Comparative Study of Ventilatory Function in Relation to Trunk Control between Acute and Chronic Stroke Patients

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ABSTRACT

Background and purpose: Stroke can have high varying effects on patient's trunk muscles and ventilatory function. The current study was done to assess the relationship between trunk muscles and ventilatory function using computerized spirometer in acute and chronic stroke patients.

Subjects: One hundred ischemic stroke patients from both sexes (78 male and 22 female) were participated in the study. The age ranged from 40-60 years. Methods: Subjects were assigned into two equal groups; Group A Patients with acute ischemic stroke, Group B Patients with chronic ischemic stroke.

Procedures: Trunk control was assessed using Trunk impairment scale and ventilatory function was assessed by using spirometer.

Results: For group (A), the results showed that there was a significant weak direct relationship between overall score of Trunk impairment scale and peak expiratory flow and maximum voluntary ventilation. For group (B), the results showed that there was a significant moderate direct relationship between overall score of Trunk impairment scale and peak expiratory flow and maximum voluntary ventilation.

Conclusion: it was concluded that the relationship between trunk muscles and ventilatory function appear to be more significant in chronic than acute stroke.

Introduction

INTRODUCTION

Stroke is the rapid loss of brain function due to interruption in the blood supply that reaches the brain. This can be due to lack of glucose and oxygen supply (ischemia) caused by embolism or thrombosis or due to a hemorrhage¹. It should not be considered an isolated event but as a clinical consequences of progressive underlying vascular disorder². Stroke is classically characterized as a neurological deficit attributed to an acute focal injury of the central nervous system by a vascular cause, including cerebral infarction, intracerebral hemorrhage, and subarachnoid hemorrhage, and is a major cause of disability and death worldwide³.

Decrease motor control of trunk muscles is a key problem area in stroke recovery⁴. Trunk control is one of the most important functional outcomes after stroke⁵. Trunk is the central key point
of the body. The primary contribution of the trunk muscles is to stabilize the spine and the trunk. Trunk muscles participate in activities involving either the trunk itself and/or the limbs. They may function as: (1) prime movers or synergists in voluntary trunk movements; (2) automatic responders to unexpected body and/or limb perturbations; (3) anticipatory postural adjusters of the trunk during temporary or ongoing activities of the limbs. Although hemiplegia affects unilateral limb activity, there is a potential to decrease the function of trunk muscles on both sides of the body affecting the proximal control. The loss of proximal stabilization affects the limbs profoundly in that the arm and leg can only be moved in spastic synergy patterns. Loss of selective activity in these muscle groups of trunk fails to enable the patient to stabilize his thoracic spine in extension while using lower abdominals in isolation, which is reflected in walking.

According to the structure which affected in stroke, the respiratory disorder appears. The maintenance of normal ventilation depends on the intact functional components of the neuromuscular system. Ventilatory disturbances occur when the diseases affect the nervous system, the muscle routes or the thoracic cage, despite the lungs being normal. The affection on the respiratory system due to stroke depends on the structures affected by the lesion. The maintenance of normal ventilation depends on the intact functional components of the neuromuscular system. Ventilatory disturbances occur when the diseases affect the nervous system, the muscle routes or the thoracic cage, despite the lungs being normal. Stroke may disrupt breathing either by causing a disturbance of central rhythm generation, interrupting the descending respiratory pathways leading to a reduced respiratory drive, or causing bulbar weakness leading to aspiration. Respiratory impairment may complicate ischemic stroke in three setting (1) it may occur as a direct result of lesions impacting brain stem control of respiration, with loss of pharyngeal tone as well as cough, swallow, and gag reflexes. (2) Consciousness may be diminished, resulting in relaxation of the pharyngeal musculature and tongue and suppression of cough and gag reflexes, the risk for respiratory impairment in association with large hemisphere stroke increases after a few days delay, as the cerebral edema intensifies. With progressive brain stem dysfunction due to herniation, a complete loss of control of pharyngeal muscle and protective reflexes is present. (3) Respiratory compromise may be caused by aspiration or systematic complications as pneumonia, pulmonary embolism or pulmonary edema. These complications should be considered any time a sudden change in respiratory status occur in patients with acute ischemic stroke.

**METHOD DESIGN**

This was an observational, quantitative and descriptive study. It was performed at the outpatient's Clinic of Neurology, Faculty of Physical Therapy, Cairo University, stroke unit and Neurology Department in El-Demerdash, Ain Shamas University and Hospital and Neurology Department at Alzhraa University hospital from May 2014 to December 2014. All patients or their legal representatives signed two copies of an informed consent form before the beginning of data collection. The present study was approved by the ethical and research committees of the involved institutions.

**Participants**

One hundred ischemic stroke Patients were included in the study.

**General Characteristics**

**Acute group**: include 50 patients of both sexes (40 male 80% and 10 females 20%) with age ranged from 40 to 59 years with the mean value of (48.3±7.7). The distribution of the right-left hemiplegia is 30 patients have right affection and 20 patients have left affection. The duration of illness ranges from one month till five months with mean value (3.12±0.95) months, as shown in Table (1).

**Chronic group**: include 50 patients of both sexes (38males76% and 12females24%) with age ranged from 41 to 58years with the mean value of (50.1±8.76). The distribution of the right-left hemiplegia is 30 patients have right affection and 20 patients have left affection. The spasticity ranges from 1+ till 2 (25 patients were 1+ and 25 patients were 2). The duration of illness ranges from ten months till thirty six months with mean value (19.9±6.33) months, as shown in Table (1).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Groups</th>
<th>Mean ± SD</th>
<th>Min - Max</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>Acute Group</td>
<td>48.3±7.7</td>
<td>40-59</td>
<td>1.27</td>
<td>0.212</td>
</tr>
<tr>
<td></td>
<td>Chronic Group</td>
<td>50.1±8.76</td>
<td>41-57</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>Acute Group</td>
<td>79.86±5.7</td>
<td>70 – 83</td>
<td>-1.27</td>
<td>0.212</td>
</tr>
<tr>
<td></td>
<td>Chronic Group</td>
<td>82.66±6.27</td>
<td>73 – 80</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Height</strong></td>
<td>Acute Group</td>
<td>168.26±6.16</td>
<td>160 – 182</td>
<td>0.25</td>
<td>0.802</td>
</tr>
<tr>
<td></td>
<td>Chronic Group</td>
<td>168.8±5.34</td>
<td>165 – 179</td>
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</tbody>
</table>

As indicated from descriptive data of the two groups (Acute and chronic), patients participated in two groups were homogenous concerning weight and height.

**Inclusion criteria**: Patient’s ages ranged from 40 to 60 years old. They were with first onset unilateral ischemic stroke. The duration of illness ranged from 1 to 6 months for acute cases (group I) and from 12 months to 36 months for chronic cases (group II).The muscle tone grade either 1+ or 2 according to Modified Ashworth scale (Appendix II).Patients were with normal or corrected vision (e.g., glasses or contacts) to see spirometer screen and get a good visual feedback. Patients were with good cognition that enables them to understand the requirements of the study.

**Exclusion criteria**: Patients with any orthopedic or chest disorders that affect trunk muscles control or cause respiratory
disorders were excluded from the study. Patients with
impairments of deep sensation. Patients who cannot follow
instructions as sensory aphasia, blindness and deafness.
Patients with cognitive and psychiatric disorders. Patients with
recurrent stroke. Patients who had participated in respiratory
exercises as diaphragmatic breathing exercises in last 6 months.

Equipment:
1- Trunk control evaluated by using the Trunk
impairment scale (TIS)
2- Ventilatory function evaluated by using Computerized
spirometer (ZAN 100 handy II),

Procedure:
Trunk control was evaluated through the Trunk Impairment
Scale (TIS)¹². The TIS has three subscales: static sitting balance
(with three items), dynamic sitting balance (with 10 items) and
co-ordination (with four items). The TIS score ranges from of 0
to a maximum of 23, which represent no and total control,
respectively. In order to perform the tests, the patients
remained sitting on a stretcher, without supporting the trunk
and the upper limbs. If the arm was hypertonic, the position of
hemiplegia was taken as the starting one. The spirometric data
were collected through a computerized spirometer where the
individuals should be in the same position as described above.
The test followed the recommendations described in the
Guidelines for ventilatory Function Tests¹³. The participant was
instructed to inhale as much as possible and then do a
sustained, quick exhalation till ordered to stop. The
experimenter demonstrated the procedure before its being
performed by the participant. In addition to avoid unwanted air
release there was a nasal clip. Data of three expiratory
maneuvers were collected, with a 1-minute interval in between
them, using the best values obtained for PEF and MVV. The
consistence of the measures was confirmed by using a
difference smaller than 10% between the performed
maneuvers. Percentage values relative to the predicted indexes
were used for age, weight, height and sex of the tested
individual, according to the Knudson’s equations.

Data analysis
For the statistical analysis of the data, Pearson’s correlation test
was used for parametric variables, with the results expressed as
means and standard deviation, and Spearman’s correlation was
used for non-parametric variables, with the results expressed as
median and 25th–75th percentile. A p < 0.05 was taken as
statistically significant. The data were statistically processed
with the Statistical Package for Social Science SPSS 10.0 (SPSS
Inc., Chicago, IL, EUA).

Results
I-Correlation Tests
1- Peak Expiratory Flow PEF

Correlation tests between the peak expiratory flow and the
overall trunk impairment scale among the two groups:

Table (2): Correlation between the values of the peak expiratory
flow and the overall trunk impairment scale between two groups.

<table>
<thead>
<tr>
<th></th>
<th>Acute Group</th>
<th></th>
<th>Chronic Group</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overall trunk</td>
<td>Actual peak</td>
<td>Overall trunk</td>
<td>Actual peak</td>
</tr>
<tr>
<td></td>
<td>impairment scale</td>
<td>expiratory</td>
<td>impairment scale</td>
<td>expiratory</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>3.65 ± 2.64</td>
<td>1.9 ± 0.49</td>
<td>14.7 ± 3.2</td>
<td>7.2 ± 0.8</td>
</tr>
<tr>
<td>Minimum – Maximum</td>
<td>0 – 10</td>
<td>1 – 3.2</td>
<td>10 – 21</td>
<td>1.41– 4.8</td>
</tr>
</tbody>
</table>

Correlation Spearman
Rho(r) 0.291 0.587
p-value 0.041 0.034
Level of Significance Significant weak direct relationship Significant moderate direct relationship

Fig.1: Correlation between the values of PEF and the overall TIS (acute group)

Fig.2: Correlation between the values of PEF and the overall TIS (chronic group).

2- Maximum Voluntary Ventilation MVV
Correlation tests between the maximum voluntary ventilation
and the overall trunk impairment scale among the two groups:

Table(3): Correlation between the values of the maximum
voluntary ventilation and the overall trunk impairment scale
between two groups.
Discussion

The aim of this study was to assess the relationship between trunk muscles and ventilatory function in acute and chronic stroke patients. The result of this study was explained by Grosselink et al (2000) and Marcucci et al (2007) whom demonstrate that Even if expiration is a passive process, patients with cerebrovascular diseases are not able to perform it efficiently, as the abdominal muscles, which are the primary agents of forced expiration, present a remarkable loss of muscle activity and tonus. The result of this study was explained also by Sutbeyaz et al., (2010) who reported that Stroke is accompanied by sensory changes, including cognitive, visual, perceptual, and language, as well as changes in respiratory muscles, the latter being important and yet little discussed in the literature. In the current study, there was significant decrease in trunk control and ventilatory function in acute stroke patient’s more than chronic one. The result of this study agreed with Marcucci et al (2007) who reported that one of the possible reasons for the significant relationship between trunk control and PEF, except for the rectus abdomens, all the other muscles of the abdominal wall is inside the central aponeurosis, which is connected to the Alba line. Thus, each hemi-side dependent on the other for the occurrence of an effective muscular action. This is because the trunk flexors of stroke patients present motor alterations in the abdominal rectum of the paretic side and perform compensations through the external oblique muscles. When these muscles are activated, the affected side in the abdominal wall elongates, not offering sustentation to the muscles that are contracting. These results were supported by Pizzi et al. (2011), who reported that in a few weeks after stroke, there may be alterations to the muscular tonus and changes to the viscoelastic properties of muscles, which interfere with the biomechanical functioning of the thorax and may lead to loss in the ability and performance of the respiratory movements and trunk. Hart et al. (2005) observed that the use of an orthopedic belt stabilizing the abdomen and trunk reduces the functional residual capacity, increasing the PEF, decreases abdominal complacence, improving diaphragm performance and diminishing the sense of respiratory effort in patients with spinal cord trauma. The present study seems to confirm this statement, because the participants with higher TIS scores — i.e. with better postural control — presented higher PEF values. These results suggest that individuals with impaired axial control are likely to present some impairment in the respiratory dynamic because of the weakness of the muscular structures controlling it. The obtained results came in agreement with Dickstein et al (2011), who evaluate the correlation between trunk muscles, ventilatory muscle strength and ventilatory function in individuals who suffered chronic stroke. They reported that there is a statistically significant correlation was found between TIS and PEF. This study revealed a significant relationship between trunk control and PEF, this result agreed with Marcucci et al (2007) whom evaluated the relationship between trunk control using TIS and ventilatory function using spirometer. They approve that there is PEF, which presented a significant relation with TIS, perhaps because it is a result of the
force peak exerted by the expiratory muscles. The obtained results agreed with Almeida et al., (2011)20 who evaluated the effects of hemiplegia on ventilatory function in 20 patients with chronic stroke compared to 14 healthy subjects. Results have shown that individuals with stroke have significantly reduced values of PEF. They concluded that in addition to the breathing pattern changes, patients affected by stroke may also show decreased ventilatory function. Results of this study came in agreement with Swanney et al. (2008)21 who described the occurrence of a decrease in abdominal muscle activation after the onset of stroke, and this modifies the thoracic cage positioning, which tends to remain in an inspiration position. In this framework, the respiratory muscles do not work efficiently, leading to a loss of respiratory function in patients with hemiparesis/hemiplegia. Also the result of this study agreed with Sutbeyaz et al., (2010)22 who reported that the reduction of the muscular respiratory force may also be related to the fact that stroked individuals are more inactive due to their physical conditions. The result of this study agreed with Ward et al., (2010)23 who reported that respiratory function is also impaired, since the trunk muscles, in addition to being responsible for the stability and mobility of the trunk, also act in breathing control. The result of this study agreed with Xiao et al., (2012)24 who compared the ventilatory function of adults following their first stroke with established normal adults standards to explore whether pulmonary function is decreased or not. There was a significant different between predicted and actual pulmonary function test values. In this study there was a significant difference in overall score of TIS in acute and chronic group. This was agreed with Karthikbabu et al., (2011)25 who evaluate trunk muscles using Trunk Impairment Scale (TIS) and reported that the trunk muscles are impaired on both the sides of the body in patients with stroke. The authors reported also that there is decrease in the trunk control due to weakness of trunk flexor-extensor and bilateral trunk rotator muscles by means of isokinetic dynamometer muscle strength testing in patients with stroke, when compared to that of age matched healthy controls. Also the result of this study concerning the overall score of trunk impairment scale was proved by Monaco et al., (2010)26 who assure that there was a significant decrease in trunk control using TIS. The result of this study agree with Verheyden et al (2006)27 who reported that stroke patients show a significant decrease in the level of their trunk muscles control performances. This result of the study disagree with Cala et al (2011)28, who find that there is no relation between trunk muscles and ventilatory function in this series of individuals who suffered from stroke.

Conclusion

Through the results of the study it could be concluded that overall score of TIS is related to ventilatory function especially PEF and MVV in stroke patients. This relation is more significant in chronic group more than acute group.

Acknowledgment

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References

10 Moro DLF, Tordi N, Lonsdorfer E and Lonsdorfer J. Ventilation efficiency and pulmonary function after a wheelchair interval- training program in subjects with


21 Swanney MP, Rupple G and Enright PL. Using the lower limit of normal for the FEV1/FVC ratio reduce the misclassification of airway obstruction, 2008; 63(12):1046-51.


