

*Full-Length Article***Tracheomelodica: A Musical Device for Improving the Pulmonary Function of Laryngectomized Patients**Patravoot Vatanasapt^{1,2}, Nida Chabnak¹, Nichanun Punya-ek^{2,3}¹Department of Otorhinolaryngology, Faculty of Medicine, Khon Kaen University, Thailand²Music for Health Research Group, Khon Kaen University, Thailand³Department of Rehabilitation Medicine, Faculty of Medicine, Khon Kaen University, Thailand**Abstract**

To determine the effectiveness of an innovative music instrument in improving the lung function of the patients undergoing total laryngectomy, this experimental study was conducted at Srinagarind Hospital, Khon Kaen, Thailand, from January - December 2013. The Tracheomelodica, a modified melodica for use via tracheostomes, was applied in laryngectomized patients from day 3 to day 14 postoperatively. The pulmonary function, chest expansion, and quality of life were measured on the pre-operative day and the 3rd and 14th days post operatively. Nine cases were eligible and recruited for the study. The pulmonary function was improved after the rehabilitation period, especially the peak expiratory flow, which was found to be significantly improved. Chest expansion also significantly increased on day 14 as compared with day 3. The quality of life tended to improve after the rehabilitation period, but the difference was not statistically significant. Tracheomelodica is a self administrated new devise for post laryngectomy patients that can be easily used with potential benefits for pulmonary function postoperatively.

Keywords: *laryngectomy , cancer, pulmonary rehabilitation ,music*multilingual abstract | mmd.iammonline.com**Introduction**

Cancer is a major health problem worldwide with an estimated 14.1 million new cancer cases diagnosed around the world [1]. Advancement of new chemotherapy, tumor targeted drug, radiotherapy techniques, including technology assisted surgery, have contributed to improved survivals in major common cancers. Nevertheless, no improvement has been found in the head and neck cancer, particularly laryngeal cancer, which is the only cancer site in which survival deterioration has been reported during the last 15 years in the US [2].

The treatment paradigm for laryngeal cancer was shifted toward an organ preservation approach by using radiation therapy or concurrent chemoradiation(CCRT). However, the

role of radical surgery, called laryngectomy, still endures as a salvage procedure after failed non-surgical treatment or for those who presented in a far extensive lesion. Moreover, recent downward trends in survivals of laryngeal cancer patients have raised considerable concern about current standard treatment led by CCRT [2].

Despite its curative capability, the consequence of removing the larynx are tremendous. Besides the inability to speak, deglutition and olfaction can also be affected. In addition, a significant concern is the pulmonary function, because 1) almost all cases have a long history of smoking resulting in a poor pulmonary function and 2) coincidental pulmonary airway obstruction is common [3]. 3) longstanding airway obstruction from tumor also affects the pulmonary pressure and 4) removing the larynx, changes the physiology of the lungs substantially. The major physiologic alterations after laryngectomy include: reduced airway dead space, inadequate warming and humidification of the inhaled air, absence of a natural airway resistance to create a back pressure to maintain the volume of the alveoli, the so called positive expiratory pressure. This potentially causes pulmonary atelectasis and further complications postoperatively.

Currently, there is no standard practice guideline for pulmonary rehabilitation of patients undergoing total laryngectomy. The first author therefore created a new device for a self-administered pulmonary rehabilitation by applying a musical instrument, the so called "Tracheomelodica". The

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Patravoot Vatanasapt, MD, MS, FRCOT; Department of Otorhinolaryngology, Faculty of Medicine, Khon Kaen University, Thailand, 40002, Email: patvat@kku.ac.th | COI statement: The authors declared that no financial support was given for the writing of this article. The authors have no conflict of interest to declare.

aim of this study was to determine its effectiveness in improving lung function and the quality of life of the patients undergoing total laryngectomy.

Methods

A pilot study was conducted in the otorhinolaryngology ward at Srinagarind Hospital, a university hospital of Khon Kaen, Thailand, between January - December 2013. All participants were scheduled for a total laryngectomy, and capable of bedside ambulation on post-operation day three. The cases with postoperative complications, e.g. wound dehiscence, pneumonia; those dependent on an assistive respirator and with an unstable hemodynamic status were excluded.

Intervention

The Tracheomelodica was developed and named by Patravoot Vatanasapt. It was modified from the 32-key melodica, a musical keyboard wind instrument. In order for it to be usable in laryngectomized patients, the mouth piece was replaced by a silicone bell shape mask (mask piece) (Figure 1). To operate the Tracheomelodica, 1) the left hand was used to hold the mask piece over the tracheostome (the opening of the trachea on the anterior lower neck), open on breathing in, and close on blowing (Figure 2). 2) The right hand was used to play the notes on the keyboard.

The participants were instructed how to operate the Tracheomelodica, and requested to use it for 10 - 15 minutes as tolerated, twice a day from post-operative day 3 to day 14. No songs or music sheets were assigned to the participants; instead, they could freely play and create a melody and/or improvise as they preferred. The piano accompaniment for a pentatonic improvisation on the black keys was provided if the patients seemed uncomfortable playing solo.

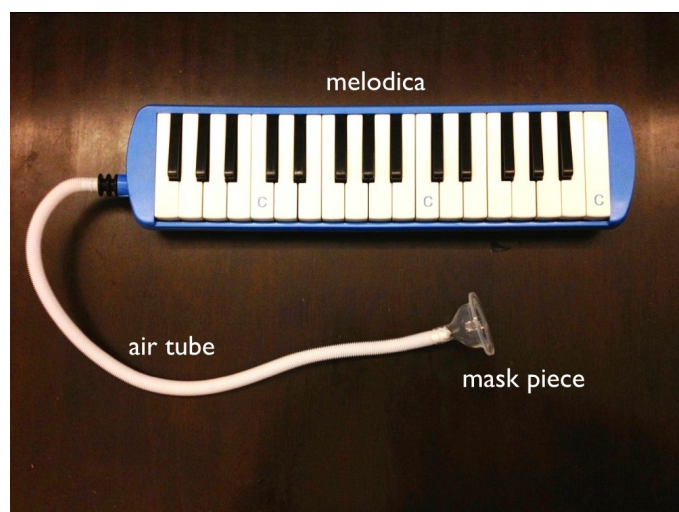


Figure 1 The components of the Tracheomelodica



Figure 2 A male patient undergoing total laryngectomy performed the Tracheomelodica on his post operation day 3.

Outcomes

The main outcomes measured included chest expansion, pulmonary function, and quality of life. The chest expansion was measured by a difference of the chest circumference between deep inhalation and full exhalation, at two levels; the lower chest (at the level of the xiphoid process), and the diaphragm (the middle between the xiphoid process and the umbilicus). The pulmonary function was assessed using KOKO[®] Spirometry, through either mouth or tracheostome breathing preoperatively depending on the previous tracheostomy status, and all cases were tested via their tracheostomes postoperatively. We determined the forced vital capacity (FVC), the forced expiratory volume in one second (FEV1), and the peak expiratory flow (PEF). The quality of life was assessed using the EORTC QLQ C-30 version 3 which was translated into Thai and tested for its reliability [4,5]. The scales were analyzed separately in 3 groups; the global health status, the functional scales, and the symptom scales.

All outcomes were measured 3 times, on the day before surgery, on day 3, and day 14 postoperatively.

Statistical analysis

The descriptive data were displayed as means, percentages, and 95% confidence intervals. As the data of the pulmonary function and chest expansion were not in a normal distribution, Wilcoxon signed-rank test was used for their comparison. The scores from the EORTC QLQ C-30 were transformed into a 100-scale for comparison. The Wilcoxon signed-rank test was also used for a comparison.

This study was approved by the Khon Kaen University Ethics Committee for Human Research (HE551308).

Results

A total of 17 eligible cases enrolled into the study, but 8 cases were excluded on day 3 postoperatively due to their unfavorable conditions, including surgical wound complications (5), pneumonia (2), and operation cancelled because of inoperability due to extensive tumor progression (1). This resulted in 9 cases participating in the study.

The mean age was 64.3 years (40 - 79) and 8 of the cases were males. 5 cases were farmers, and the rest were: a hair dresser, a builder, a retired government officer, and an unemployed man.

All cases had advanced stages of cancer (*Table 1*). All reported themselves as liking listening to music. 5 cases favored singing prior to the surgery, three disliked singing, and one was neutral. Only 2 of 9 cases had experience in local traditional music performance. None of them ever played keyboard instruments.

Tracheomelodica uses

The participants reported that the duration of their usage ranged from 2 to 20 minutes (mean 7 minutes) per session. There was no significant change in the chest expansion and the pulmonary function on day 3 after the surgery.

The chest expansion was found to improve when comparing before and after using Tracheomelodica (day 3 and day 14) in both levels of measurement (*Table 2*). For the pulmonary function, the PEF was significantly increased on day 14. The FVC and FEV1 were slightly improved on day 14, but the difference was not statistically significant (*Table 3*).

For the quality of life, we found the scores on the global health and the functional scales increased, and the symptom scales were decreased on day 14. However, the difference was not statistically significant (*Table 4*).

	Sex	Age (years)	Sites of cancer	Stage	Neck Dissection	Smoking	Alcohol Drinking
1	Male	46	Glottis	4	None	Yes	Yes
2	Male	40	Supraglottis	4	Bilateral	Yes	Yes
3	Female	61	Thyroid	4	Unilateral	No	No
4	Male	79	Glottis	3	None	Yes	Yes
5	Male	77	Supraglottis	3	Bilateral	Yes	No
6	Male	68	Glottis	3	Unilateral	Yes	Yes
7	Male	59	Hypopharynx	3	Bilateral	Yes	Yes
8	Male	73	Glottis	3	None	Yes	Yes
9	Male	46	Glottis	3	None	Yes	Yes

Table 1 The characteristics of the participants in this study

Level	Pre-op mean (95%CI)	Post-op day3 mean (95%CI)	p-value ¹	Post-op day14 mean (95%CI)	p-value ²
Lower chest(cm)	2.11 (1.21-3.01)	1.77 (1.27-2.29)	p = 0.3	3.52 (2.06-4.98)	p = 0.01
Diaphragm(cm)	1.94 (1.32-2.57)	1.83 (1.14-2.53)	p = 0.2	2.94 (1.65-4.24)	p = 0.04

Table 2 Comparison of chest expansion between preoperative values and days 3 and 14 postoperatively. ¹p-value comparing between pre-op and post-op day 3 by Wilcoxon-signed rank test; ²p-value comparing between post-op day 3 and post-op day 14 by Wilcoxon-signed rank test

	Pre-op mean(95%CI)	Post-op day3 mean (95%CI)	p-value ¹	Post-op day14 mean (95%CI)	p-value ²
FEV1(L)	1.24 (0.86-1.62)	1.27 (0.74-1.80)	p =0.9	1.59 (1.29-1.88)	p = 0.1
FVC(L)	1.70 (1.18-2.22)	1.52 (0.90-2.15)	p = 0.3	1.95 (1.60-2.30)	p = 0.09
PEF(L/s)	1.83 (1.28-2.38)	1.92 (1.20-2.64)	p = 0.9	3.11 (2.41-3.80)	p = 0.02

Table 3 Comparison of pulmonary function test results between preoperative values days 3, and 14 postoperatively. ¹p-value comparing between pre-op and post-op day 3 by Wilcoxon-signed rank test; ²p-value comparing between post-op day 3 and post-op day 14 by Wilcoxon-signed rank test

	Pre-op, mean (SD)	Post-op D3, mean (SD)	Post-op D14, mean(SD)
Global health			
Quality of life	48.1(13.4)	50.0(34.1)	62.5(13.8)
Functional scales			
Physical	60.0(27.2)	48.7(22.5)	65.3(20.1)
Role	55.6(23.2)	43.3(28.2)	66.7(22.2)
Emotion	62.0(21.3)	60.2(28.0)	65.8(17.1)
Cognition	64.8(17.7)	68.5(28.1)	61.7(32.7)
Social	53.7(21.7)	55.6(36.5)	60.0(34.4)
Symptom scales			
Fatigue	33.3(21.4)	43.2(15.6)	34.4(21.6)
Nausea/Vomiting	3.7(11.8)	3.7(7.7)	0.0
Pain	24.1(15.3)	40.7(33.0)	28.3(40.3)
Dyspnea	29.6(30.9)	33.3(27.8)	26.7(30.9)
Insomnia	59.3(25.2)	29.6(30.9)	30.0(33.3)
Appetite	14.8(35.6)	3.7(11.8)	6.7(14.7)
Constipation	25.9(33.0)	29.6(35.6)	6.7(14.7)
Diarrhea	3.7(11.8)	14.8(30.9)	0.0
Financial	44.4(25.2)	37.0(46.3)	40.0(33.3)

Table 4 Comparison of mean scores for quality of life between those obtained preoperatively and days 3 and 14 postoperatively.

No participants reported any adverse effect while using the Tracheomelodica, and no clinical complication was found due to this intervention.

Discussion

This is the first report of the use of a musical instrument for pulmonary rehabilitation of laryngectomized patients. It was primarily created to counter alveolar collapse due to absence of the physiologic resistance of the upper airway. The clinical application of the Tracheomelodica was driven by the following mechanisms:

1. It is a wind instrument requiring a full range of respiration for its use. The effort required for blowing could be expected to strengthen the respiratory muscles.
2. The resistance created by the reeds inside a melodica is not only a further challenge to the respiratory muscle strength, but also resembles the physiologic resistance of the larynx and upper airway which enhances the positive expiratory pressure, and eventually maintains alveoli expansion.
3. The loudness of the sound produced by the Tracheomelodica indicates the intensity of the expiratory force of each blow. The patients or physicians can observe this as a means of biofeedback.
4. As the patients are aphonic, creating sounds is rewarding and motivating and can lead toward maximizing the duration of rehabilitation session.
5. Music making with the Tracheomelodica without rigid instructions allows the patients to freely express their internal quality via their own melodies according to their abilities and limitations.

A multicenter randomized controlled trial of applying a temporary positive expiratory pressure with a respiratory therapy device showed an improvement in dynamic lung volumes and respiratory muscle strength, and acceleration of the improvement in the bronchial encumbrance in patients with lung diseases and hypersecretion [6]. In addition, the use of positive expiratory pressure in patients with pneumonia decreased the duration of fever and hospital stay [7].

Although no study on the effects of positive expiratory pressure in patients undergoing total laryngectomy has been carried out, the relevant evidence supports the potential benefit in this population. Without being a sophisticated machine, such as an intermittent positive pressure breathing device, the Tracheomelodica provides a positive expiratory pressure using a similar principle to that of the incentive spirometer [8].

In order to compare the benefits on pulmonary function, we examined the results of previous studies on physiologic changes after laryngectomy [9]. The functioning volume of the lungs tends to decrease, whereas airflow tends to increase after laryngectomy, in both short and long term, postoperatively (Table 5). Our study, however, showed increasing trends in both the volume and flow of expiration, especially the peak expiratory flow, which dramatically improved after 12 days of applying the Tracheomelodica. This shows an improvement in both strength and volume, which was also indicated by increased chest expansion.

	FVC	FEV1	PEF
Without intervention [9] (9 days post-op)	-6.7 %	-3.5 %	4.0 %
Without intervention [9] (6 months post-op)	-6.7 %	-6.9 %	19.5 %
With Tracheomelodica (2 weeks post-op)	12.8 %	28.23 %	70.0 %

Table 5 The changes in pulmonary function in post-laryngectomy patients without the use of the Tracheomelodica (short and long term), and with Tracheomelodica use

The Tracheomelodica is a self-administered device created for pulmonary rehabilitation via tracheostomes, and presents with a musical reward. Besides its direct benefits on pulmonary function, it is a music-oriented device. A systematic review has shown a potential benefit of music on anxiety, pain, mood and quality of life in cancer patients [10]. Moreover, active performing of music or active music engagement is associated with greater coping-related behaviors, as compared to passive listening to music or an audio story book [11]. The Tracheomelodica provided a mechanism for patients to freely create the melody according to their abilities and personal musical ease and satisfaction. A self-reward basis can enhance the patients’ compliance and motivate patients to maximize the use of the device. Additionally, lack of experience in music did not restrict their compliance with the Tracheomelodica.

This study is a pilot experiment in a limited sample size without a control group, so potential confounding factors might contribute to the results. However, based on a

comparison with published data, a potential benefit to pulmonary function is achievable with no adverse effect. We are, therefore, developing further research to determine the efficacy of the Tracheomelodica in a larger sample size with a comparison group.

Conclusion

This study is the first report on the use of a musical instrument, called the Tracheomelodica, for pulmonary rehabilitation in post-laryngectomy patients. We found a potential benefit, notably an increase in peak expiratory flow and chest expansion after 12 day of use with no adverse effects. A future study is needed to evaluate its efficacy with a larger sample size and a comparison group, and to determine the long-term outcome of its use.

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Biographical Statements

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