Review Article

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Effects of Stroke Duration and Subtypes on Peak Expiratory Flow Rate

Vaibhav Agarwal*, Vivek Gaur, Shiv Kumar Verma***

Abstract

Background and Purpose: A large number of stroke patients present with dysphagia and aspiration especially in early phase of disease. On the other hand lung functions are also surely affected in stroke patients and constitute the largest factor behind mortality and longer hospital stay in such patients. We believe this might be the prime reason behind dysphagia, aspiration and pulmonary infections in stroke patients. This research with help of bedside assessment tool tries to assess the lung efficiency in acute stroke, chronic stroke and compares it with that of normal nonsmoking age and gender matched controls. *Methodology:* This study was carried out with 60 male subjects between age 50-80 at Himalayan hospital premise. 15 Acute stroke subjects (Group-A), 15 chronic stroke subjects (Group-B) and 30 healthy age and gender matched non-smokers (Group-C) were selected according to the selection criteria for the study. After thorough assessment and informed consent, PEFR readings were obtained at the specified timed during the day. After a visual demonstration and instructions, three consecutive readings of PEFR were recorded in each subject and duly noted according to the type and duration of stroke. *Results:* Comparison of PEFR value among acute stroke, chronic stroke and control group shows that there is a statistically significant difference between the PEFR values. Acute stroke shows PEFR values $\leq 50\%$ of age and gender matched control. While chronic stroke demonstrates PEFR values only 60-70% of normal. *Conclusion:* There exists a statistically significant difference between the PEFR values of acute stroke, chronic stroke and control group. Acute stroke patients has less than half of capacity of exhaling out air as compared to normal age and gender matched subjects, perhaps this is the reason why acute stroke patients are most likely to present with dysphagia and aspiration. Although chronic stroke patients also demonstrate dysphagia and aspiration but at much lower rate. This is in line with their PEFR values which show an improving capacity of force of exhalation. The study points out for more elaborate research on the topic and need of cardiorespiratory rehabilitation in stroke patients as early as possible.

Keywords: Peak Expiratory Flow Rate; Ischemic Stroke; Lung Functions; Dysphagia; Aspiration.

Stroke as defined by WHO is rapidly developing clinical signs of focal (or global) disturbance of cerebral function with symptoms lasting 24 hours or longer or leading to death, with no apparent cause other than vascular origin [1].

In other words, Stroke or Cerebrovascular disease is a focal neurological disorder due to either ischemia or hemorrhage that manifests into focal symptoms of weakness, sensory disturbances, speech disturbances and visual disturbances etc.

Stroke is the leading cause of mortality in developing world which accounts for nearly 86% share of stroke population. Stroke occurrence has fallen by 40% in developed world since 1970 to 2008 whereas it has doubled in developing world during same time span, with fatality rate 25% higher for developing countries as compared to developed nations [1].

The 2011 Indian National Census has reported that average age of Indian population increased to 68.89 years as compared to 63 years (2001 Indian National Census) [1] and therefore on an average Indian population is surviving through the peak

Author Affiliation: *Lecturers **PG. Student, Department of Physiotherapy, Swami Rama Himalayan University, Jolly Grant Dehradun UK.

Reprint Request: Vaibhav Agarwal, Lecturers, Department of Physiotherapy, Swami Rama Himalayan University, Jolly grant Dehradun Uttarakhand - 248016.
E-mail: vaibhavagarwalphysio@yahoo.in

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years of occurrence of stroke which is 55-65 years although with lesser mortality rate due to improved health care access [2,3]. The largest community survey in India thus far found the Crude prevalence rate of stroke around 220/100,000 of population.

Stroke has substantial mortality in Indian society perhaps due to the unique lifestyle habits like a large number of people smoke cigarettes and chew oral tobacco. Stroke kills nearly 7.7 lakh people is India and has nearly 10 Disability Adjusted Life Years (DALYs) as marker of disability.

Past cohort trials has identified reduced lung functions as an independent risk factor for stroke. Even after occurrence of stroke reduced lung functions remains one of the biggest complications resulting in mortality. A large trial has shown that 30% stroke subjects with pneumonia die before hospital discharge similarly another study has pointed out that chest aspiration increases 11fold risk of chest infections [2,3]. The voluntary cough is compromised after stroke [2,3], which is in turn associated with increases chances of aspiration pneumonia [2].

Studies has also demonstrated inadequate movement of diaphragm and chest on hemiparetic side, respiratory muscle insufficiency and impaired voluntary cough [2,3,4]. This has been strengthened by a study that used Transcranial Magnetic Stimulation (TMS) demonstrated increase latency and decrease amplitude of motor evoked potentials of respiratory muscles in acute stroke [2]. Perhaps this is also the reason that dysphagia is a common presentation in acute stroke.

Therefore some clinical trials have provided indirect evidences of increase chances of aspiration after occurrence of stroke. Similarly some studies proposed reduce Reflex Cough (RC) and Voluntary Cough (VC) as a measure of compromised lung efficiency after stroke [2].

All ischemic stroke patients has a localized infarct area in brain which is than surrounded by ischemic penumbra which represents neurons that are not necrosed but receiving less than critical blood supply to function normal [2]. This is the salvageable brain tissue which upon receiving blood and oxygen can be revived back [2]. We believe pulmonary rehabilitation would provide improvement in oxygenation capacity and thus might have role in early recovery in stroke as already been proven animal studies yet not conclusively established in humans [2,3,4].

Most studies to this date have used spirometery to evaluate effect of stroke on lung functions. However this is only possible in chronic stroke individuals. Because pulmonary rehab is rarely part of the treatment of acute stroke patients, it is not deemed feasible moving patients into spirometery Lab. Therefore there is a need of bedside clinical procedure that doesn't need transporting patient into respiratory lab, saves time and cost.

In this research we have used Peak Expiratory Flow rate (PEFR) monitor to assess the exhaling capacity of the patient which is essentially required during protective cough against aspiration and for speech production [8,15].

Nature of the Study

A comparison was tried to be drawn between the PEFR values of acute and chronic individual with stroke and that of healthy subjects of same age group. The outcome measure was the standard method of PEFR measurement in both groups by the use of PEFR meter [12].

Research Setting

The study was performed in the Neuromedicine ward and OPD of Department of Physiotherapy, HIHT university, Jolly Grant, Dehradun, UK.

Informed Consent from Patient

Approval from ethical consideration was taken from Ethical Committee and informed consent was taken for each subject to be included in the study.

Design of the Study

Observational Study-comparative design.

Population

Patient admitted to Neuromedicine ward or seeking consultations at Neuromedicine OPD and Physiotherapy OPD.

Sample Size and Sampling Method

Criteria based consecutive sampling of 60 individuals, 15 acute stroke patients, 15 chronic stroke patients, 30 normal individuals.

Selection Criteria

Inclusion Criteria

Acute Stroke (Group-01)

1. Age 50-80 years.
2. Stroke presented within 2 weeks of symptom onset.
3. Stroke as confirmed by physician on CT/MRI.
4. GCS Score above 12.
5. MMSE Score above 25.
6. Lacunar stroke/ recurrent stroke or bilateral stroke was not found to be limitation rather divided into disease category.

Chronic Stroke (Group-02)

7. Age 50-80 years.
8. Stroke presented at 6 months or after 6 months of symptom onset.
9. Stroke as confirmed by physician on CT/MRI.
10. GCS Score 12 or more.
11. MMSE Score 25 or more.
12. Lacunar stroke/ recurrent stroke or bilateral stroke was not found to be limitation rather divided into disease category.

Normal Subjects (Group-03)

13. Age 50-80 years.
14. No long standing neurological/ musculo skeletal/ cardiovascular or respiratory disease/ disorders/trauma that can limit the lung functions.

Age Subgroup in category of Group 01, 02 and 03 were as follows:

i. 50-59.
ii. 60-69
iii. 70-79

Category of Disease Subgroup

A. ACA Stroke.
B. MCAStroke.
C. PCA and Brainstem Stroke.
D. Lacunar Stroke.
E. Bilateral/Recurrent Stroke.

Exclusion Criteria

1. Previous long term chest conditions ex. Asthma, copd, atelectasis etc.
2. Previous congenital cardio-respiratory conditions ex. mitral valve stenosis, Co-arctation of aorta, Fellot's teratology etc.
3. Previous cardiac abnormality ex. Cardiac failure, Symptomatic arrhythmias etc.
4. Musculoskeletal abnormality hampering cardio-respiratory functions ex. Scoliosis, kyphosis, gibbus etc.

Variables of the Study

5. Dependent variable- PEFR (Peak expiratory Flow rate).
6. Independent variable- Type and duration of stroke.

Instrumentation

1. Peak Flow Meter.
2. Inch-tape.
3. Data Collection Sheet.
4. Pen-Pencil-Paper.
5. Stethoscope.
6. Knee Hammer.

Stroke patient performing on peak flow monitor.

Fig. 1:

Fig. 2:

Procedure

60 subjects were divided into 3 intended groups according to their respective category (Group 01 - Acute Stroke, Group 02 - Chronic Stroke, Group 03 - Control Group).

15 acute stroke subjects (mean age 62 ± 8.02 years), as diagnosed by neuro-physician were selected. Subjects were then finalized according to the inclusion and exclusion criteria of the study. They were informed about the study and testing procedure and informed consent was taken from every subject before their participation in the study.

The European Respiratory society guidelines were followed for PEFR Measurements [2]. Subjects were asked to perform the maneuver 3 times in similar way with 20 seconds gap between each attempt. The mean value of three attempts was recorded.

All the necessary adjustments were done for patients comfort during the procedure.

Similarly 15 chronic stroke subjects (mean age 61 ± 6.14 years), were taken for the study with information about study and procedure prior given to them while informed consent was obtained beforehand. The testing procedure was same for the chronic stroke subjects too.

30 normal subjects (mean age 64 ± 8.01) who fitted into the selection criteria were selected from the hospital premises to be the control group. Information about study and testing procedure was given to them and informed consent taken. The subjects were made to sit upright on a chair with back supported. Demonstration was given to them. The Testing procedure was same as that mentioned previously.

PEFR Recording in Facial Palsy

As stroke subjects frequently present with facial palsy of varying degree, it is reasonable to ask how PEFR recording was done with and doesn't air passes between the lips and mouth piece of instrument. Can patient generate a forceful exhalation and execute it as expected?

Authors in this study, having idea about the Neuroanatomy behind the facial palsy can say with confidence that most of the patients, especially those in chronic stage of recovery won't have this trouble if adequate precautions are taken prior the testing procedure.

The lower part of facial nucleus, muscles supplied by it and Genuglossus are the only muscles those do not have bilateral innervations from cerebral cortex. Henceforth most of the facial muscles are expected to have some capability to function normal, except under most severe circumstances.

Slight adjustments were done during the procedure and with the instrument. One of the therapists stood behind the patient and tried to keep his jaw in midline by holding mandible at its angle bilaterally, manual support was given to the side of mouth by pacing middle finger and ring finger below and over the lower and upper lips.

The mouth piece of the instrument was modified by applying 2-3 layers of dynoplast over it so that it becomes easier for patient to hold it in mouth. A flat mouth piece for instrument is further advisable for such subjects.

We had overall 8 patients with facial asymmetry, 5 (2 acute stroke patients, 3 chronic stroke patients) who could perform on Peak flow meter with satisfactory performance after adjustments. Although 3 other subjects had to be excluded with facial palsy that despite adjustment with procedure and instrument could not perform it satisfactorily [6,7].

Stroke and Aphasia

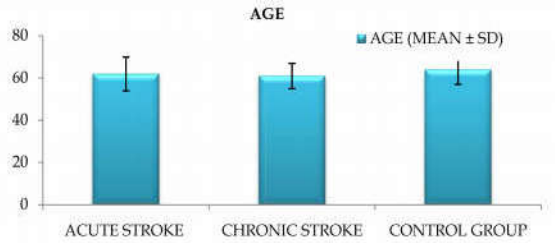
Patients even with Broca's aphasia where comprehension was supposedly intact and able to performed simpler motor commands of examiner, for some reasons these patients too could not perform when asked to exhale into PEFR monitor [11].

Data Analysis

The data was analyzed by SPSS - 22nd version as required. The significance level was set $p < 0.05\%$ and confidence interval was set at 95%. The dependent variable used for the study was duration of stroke (acute stroke and chronic stroke), type of stroke, and age categories of 50-59 years, 60-69 years, 70-79 years. The independent variable for the study was PEFR value.

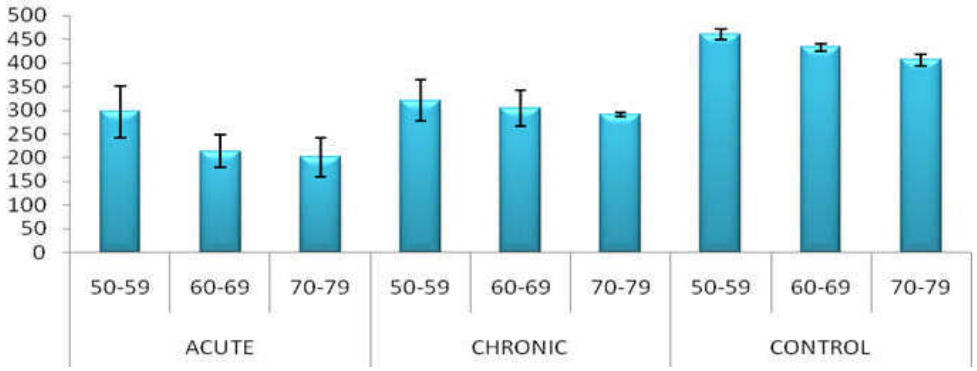
The inter group age analysis was done by one way ANNOVA. The intergroup analysis of mean PEFR, interaction and comparison between categories of disease and age was done by two way univeriate ANNOVA.

Results



Grah. 1: Mean age among acute stroke, chronic stroke.and control subjects

Mean PEFR Values in Different Age Groups of Acute Stroke, Chronic Stroke and Control Group



Graph 2: Comparisons between the mean PEFR values in different age sub-groups in acute stroke, chronic stroke and control subjects

Discussion and Conclusion

Lung efficiency is an important aspect to evaluate in stroke population. These are a group of physiological functions easily and almost certainly adversely affected in such individuals. Large sample cohort trials as noted in review of literature has already proved that many cardiovascular abnormalities and age related changes has effects on lung functions which is an independent risk factor for stroke.

Many of these studies use the absolute or quartile values of PEFR to predict the relative risk of stroke due to abnormal lung functions [2]. For example the Whitehall study over 18, 403 cohorts men found out that those with PEFR <3 liters independent of other risk factor were almost twice as likely to die from stroke as those with an PEFR >3.5 liters [3].

Our outcome variable in this study was Peak Expiratory Flow Rate (PEFR). A large number of physiological, lifestyle and pathological factors in addition to certain medications has impact on Peak Expiratory Flow rates.

Physiological Factors those affect PEFR such as age, height, built, BMI, body surface area, gender, race, ethnicity/ancestry, region, climate, pollution and physical exercise status are important to note. Among the Lifestyle factors Smoking status largely impacts upon the PEFR values. Sedentary lifestyle and stress may also impact PEFR values adversely. Among the Pathological factors, Respiratory anomalies viz, Asthma, COPD, CRPD, bronchiolitis, Pneumonia, chest congestion etc, Cardiac Anomalies viz. ASD, VSD, Teratology of Fallot and valvular defects etc, dorsal spine deformity viz. scoliosis, kyphosis etc, neuromuscular syndromes eg. Myasthenia gravis and a large number of debilitating conditions such as Stroke, MS, Parkinson's, Dementia disorders, Alzheimer's, bulbar and pseudo bulbar palsies might adversely affect the PEFR measurements [2]. Studies has pointed out that Polycythemia, increase hematocrait levels (51% or more) and increased alcohol intake can lead to reduced lung functions and stroke [3,4,5,6].

Dysphagia constitutes a significant problem in stroke and it's reasonable to think that reduced expiratory functions should have some influence on dysphagia. A study by Kidd examining a cohort of 60 patients evaluated on videofluroscopy found that 25 of these patients had aspirations within 72 hours of stroke onset however it remarkably improved at 3 month follow up in all but 3 subjects [2]. A similar study by Smithard et al where they followed 121 acute stroke subjects found 61 (51%) of their subjects had dysphagia which resolved in few days in 33 of patients and at the end of 6 month only 6 of such subjects were left with dysphagia [2].

The primary reason cited for dysphagia and aspiration associated with stroke is due to the disruption of CNS input to associated sensory, motor and protective reflexes [2]. Cough is a protective reflex and lower PEFR values can interfere with cough strength. This inefficient cough strength and dysphagia can ultimately risk an individual to aspire the food content, leading to aspiration related complications. The mortality in stroke patients with dysphagia is mainly due to increase chest infection, dehydration and death [7].

Interpretation of Results

Regarding the PEFR measurements in Indian

Population a few works could be noted here although a large scale cross-sectional study or cohort study in Indian population are missing on normal or diseased population.

A review article by Dikshit, Raje and Agarwal, published in Indian journal of physiology and pharmacology in 2005 discusses the Peak Expiratory flow rate guidelines, measurement tools, normal values, factors affecting PEFR and regression equation to calculate PEFR according to age and height in Indian population [3].

In the same study Dikshit and colleagues predicted the normal values for PEFR for age 50-60 which was 455±19.9. Our observed value for control group in same age category was also in the same limits (460±11.46). Although above 60 years of age Dixit and colleagues had given vague values of 377±71.8. Our observed values in 10 non-smoker healthy subjects in age group 60-70 was 433±8.43 and in 70-80 age group subjects it was 406±13.80 in same number of healthy non-smoker controls. From the Dikshit study adding the standard deviation to obtain upper limits of PEFR values in population above age 60 can be quantified and then it falls in similar numbers as observed by us.

Apart from all the factors described above, the PEFR readings can be significantly altered by diurnal variation, voluntary efforts, depressive status and muscular weakness. To eliminate the diurnal variation in our subjects we measured the PEFR between 11:00 AM to 01:00 PM (2 hours period).

All stroke patients undergo a significant amount of stress and depressive illness which has been established in past through various studies [3]. This factor could not be eliminated from our study yet patients were encouraged all throughout the study, closely monitor for any significant depressive illness and no patient was found to have any previous psychiatric illness before the initiation of study.

Ezeugwu, and Olaogun in their study has proposed muscular weakness of diaphragm, intercostal and abdominal muscles as reason behind the reduced lung functions in stroke survivors. We also propose the same mechanism responsible for reduced PEFR recording in our study.

The lung functions are markedly reduced in stroke and dysphagia/aspiration/chest infections are common problems in such patients. It is probable to think that a correlation exists among them as also pointed out by some researches. Our study not only tries to evaluate the amount of reduced lung functions in different duration and categories of stroke by a cost & time saving, simple bed-side procedure, but it also proposes a mean of quick bedside ventilatory assessment and possible identification of stroke subjects at risk of dysphagia/aspiration who performed low on Peak Flow Meter.

However what threshold of expiratory effort or cough reflex efforts should be taken as a safe limit below which dysphagia becomes increasingly likely to occur is a question this study couldn't look into. Assessing validity of Peak Flow Meter in identifying stroke subject at risk of dysphagia/aspiration is a topic of debate and best left to future research.

Clinical Relevance

This study highlights the need of more attention to the problem of reduced lung functions in stroke and need to address the possible reasons behind it. Patient's unconscious status, more characteristic and prominent other symptoms and physician's priority at dealing with more serious problems might make it difficult for even expert physicians to overlook the reduced respiratory efficiency of patient which may prove harmful for the patient in long run. Therefore it is the view of the authors in this study that an early respiratory assessment and prompt rehabilitation by help of multidisciplinary team would be the best suited practice in present stroke care units. As described in introduction, Animal model has already shown a beneficial effect of cardiovascular exercise on infarct size. It might even have favorable effects on salvageable penumbra which is only speculation at present yet a very strong concept to look at as stroke patients who have been put on early exercise do well on all parameters of mobility, efficiency and endurance as well as on cognitive profile [3,4].

Another reason for early cardio-respiratory rehabilitation is focus on dysphagia which is a disability in its own terms and prominent reason of aspiration and chest infections. This imposes significantly increased mortality, morbidity, substantial increase in economic burden in terms of healthcare expenditure and days lost to disability of the patient.

Future research that correlates and calibrates reduced lung functions and dysphagia might give us a more clinically relevant, quick bedside assessment tool i. e. Peak Flow Meter, to identify the potential aspirators or dysphagics, unlike present time's Videofluoroscopy Swallow Study (VSS) or Fibreoptic Endoscopic Evaluation of Swallow study (FEES), both of which are invasive, unpleasant to patients, relatively costly and time consuming procedures.

Limitations

Small Sample Size.

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