-week follow-up ($P > 0.05$).

Conclusions: Our study shows that Buteyko breathing technique might be an effective adjunctive intervention in treatment of obstructive ETD, especially for those patients who are refractory to medical treatment and cannot afford Eustachian tube balloon dilation surgery.

1. Introduction

Eustachian tube dysfunction (ETD) is a condition that the function of the Eustachian tube (ET) for ventilation and drainage of the middle ear is compromised, which causes aural fullness, hearing loss, otalgia, and tinnitus. Complications associated with persistent ETD include otitis media with effusion (OME), middle ear atelectasis, chronic otitis media and even cholesteatoma [1–3]. Generally, ETD can be categorized into two major subtypes: obstructive dysfunction and patulous dysfunction [4]. Notably, obstructive ETD is the most common subtype of ETD and is estimated to have a prevalence of 1% among adults [1,5–7]. Despite considerable efforts, the exact pathophysiology of obstructive ETD has not been well elucidated yet [8]. Therefore, there is no gold standard treatment for obstructive ETD. Conventional medical treatment including nasal steroid, decongestants and antihistamines aimed at improving mucosal conditions of the ET. However, their efficacy has not been proven because of lack of high-quality studies [9,10]. Recently, Eustachian tube balloon dilation (ETBD) is emerged as a promising intervention for treatment of patients with obstructive ETD refractory to medication [11–15]. However, the high hospitalization cost for ETBD surgery limits its wide use in many developing countries. The Buteyko breathing technique was developed to reduce hyperventilation. Previous studies have demonstrated that it can reduce both asthma and nasal symptoms [16,17]. Intriguingly, a recent case report described that a soldier's condition associated with ETD resolved rapidly after implementation of Buteyko breathing technique [18].

The aim of the present study is to evaluate the effectiveness of Buteyko breathing technique in conjunction with nasal steroid compared to nasal steroid alone in patients with obstructive ETD.

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2. Methods

2.1. Patients

A single-centre randomized controlled trial was carried out at our outpatient clinic between June 2018 and November 2018. Eligible patients were 20 years and older with obstructive ETD who had persistent symptoms for > 3 months and had not received any medication treatment before enrollment. Obstructive ETD was defined by patient-reported symptoms that meet the criteria of mean item score ≥ 2.1 of the Eustachian Tube Dysfunction Questionnaire (ETDQ-7) [19] in combination with a type A or type C tympanogram after exclusion of patulous ETD [20]. Exclusion criteria also included chronic suppurative otitis media, history of OME, chronic rhinosinusitis, history of radiation, fluctuating sensorineural hearing loss, acute upper respiratory infection and temporomandibular joint disorder.

2.2. Treatment

At the point of entry into the trial, patients were allocated to Buteyko breathing plus nasal steroid group (Buteyko breathing group) or nasal steroid alone groups (control group) using a randomly allocated computer-generated code. No other treatments were permitted in either group. Patients in the Buteyko breathing group were taught the breathing technique by a Buteyko practitioner and were encouraged to practice the exercise repeatedly throughout the day. This training involves a series of exercises in which subjects reduced the depth and frequency of breathing [21]. The aim of the Buteyko breathing was to correct the patient's breathing pattern by reducing hyperventilation. Nasal steroid regimen consists of two sprays of budesonide to each nostril once per day (256 μg total daily dose). The ETDQ-7 symptom scores and positive Valsalva maneuver were recorded at baseline, 6- and 12-week follow-up. Tympanogram were recorded at baseline and 12-week follow-up. Otoscopic examination and pure tone audiogram were also performed at baseline and 12-week follow-up. The effectiveness was defined as ETDQ-7 scores normalization (mean item score < 2.1), tympanogram normalization (type A) and positive Valsalva maneuver ability. The study was approved by the ethical review board of Sun Yat-sen Memorial Hospital, Sun Yat-sen University, China, and informed consent was obtained from all participants.

2.3. Statistical analysis

The results were analyzed using SPSS 16.0 (Chicago, IL, USA). Statistical analysis was performed by Chi-square test and Student's *t*-test. A P value of < 0.05 was considered to be statistically significant.

3. Results

Fifty-six consecutive patients with obstructive ETD aged between 21 and 62 years satisfied the inclusion criteria and were enrolled in the present study prospectively. Twenty-nine patients were randomly allocated to the Buteyko breathing group, and the remaining twenty-seven to the control group. Two patient from the Buteyko breathing group and three patients from the control group were lost to follow-up. Finally, 51 patients (77 ears) finished the trial (Fig. 1). Baseline characteristics for enrolled patients are shown in Table 1. Mean age in the Buteyko breathing group and the control groups is 39.3 years (range 24–62) and 40.8 years (range 21–61), respectively. Male:female ratio was 16:11 in the Buteyko breathing group and 13:11 in the control group. Thirteen patients (48.1%) had the symptoms in both ears in the Buteyko breathing group, while 13 patients (54.2%) had bilateral symptoms in the control group (Table 1). No tympanic membrane perforations and retraction pockets were observed in all patients. Two patients in the Buteyko breathing group and 3 patients in the control group showed slight sensorineural hearing loss at 4000 and 8000 Hz. Other patients had normal hearing at all tested frequencies.

Mean score of ETDQ-7 was 4.5 (range 3.6–5.7) and 4.6 (range 3.4–6.1) in the Buteyko breathing group and the control group at baseline, respectively. At 6-week follow-up, more patients in the Buteyko breathing group had normal ETDQ-7 symptom scores (mean item score < 2.1) in comparison to the control group (30.0% [12/40 ears] vs. 16.2% [6/37 ears]; Difference in proportions, 13.8%; 95% CI, −4.73% to 32.3%; $P = 0.153$), although the difference did not reach statistical significance. At 12-week follow-up, significant more patients in the Buteyko breathing group reported their symptoms were completely relieved compared to the control group (50.0% [20/40 ears] vs. 24.3% [9/37 ears]; $P = 0.020$) (Fig. 2).

Improvement in tympanogram was correlated with normalization of ETDQ-7 scores. At baseline, type A tympanogram was presented in 30.0% (12/40) and 29.7% (11/37) of ears in the Buteyko breathing group and the control group, respectively. In contrast, type C tympanogram was presented in 70.0% (28/40) and 71.3% (26/37) of ears in the Buteyko breathing group and the control group, respectively. At 12-week follow-up, 53.6% of type C tympanogram ears (15/28) in the Buteyko breathing group achieved tympanogram normalization. However, only 26.9% of type C tympanogram ears (7/26) normalized tympanogram in the control group ($P = 0.046$) (Fig. 3).

At baseline, positive Valsalva maneuver was only present in 22.5% (9/40) and 27.0% (10/37) of ears in the Buteyko breathing group and the control group, respectively. At 6-week follow-up, nearly equal ears regained the ability of positive Valsalva maneuver in the Buteyko breathing group compared to the control group (32.3% [10/31] vs. 29.6% [8/27]; Difference in proportions, 2.7%; 95% CI, −21.2% to 26.5%; $P = 0.829$). At 12-week follow-up, the ratio was slightly higher, though not significantly different, in the Buteyko breathing group compared to the control group (41.9% [13/31] vs. 29.6% [8/27]; Difference in proportions, 12.3%; 95% CI, −12.2% to 36.8%; $P = 0.331$) (Fig. 4).

Individual patient data in the Buteyko breathing group and the control group was shown in Tables 2 and 3, respectively.

4. Discussion

The pathogenesis of ETD remains largely unknown. Currently, treatment for ETD includes watchful waiting, autoinsufflation, pharmaceutical interventions (nasal steroid, topical decongestant and antihistamine) and surgery [4,10]. However, there is no strong evidence supporting the efficacy of non-surgical interventions [3]. Conventional surgical interventions include tympanostomy tube placement and Eustachian tuboplasty. Although insertion of tympanostomy tube improves the symptoms of ETD substantially, repeated need for tubes occurs commonly and long-term tabulation is associated with increased complications such as tympanic membrane perforation, infections, myringosclerosis and even cholesteatoma [3,10]. Eustachian tuboplasty using multiple techniques was reported to have some degrees of effect but in smaller series of patients [22].

ETBD, a newly developed therapeutic approach, has showed promising outcomes in treatment of obstructive ETD since 2010 [5,12,15,23]. ETBD dilates the ET directly by inflation of a non-compressible balloon in the cartilaginous ET. The histological study also demonstrated ETBD crushes portions of irreversibly inflamed epithelium and reduces inflammatory burden of the ET [24]. A recent prospective multicenter randomized controlled trial provided convincing evidence showing superiority of ETBD plus nasal steroid compared to nasal steroid alone to treat obstructive ETD [13,14]. However, the cost for ETBD surgery is relatively high in many developing countries, including China. For instance, the expenditures of total hospitalization for ETBD surgery were estimated to 4000 US dollars per person in Guangzhou, the third largest city in China. In addition, ETBD surgery is not covered by regular health insurance in China. Therefore, the majority of patients with ETD in China cannot afford ETBD surgery due to

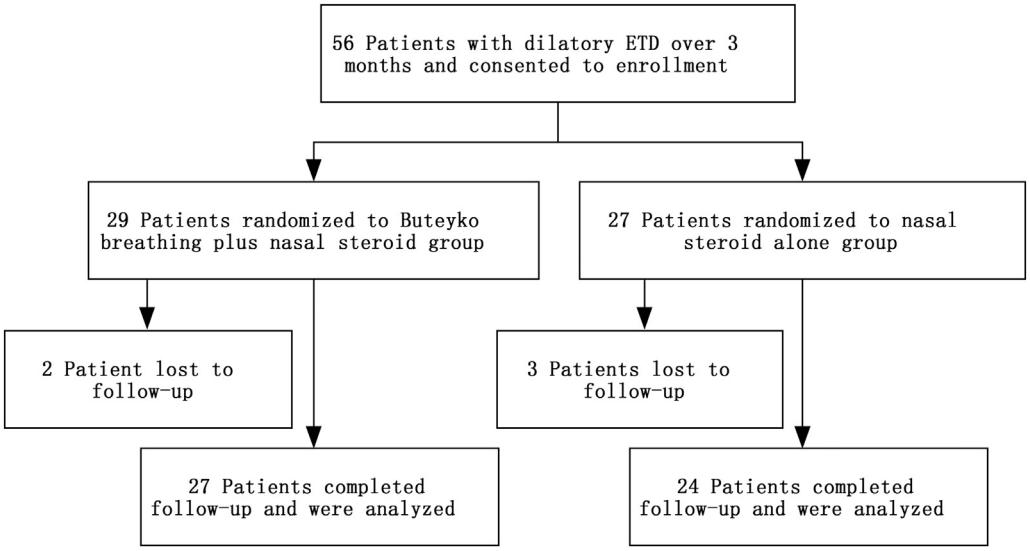

Fig. 1. Study flowchart.

Table 1
Patient demographics and baseline characteristics.

	Buteyko breathing plus nasal steroid group $N = 27$ Patients, 40 ears	Nasal steroid alone group $N = 24$ Patients, 37 ears	*P* value
Age, yr, mean (SD)	39.3 (9.8)	40.8 (11.1)	> 0.05
Sex, female, no. (%)	11 (40.7)	11 (45.8)	> 0.05
Indicated side, unilateral, no. (%)	14 (51.9)	11 (45.8)	> 0.05
Average ETDQ-7, mean (SD)	4.5 (0.6)	4.6 (0.8)	> 0.05
Tympanogram type by ear, no. (%)			
Type A	12 (30.0)	11 (29.7)	> 0.05
Type C	28 (70.0)	26 (71.3)	> 0.05
Positive Valsalva maneuver, no. (%)	9 (22.5)	10 (27.0)	> 0.05

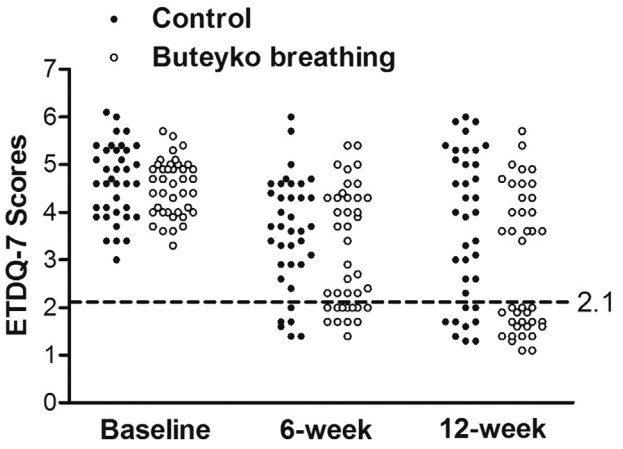

Fig. 2. ETDQ-7 scores in the Buteyko breathing group and the control group at baseline, 6 and 12-week follow-up. Each dot represents individual ear.

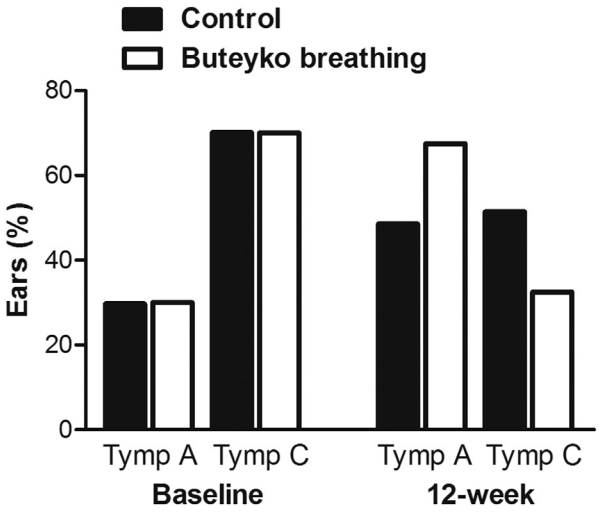

Fig. 3. Tympanogram in the Buteyko breathing group and the control group at baseline and 12-week follow-up.

economic conditions. Moreover, ETBD surgery is not available in most of the rural regions in China. For these reasons, ETBD is not the first therapeutic option for patients with obstructive ETD in China.

The Buteyko breathing technique is a special breathing approach that uses breath control and breath-holding exercise to treat a variety of diseases believed to be connected to hyperventilation and low CO_2 [25]. Several clinical trials have claimed that Buteyko breathing is a successful treatment for asthma [26–29]. However, whether Buteyko breathing is an effective treatment option for obstructive ETD remains unknown. In the present study, we found significant more patients with obstructive ETD had normalization of ETDQ-7 scores and tympanogram in the Buteyko breathing group compared to the control group at 12-week follow-up. These findings suggest Buteyko breathing confers beneficial effects for obstructive ETD. The underlying mechanism of effectiveness of Buteyko breathing for ETD is supposed to be complicated. Buteyko breathing is generally known to increase both CO_2 and nitric oxide levels in the blood and tissues [28,30]. Elevated CO_2 and nitric oxide can subsequently increase middle ear pressure, leading to the easier opening of the ET and thus ease the discomfort of obstructive

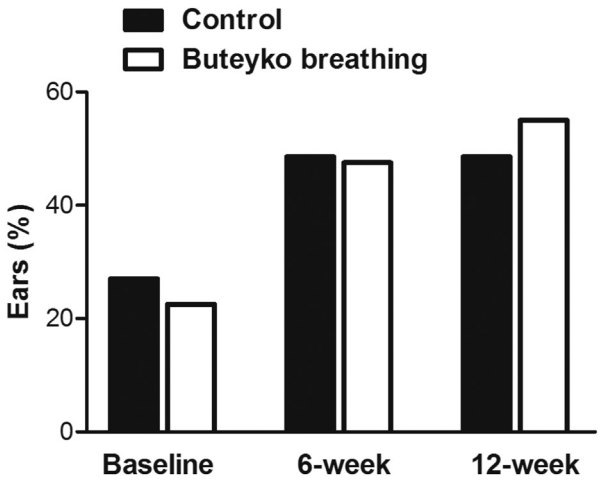

Fig. 4. Positive Valsalva maneuver in the Buteyko breathing group and the control group at baseline, 6 and 12-week follow-up.

ETD syndromes [18]. Moreover, previous study demonstrated that hypercarbic gas decreases opening pressure of the ET, which reduces the passive and active resistance [31]. In this case, patients with obstructive ETD can easily perform the Valsalva maneuver to equalize pressure in the ears. In addition, Buteyko breathing is also considered to help reduce the symptoms of anxiety [30], which is prevalent in patients with obstructive ETD.

The present study has some limitations. First, although Buteyko breathing significant improve ETD symptoms compare to the control, nearly 50% of patients in the Buteyko breathing group still did not achieve normalization of ETDQ-7 scores and tympanogram. It is also noteworthy that patients with a type B tympanogram were excluded in the presented study. It is generally known that ETD is a major risk factor for development of OME. Presence of OME usually means that a middle ear suffers from long-lasting and severe ETD, which is always refractory to conventional non-surgery interventions. Our preliminary study also demonstrated patients with OME showed nearly no response to Buteyko breathing in combination of steroid nasal spray (data not shown). That's the reason why ETD patients with a type B tympanogram (indicative of OME) were excluded in the present study. Therefore, only patients complaining of ETD syndromes with a type A or type C tympanogram (indicative of less severe ETD) were enrolled in the present study. Future research is needed to define a subpopulation of patients with ETD who will benefit maximally from Buteyko breathing.

Furthermore, inflammation within the cartilaginous portion of the ET was the common finding in obstructive ETD and ETBD is reported to substantially improve such mucosal inflammation [13,24]. However, we did not grade the level of mucosal inflammation throughout the trial. Exploring whether Buteyko breathing could improve mucosal inflammation needs further study.

Lastly, the value of the present study is also limited by relatively small numbers of patients and short duration of follow-up. Thus, we need to elucidate the effectiveness of Buteyko breathing for obstructive ETD with a large sample size and longer-term follow-up in the future study.

5. Conclusion

Our results demonstrated the beneficial effects of Buteyko breathing technique on symptoms and tympanogram normalization of patients with obstructive ETD. Buteyko breathing is an effective adjunctive intervention for obstructive ETD, especially for patients who are refractory to medical treatment and cannot afford ETBD surgery.

Declaration of Competing Interest

The authors have no conflict of interests.

Table 2
Individual patient data in the Buteyko breathing plus nasal steroid group.

Initials	Age	Sex	Side	ETDQ-7 scores			Tympanogram		Positive Valsalva maneuver		
				Baseline	6-week	12-week	Baseline	12-week	Baseline	6-week	12-week
LDG	62	M	U	4.7	2.0	1.3	C	A	×	√	√
DJJ	33	M	U	5.0	4.3	4.6	A	A	×	×	×
YRN	38	M	U	5.6	5.4	4.6	C	C	×	×	×
CK	44	M	B	5.3/5.0	5.0/5.0	4.3/4.3	A/A	A/A	×/×	×/×	×/×
TJ	34	M	U	5.7	5.4	4.9	C	C	×	×	×
CYL	48	F	U	4.1	3.9	4.7	C	C	√	√	√
LXM	31	F	B	4.4/3.7	4.4/3.4	4.0/3.4	A/A	A/A	×/√	×/√	×/√
ZBY	24	M	B	3.9/4.3	2.3/2.7	2.0/2.0	C/C	A/A	√/√	√/√	√/√
HZH	29	M	B	3.7/3.6	2.0/2.0	1.9/1.6	C/C	A/A	√/×	√/√	√/√
LKS	34	M	U	4.9	2.4	2.0	A	A	×	√	√
LMS	49	M	U	4.7	1.7	1.4	C	A	×	√	√
LLS	52	F	U	4.1	2.0	1.7	A	A	√	√	√
LLC	45	F	B	4.4/4.9	2.0/1.7	1.9/1.9	A/A	A/A	×/×	√/√	√/√
SHH	28	M	U	5.0	2.9	1.4	C	A	×	√	√
YXS	32	F	U	4.0	1.4	1.1	C	A	×	√	√
BSQ	40	M	U	5.4	4.3	5.7	C	C	×	×	×
OYML	48	F	B	4.9/4.9	4.3/4.6	4.0/4.0	A/A	A/A	×/×	×/×	×/×
LZY	42	F	U	4.0	2.0	1.7	C	A	√	√	√
ZYW	28	M	B	4.7/5.1	4.0/4.3	3.6/3.6	C/C	C/C	×/×	×/×	×/×
LF	58	M	U	5.1	4.6	5.4	C	C	×	×	×
ZWH	37	F	U	4.6	2.3	1.6	A	A	×	×	√
WJY	48	F	B	4.0/4.4	2.3/2.6	1.7/1.7	C/C	A/A	×/√	×/√	√/√
HX	29	F	B	4.0/3.6	2.0/1.7	1.4/1.6	C/C	A/A	×/×	√/×	√/√
CXM	35	M	B	4.7/4/4	4.9/4.0	4.9/3.6	C/C	C/C	×/×	×/×	×/×
LQ	37	M	B	4.9/4.9	4.3/4.0	4.6/5.0	C/C	C/C	×/×	×/×	×/×
SJH	25	F	B	3.3/3.9	3.7/3.7	3.6/3.6	C/C	C/C	×/×	×/×	×/×
TJQ	51	M	B	5.0/4.0	2.3/1.7	1.4/1.1	C/C	A/A	×/√	√/√	√/√

Age: years; M: male; F: female; U: unilateral; B: bilateral; X/X: left/right; √: positive Valsalva maneuver; ×: unable to perform Valsalva maneuver.

Table 3
Individual patient data in the nasal steroid alone group.

Initials	Age	Sex	Side	ETDQ-7 scores			Tympanogram		Positive Valsalva maneuver		
				Baseline	6-week	12-week	Baseline	12-week	Baseline	6-week	12-week
LQ	42	M	B	5.3/4.6	3.7/3.7	5.4/5.4	C/C	C/C	×/×	×/×	×/×
XH	36	F	B	5.1/5.4	6.0/5.7	6.0/5.9	C/C	C/C	×/×	×/×	×/×
CTF	60	M	U	6.0	4.0	5.3	C	C	×	×	×
WWL	55	F	U	4.6	1.7	1.4	A	A	√	√	√
CJ	21	M	U	4.7	4.3	4.0	C	C	√	√	√
ZH	40	M	U	5.1	2.9	2.3	A	A	√	√	√
PHW	45	M	U	3.0	3.6	3.3	A	A	√	√	√
HLF	51	M	B	4.6/4.9	2.6/2.9	2.0/2.0	C/C	A/A	×/×	√/√	√/√
MZF	40	F	B	4.6/4.0	1.7/2.0	1.7/1.7	C/C	A/A	×/×	√/√	√/√
DM	32	F	U	4.1	1.4	1.3	C	A	√	√	√
LL	61	F	B	4.3/3.7	3.4/3.7	2.6/4.3	A/A	A/A	√/√	√/√	√/√
HP	48	M	B	5.3/5.0	4.6/4.6	5.0/5.3	C/C	C/C	×/×	×/×	×/×
ZJW	40	F	U	3.9	3.9	4.6	A	A	×	×	×
TXB	30	F	U	5.4	4.7	5.1	C	C	×	×	×
ZF	22	M	U	3.4	1.6	1.6	A	A	√	√	√
ZFF	40	F	U	5.7	4.3	4.0	C	C	×	×	×
WHX	49	M	B	4.6/3.9	3.6/3.3	3.0/3.9	A/A	A/A	√/√	√/√	√/√
HZ	52	F	U	6.1	4.3	5.0	C	C	×	×	×
LFL	32	M	B	5.3/5.4	4.3/4.6	3.1/3.4	C/C	C/C	×/×	×/×	×/×
XY	39	M	B	4.1/3.4	3.4/3.1	2.6/3.0	A/A	A/A	×/×	×/×	√/√
CL	37	M	B	5.7/5.4	5.0/4.7	5.9/5.7	C/C	C/C	×/×	×/×	×/×
CYJ	50	M	B	4.1/4.9	4.4/4.6	4.7/5.3	C/C	C/C	×/×	×/×	×/×
XLQ	23	F	B	3.9/3.4	3.3/2.9	4.3/4.6	C/C	C/C	×/×	√/√	×/×
YY	35	F	B	4.9/3.9	2.4/1.4	1.3/1.7	C/C	A/A	×/×	√/√	√/√

Age: years; M: male; F: female; U: unilateral; B: bilateral; X/X: left/right; √: positive Valsalva maneuver; ×: unable to perform Valsalva maneuver.

Acknowledgments

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