Assessment of Voice Before and After Bariatric Surgery in Morbid Obesity

Original Article

Marowa Abd El Wahab[1]; Zeinab khalaf[1]; Doaa Mohammed Ali[1]; Mohamed Khalafallah Kamel[2], Alshimaa Abdelmenem[1] and Wafaa Helmy Abd El-hakeem[1]

[1]Phoniatric Unit, [2]Department of General Surgery, Faculty of Medicine, Minia University, Egypt

ABSTRACT

Background: The Voice communicates a speaker's social standing, psychological attributes, and emotional state. Obesity is a health problem that has an impact on several bodily functions. By producing abnormal fat deposition in the abdomen and upper airways, obesity alters voice qualities.

Objectives: In this study, We assess the impact of bariatric surgery on patients' voices who are morbidly obese.

Patients and Methods: In this prospective, longitudinal study, 50 patients with planned bariatric surgery were examined pre-operatively and 6 months after surgery. The preoperative evaluation included Body Mass Index, Neck Circumference, Auditory Perceptual Assessment (APA), Voice Handicap Index (VHI) questionniare, laryngoscopic examination and acoustic analysis. Six months after surgery, patients were re-evaluated using the same pre-surgical data collection methods.

Results: This study's findings revealed statistically significant differences in phonasthenia and almost of acoustic parameters mainly jitter, harmonic to noise ratio and maximum phonation time. Furthermore, there were significant differences in the voice handicap index.

Conclusion: It is possible to conclude that an individual suffering from morbid obesity has significantly different vocal features. This study suggests that successful weight loss after bariatric surgery may influence voice acoustic characteristics.

Key Words: Bariatric surgery, dysphonia, jitter, shimmer.

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Corresponding Author: Wafaa Helmy Abdel Hakeem, MD, Phoniatric Unit, Faculty of Medicine, Minia University, Egypt, **Tel.:** +2 010 9181 3874, **E-mail**: dr.fofahma@gmail.com - Wafaa.helmy@mu.edu.eg

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INTRODUCTION

Voice is the main form of communication and plays a significant role in daily life. The speaker's social standing, personality, emotional state, and attributes are all communicated through the voice[1].

The vocal folds' self-sustaining vibration causes phonation, which modifies glottal airflow and produces sounds. Sound is produced by the interplay of the power source, oscillator, and resonator[1]. According to[1], the vocal system consists of the lungs and lower respiratory airway, which provide airflow and air pressure; the vocal fold's vibration affects airflow and creates the voice source; then the vocal tract modifies the voice source and subsequently generates certain output sounds. According to Yanovski (2018)[4], a persistent energy imbalance between too many calories taken and too few calories burned leads to obesity. Numerous bodily functions, such as breathing and speaking, are impacted by obesity[2].

Because extra body weight affects the ability of the abdominal muscles to support breathing during speech production, obesity and voice are related. Due to a much smaller pharyngeal lumen caused by obesity, resonance can be severely impaired[5]. By resulting in improper fat deposition in the abdomen and upper airways, obesity alters voice qualities. Vocal symptoms in obese people are uncommon, and some authors report that their voices are similar to those of non-obese people. However, some authors report that 70% of obese patients report having dysphonia[3].

PATIENT AND METHODS

Between January 2022 and September 2022, this cohort study was conducted in the Phoniatrics Unit and Otolaryngology Department at Minia University Hospital. The Ethics Committee for Research in the Faculty of Medicine at Minia University approved this study (Approval No. 209:2022). The purpose, procedure, and disclosure of the study's results were all explained to the subjects. They signed an informed consent form following their agreement. From the General Surgery outpatient clinic at Minia University Hospital, 50 people (the studied sample mean age was 36.8±9.6 years, 18 (36%) of patients

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were males, and 32 (64%) of patients were females) with a BMI of 40 or more who were identified as morbidly obese and whose ages ranged from 20 to 55 were selected for this study. The exclusion criteria included a history of blood diseases, voice irregularities, upper airway diseases, or allergies during sample collection.

The participants in this study went through two stages: Before having bariatric surgery, 50 patients who had been defined as having morbid obesity underwent a first evaluation (S1). Six months later, the same group underwent a second evaluation (S2). Body Mass Index > 40, Neck circumference (in cm). The whole voice evaluation protocol in the Phoniatrics Unit was measured on all participants (S1)[6], including symptoms of reflux. Voice Handicap Index (VHI): This was initially developed and validated for English-speaking populations by[7].

The VHI was used in Arabic (Appendix), and it comprises a 30-item self-administrated questionnaire that asks patients to describe their voices and quantify the functional, physical, and emotional effects of a voice disease on a patient's quality of life[8]. If they were literate, individuals completed the Voice Handicap Index (VHI), while illiterate patients had the researcher fill in the blanks. Examination using a laryngoscope, Telepack X LED, 8.5 mm 70 rigid laryngoscopes (KARL STORZ endoscope). Acoustic measurements: Data was collected in a sound-treated room and analyzed using the Multidimensional Voice Program (MDVP) software. We captured their vocal samples by positioning a microphone 10 cm in front of their mouths and phonating continuously. The vocal characteristics were analyzed using a sustained /a/ vowel for 9 seconds, with the first and last 3 seconds' irregularities eliminated. The vowel was sampled three times, with the average calculated statistically. All patients underwent bariatric surgery Single Anastomosis Sleeve Illeal SASI bypass. In contrast, under general anesthesia and six months after the procedure, the patients underwent evaluations for their voice, vocal symptoms, and reflux, as well as their BMI, neck circumference, VHI, laryngoscopic examination, and acoustic parameters.

Statistical Package for Social Science (SPSS) was used for data entry and analysis using Windows 13. In Excel, graphics were made. The standard deviation and mean were used to show parametric quantitative data, the interquartile range and median (IQR) were used to present nonparametric data, and the frequency distribution was used to present qualitative data. Before and after surgery, each subject's data were gathered, and an analysis of small samples (Wilcoxon nonparametric paired test) was carried out. Both the design (pre and postoperative) and the data collection method were considered in the analysis. The Paired T-test was used when comparing parametric quantitative data from the two groups; however, nonparametric quantitative data were analyzed differently. The Mann-Whitney and Mc-Nemar tests were used for nonparametric quantitative data analysis, while the paired T-test was used for parametric quantitative data analysis between the two groups.

RESULTS

The study sample's mean age was 36.8±9.6 years; 18 (36%) patients were males, and 32(64%) were females. (Table 1).

Table 1: Sociodemographic data (N= 50)

Age	Mean ±SD	36.8±9.6
Sex	Male	18(36%)
	Female	32(64%)

SD= standard deviation, S= step

The study group's preoperative and postoperative examinations revealed highly statistically significant differences concerning phonasthenic symptoms (APA). (Table 2)

Table 2: Pre and postbariatric surgery according to phone asthenia

Phonasthenia	preoperative	postoperative	*P-value*
No	17(32.3%)	39(74.2%)	0.004
Yes	33(67.7%)	11(22.6%)	

Mc-Nemar test, S= step

Preoperative and postoperative examinations of the study group revealed statistically significant differences in the reflux symptoms (Table 3)

Table 3: pre and postbariatric surgery as regards reflux

Variable	preoperative	postoperative	*P-value*
Absent	23(46.7%)	48(96.7%)	<0.001
Present	27(53.3%)	2(3.3%)	<0.001

Paired sample t-test, Wilcoxon test, Mc-Nemar test S=step

Statistically significant differences were found in the BMI between the study group's preoperative and postoperative examinations (p <0.001) (Table 4).

Table 4: pre and postbariatric surgery according to BMI

	preoperative	postoperative	*P-value*
BMI (kg/m^2)	52.3±9.4	38.07±7.4	<0.001

Paired sample t-test, Wilcoxon test, Mc-Nemar test

BMI = body mass index, step

The study group's preoperative and postoperative neck circumference measurements revealed significant differences (Table 5).

Table 5: Pre and postbariatric surgery as regards neck circumference

Variable	preoperative	postoperative	*P-value*
Neck circumference	40.5±1.9	32.2±1.07	<0.001

Paired sample t-test, Wilcoxon test, Mc-Nemar test S= step

Regarding the VHI functional and physical handicap, there were highly significant differences before and after bariatric surgery (p <0.01).

Regarding the level of emotional VHI, there are significant differences between the study group's preoperative and postoperative examinations (*P-value* <0.05). Preoperative and postoperative assessments for the VHI total score showed significant differences (p< 0.01)(Table-6).

Table 6: pre and postbariatric surgery as regards VHI

Variable		preoperative	postoperative	*P-value* (S1VS S3)
Functional	Median IQR	1 (0-5)	0 (0-0)	<0.001
Physical	Median IQR	15 (3-25)	0 (0-0)	<0.001
Emotional	Median IQR	0 (0-2)	0 (0-0)	0.012
Total	Median IQR	19 (3-36)	0 (0-0)	0.001

Paired sample t-test, Wilcoxon test, Mc-Nemar test

S= step, IQR=interquartile range

Preoperative and postoperative examinations of the endoscopic pictures showed statistically significant differences (*P* <0.001). Before surgery, all patients showed abnormal laryngoscopic findings, involving mild vocal fold congestion in 18 (36.7%) patients, vocal fold edema in 3, irregularities in the inter arytenoid regions in 26 (51.6%), and moderate vocal fold congestion in 3 (6.5%) individuals (Figure 1). While an eight-month follow-up examination showed that ten patients (19.4%) had normal laryngoscopic findings, 37 patients (74%) had mildly congested vocal folds, and in 3 patients (3.2%), congestion and abnormalities of the interarytenoid cartilages, were found (Figure 2, Table-7).

Table 7: pre and postbariatric surgery as regards laryngoscopy

	preoperative	postoperative	*P value*
Normal	0(0%)	10(19.4%)	0.035
Mildly congested	18(36.7%)	37(74%)	0.007
Mildly congested +edematous	3(6.5%)	0(0%)	0.489
Mildly congested + irregularity of inter arytenoid area	26(51.6%)	3(3.2%)	<0.001
Moderately congested	3(6.5%)	0(0%)	0.489

Paired sample t-test, Wilcoxon test, Mc-Nemar test S=step

Fig. 1: Preoperative laryngeal findings.

Fig. 2: Postoperative laryngeal findings.

Concerning jitter, there were highly significant variations between preoperative and postoperative examinations (*P-value* <0.001). Since S1 had a median of 0.7 and S2 had a median of 0.4. Significant variations in MPT and HNR were found before and after surgery (*P*< 0.05). Non-significant variations in fundamental frequency were found between the preoperative and postoperative examinations (*P*>0.05, Table-8).

Table 8: pre and postbariatric surgery as regards acoustic analysis

		preoperative	postoperative	*P-value*
Jitter	Median IQR	0.7 (0.5-1.5)	0.4 (0.3-0.5)	<0.001
Shimmer	Median IQR	0.6 (0.4-0.9)	0.4 (0.3-0.5)	0.082
HNR	Median IQR	6.8 (3.7-9.3)	6 (3.3-7)	0.019
MPT	Median IQR	8 (6-12)	15 (12.7-20)	0.001
Pitch	Median IQR	225 (130-247)	210 (126-240)	0.472

Paired sample t-test, Wilcoxon test, Mc-Nemar test

S=step, HNR= harmonic noise ratio, IQR= interquartile range, MPT= maximum phonation time

DISCUSSION

According to this study, obese patients have a larger NC, higher (phonasthenic symptoms, jitter, shimmer), a more harmonic-to-noise ratio, a higher voice handicap score, and a lower MPT. Due to weight loss, all of these measurements improved six months after bariatric surgery.

There were statistically significant differences in phonasthenia between S1 and S2. This finding could be attributed to weight loss following bariatric surgery, which removes abnormal fat deposition in the abdomen and upper airways, particularly posterior and the lateral walls of the pharynx, soft palate, uvula, and posterior part of the tongue. This finding reduces the effort required to produce sustained phonation and lessens vocal fatigue. This aligns with Hamdan's (2014)[14] findings, which showed that their voice improved in one-third of the patients with weight loss after bariatric surgery. We also agreed with Sneitha *et al*. (2023)[15], who reported that weight loss after bariatric surgery can improve voice quality in areas such as vocal symptoms, auditory perceptual ratings, and maximum phonation time.

Higher phonasthenic symptoms and VHI domains in morbidly obese patients before bariatric surgery have been explained by pneumo-phonoarticulatory imbalance caused by the accumulation of fat in the abdominal wall and changes the resonance of the vocal tract, which interferes with vocal production and results in vocal complaints. Moreover, this is in line with Souza *et al*.'s (2015)[9] Da Cunha al.'s 2011[12] findings, which showed that regardless of whether or not study participants had previously reported vocal issues, all said their voices had improved after bariatric surgery.

The Voice Handicapped Index (VHI) is a helpful tool that may be used by the patient and the therapist to evaluate the level of handicap caused by a change in voice quality. According to our research, there were statistically significant differences between S1 and S2 in their assessments of the functional, physical, emotional, and total domains of VHI.

This result may be explained by improving phonasthenic symptoms, such as throat pain, vocal fatigue, and globus sensation, resulting from decreased BMI following bariatric surgery. Additionally, the result may be explained by the improvement of fat deposition around the viscera and diaphragm, resulting in improved respiratory functions and aerodynamics.

The results showed statistically significant differences between S1 and S2 regarding laryngoscopic findings, such as vocal fold congestion and irregularity of the interarytenoid area. This finding may be due to decreased reflux and improved stomach emptying, which is impaired by obesity. This finding is in line with Bosso *et al*. 2021[2], who reported that the voice of the obese becomes more hoarse and unstable; laryngoscopic pictures in morbid obesity are edema and hyperemia of vocal folds and posterior pachydermia, owing to gastroesophageal reflux.

Inflammation, epithelial thickening, and edema are caused by gastric juice components that act as irritants to the laryngeal and pharyngeal tissues. This finding supports Valezi *et al*. (2018)[10] and Bosso *et al*. (2021)[3], who revealed that the fat deposition in the abdomen secretes several hormones that enhance GERD.

Regarding acoustic measurements, we found a significant difference between S1 and S2 in jitter, MPT, and HNR. This outcome could be explained by the positive effect of decreased BMI in the neck, chest, abdomen, and viscera following bariatric surgery, which contributed to improved pulmonary and phonatory functions.

There were statistically significant differences between S1 and S2 in terms of MPT. This finding can be explained by how weight loss following bariatric surgery has improved the aerodynamic and myoelastic forces of the larynx.

The group showed decreased MPT in the current study, but the values increased after surgery. The reduced neck circumference could explain increased MPT postbariatric surgery. The loss of accumulated fat in the neck improves the interaction between vocal folds' aerodynamic and myoelastic forces and increases MPT. Furthermore, losing fat in the ribs, abdomen, and viscera modifies respiratory function. In this case, the loss of fat accumulation in the vocal tract may result in decreased pharyngeal resistance, which minimizes the phonatory effort and increases the mean MPT of obese individuals.

This finding is consistent with that of de Souza *et al.* (2017)[11], who reported that morbidly obese women had lower MPT for all vowels when compared to the Control Group. However, postbariatric surgery, the values improved and reached Control Group values. This finding also agrees with Snehitha *et al*. (2023)[15], who found that A study of aerodynamic data revealed a negative association between MPT and BMI. In other words, MPT improved as BMI fell after bariatric surgery.

According to de Souza *et al*. (2018)[11], patients with morbid obesity had lower MPT than the control group. However, the values were improved after bariatric surgery and reached the control group levels. This result is consistent with their findings. Additionally, Bosso *et al*. (2021)[3] observed that voice instability had improved and MPT levels had increased after 12 months following bariatric surgery.

This study's shimmer, jitter, and noise-to-harmonic ratio parameters decreased postbariatric surgery. However, Hamdan *et al*. (2014)[14] reported that parameters of shimmer, jitter, and harmonic-to-noise ratio before and after bariatric surgery showed no changes. Also, Ervaci *et al*. (2021)[13] reported that the shimmer and jitter tended to increase. However, de Souza *et al*. (2017)[11] showed that the shimmer values in the study group increased after bariatric surgery compared to those in the non-obese group. In addition, it was observed that the shimmer tended to increase following surgery, according to Eravci *et al*. (2021)[13] and de Souza *et al*. (2017)[11] findings that jitter was significantly different in the morbidly obese group following bariatric surgery compared to the control group. Our study showed non-significant variations in shimmer between the preoperative and postoperative examinations. These findings could be attributed to differences in anatomic location (tongue, lateral pharyngeal walls, vocal folds, and soft palate) and the reduction in aberrant fat accumulation. The improvement in acoustic measurements in the postoperative phase may take longer than predicted, dependent on weight reduction rather than time, i.e., not finished at the time of evaluation.

Nutrient deficiencies following bariatric surgery, such as vitamin D, B-12, protein, zinc, and copper, may be related to the cause of the reported shimmer change. Also, morbidly obese patient

Our study showed that the Fundamental frequency decreased postbariatric surgery but with a small, insignificant value. This finding is consistent with Solomon *et al*. (2011)[16], who showed a significant decrease in the fundamental frequency after bariatric surgery in morbidly obese patients, although at quite a small value. Eravci *et al*. (2021)[13] reported that the results of their study showed that the F0 tended to decrease after bariatric surgery. In terms of f0, it was discovered that obese women had lower values than the control group, which contradicted previous studies that found no relationship between body weight and this variable. Also, Hamdan *et al*. (2014)[14] reported no significant difference in the perceptual and acoustic measures in patients before and after surgery.

This study's limitations include the small sample size, the lack of measurements of the vocal tract diameters, and the need for a control group. The authors advise that future research examine other aspects of the multidimensional voice evaluation, like formants.

CONCLUSION

It is possible to conclude that an individual suffering from morbid obesity has significantly different vocal features. This study suggests successful weight loss after bariatric surgery may influence voice acoustic characteristics.

ABBREVIATIONS

(BMI): Body Mass Index, **(NC):** Neck Circumference, **(APA):** Auditory Perceptual Assessment, **(VHI):** Voice Handicap Index, **(MPT):** Maximum Phonation Time, **(HNR):** Harmonic To Noise Ratio, **(SASI) bypass):** Single Anastomosis Sleeve Illeal, **(MDVP) software:** Multidimensional Voice Program.

CONFLIC OF INTERESTS

There are no conflicts of interest.

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Appendix A
VOICE HANDICAP INDEX (ORIGINAL)

These are statements that many people have used to describe their voices and the effects of their voices on their lives. Circle the response that indicates how frequently you have the same experience.

0 - never 1 - almost never 2 - sometimes 3 - almost always 4 - always

Part I-F

1. My voice makes it difficult for people to hear me.....0 1 2 3 4
2. People have difficulty understanding me in a noisy room.....0 1 2 3 4
3. May family has difficulty hearing me when I call them throughout the house.0 1 2 3 4
4. I use the phone less often than I would like.....0 1 2 3 4
5. I tend to avoid groups of people because of my voice.....0 1 2 3 4
6. I speak with friends, neighbors, or relatives less often because of my voic.....0 1 2 3 4
7. People ask me to repeat myself when speaking face-to-face.....0 1 2 3 4
8. My voice difficulties restrict personal and social life.....0 1 2 3 4
9. I feel left out of conversations because of my voice.....0 1 2 3 4
10. My voice problem causes me to lose income..... 0 1 2 3 4

Part II-P

1. I run out of air when I talk.....0 1 2 3 4
2. The sound of my voice varies throughout the day.....0 1 2 3 4
3. People ask, “What’s wrong with your voice?”.....0 1 2 3 4
4. My voice sounds creaky and dry.....0 1 2 3 4
5. I feel as though I have to strain to produce voice.....0 1 2 3 4
6. The clarity of my voice is unpredictable.....0 1 2 3 4
7. I try to change my voice to sound different.....0 1 2 3 4
8. I use a great deal of effort to speak.....01 2 3 4
9. My voice is worse in the evening.....01 2 3 4
10. My voice “gives out” on me in the middle of speaking.....01 2 3 4

Part III-E

1. I am tense when talking to others because of my voice.....0 1 2 3 4
2. People seem irritated with my voice.....0 1 2 3 4
3. I find other people don’t understand my voice problem.....0 1 2 3 4
4. My voice problem upsets me.....0 1 2 3 4
5. I am less outgoing because of my voice problem.....0 1 2 3 4
6. My voice makes me feel handicapped.....0 1 2 3 4
7. I feel annoyed when people ask me to repeat.....0 1 2 3 4
8. I feel embarrassed when people ask me to repeat.....0 1 2 3 4
9. My voice makes me feel incompetent.....0 1 2 3 4
10. I am ashamed of my voice problem.....0 1 2 3 4

The Voice Handicap Index (VHI): Development and Validation
Barbara H. Jacobson, Alex Johnson, Cynthia Grywalski, Alice Silbergleit, Gary Jacobson, and Michael S (1997). Benninger .American Journal of Speech-Language Pathology, Vol 6(3), 66-70, Words in bold and underlined are those that are further explained in the Arabic version.

Appendix B
مؤشر الإعاقة الصوتية

اختر أحد الأرقام المقابلة لكل سؤال والذي يصف شدة المشكلة لديك:

صفر= أبدا. ١= نادرا. ٢= أحيانا. ٣= غالبا. ٤= دائما.

الجزء الأول:

١. صوتي يصعب على الآخرين سماعه.....صفر ١ ٢ ٣ ٤
٢. يجد الناس صعوبة في فهمي (سماع صوتي) عندما أتحدث في غرفة كثيرة الضوضاء.....صفر ١ ٢ ٣ ٤
٣. تجد عائلتي صعوبة في سماع صوتي عندما أناديهم في المنزل.....صفر ١ ٢ ٣ ٤
٤. صوتي يجعلني استعمل الهاتف بشكل أقل مما أحب.....صفر ١ ٢ ٣ ٤
٥. أميل إلى تجنب الإجتماع بالناس بسبب صوتي.....صفر ١ ٢ ٣ ٤
٦. صوتي يجعلني أتحدث مع الأصدقاء والمعارف بشكل أقل مما أحب.....صفر ١ ٢ ٣ ٤
٧. الناس تطلب مني أن أكرر ما أقول عندما أتحدث إليهم وجها لوجه.....صفر ١ ٢ ٣ ٤
٨. مشاكل الصوت لدي أثرت سلبا على حياتي الشخصية والإجتماعية.....صفر ١ ٢ ٣ ٤
٩. أحس بأنه يتم إهمالي في المناقشات (السوالف) بسبب صوتي.....صفر ١ ٢ ٣ ٤
١٠. مشكلة الصوت لدي تسببت في تقليل دخلي المادي.....صفر ١ ٢ ٣ ٤ المجموع =

الجزء الثاني:

١. ١- أفقد الكثير من هواء التنفس عندما أتحدث.....صفر ١ ٢ ٣ ٤
٢. ٢- صوتي يتغير خلال اليوم.....صفر ١ ٢ ٣ ٤
٣. ٣- يسألني الناس دائما "ماذا حدث لصوتك؟". .....صفر ١ ٢ ٣ ٤
٤. ٤- صوتي ناشف وله صرير (خشن). .....صفر ١ ٢ ٣ ٤
٥. ٥- أحس أنه علي أن أضغط على حنجرتي (أجهدها) لإخراج صوتي.....صفر ١ ٢ ٣ ٤
٦. ٦- صفاء صوتي لا يمكن التنبؤ به. .....صفر ١ ٢ ٣ ٤
٧. ٧- أحاول أن أغير صوتي ليبدو مختلفا (أفضل). .....صفر ١ ٢ ٣ ٤
٨. ٨- أقوم بكثير من الجهد لأتحدث. .....صفر ١ ٢ ٣ ٤
٩. ٩- صوتي أسوأ في المساء. .....صفر ١ ٢ ٣ ٤
١٠. ١٠- ينقطع صوتي أثناء الحديث. .....صفر ١ ٢ ٣ ٤ المجموع =

الجزء الثالث:

١. أكون متوترا عندما أتحدث مع الآخرين بسبب صوتي.....صفر ١ ٢ ٣ ٤
٢. ينزعج الناس بسبب صوتي... .....صفر ١ ٢ ٣ ٤
٣. أجد أن بعض الناس لا تفهم طبيعة مشكلة صوتي.....صفر ١ ٢ ٣ ٤
٤. مشكلة صوتي تحزنني. .....صفر ١ ٢ ٣ ٤
٥. أقلل الخروج من البيت بسبب مشكلة صوتي.....صفر ١ ٢ ٣ ٤
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