RADIOAEROSOL MUCOCILIARY CLEARANCE OF TRACHEOBRONCHIAL TREE IN NORMAL SUBJECTS AND IN PATIENTS WITH RESPIRATORY DISEASES

Pages with reference to book, From 40 To 42

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ABSTRACT

The rate of mucociliary clearance in the tracheobronchial tree was studied both in patients and controls using radioisotopic techniques. The radioisotope is deposited in the larger airways and its rate of movement is measured as it is being transported up the trachea due to mucociliary activity. The BARO aerosol generation system was modified and used for this purpose. One hour study was acquired on a computerised gamma camera in each case. The rate of movement of the bolus of radioactivity was calculated by measuring the distance travelled in a known period of time. The mean velocityof transport was 9.0mm/min in normal subjects. In patients variable speed of transportation was obtained ranging from absolutely no movement to near normal speeds. Different patterns of transport were observed including linear, spiral, static and regurgitative. It was concluded that this simple non-invasive technique can be used for in vivo monitoring of mucociliarytracheal activity (JPMA 42: 40, 1992).

INTRODUCTION

activity of the tracheobronchial tree is the most effective and elaborate system of clearing the air passages. The mechanism has been studied in the nose[1]. The ciliary activity is impaired in various airway diseases which may either be due to primary defect of the cilia, chronic smoking or occupation related diseases of the chest. Monitoring this activity cannot only help in distinguishing primary from secondary bronchiectasis but also help to study the effects ofvarious pharmacological agents that may influence this vital function of the tracheobronchial tree. In the past various methods have been employed to study this function. Teflon discs were implanted in the trachea and their movement observed through a bronchoscope[2]. Friedman used radiopaque teflon discs[3] and others studied the ciliary beat frequency in vitro[4]. However, all these procedures are invasive. The radioaerosol mucociliary clearance is an in vivo non-invasive and reliable method to study this function[5,6].

PATIENTS AND METHOD

Four healthy controls (2 males and 2 females) with ages ranging from 22 to 43 years, volunteered for the study. They were non-smokers and had no evidence of pulmonary disease. Their chest x- rays and spirometric tests were also within normal limits (Table I).

TABLE I. Transit time and rate of mucociliary activity of trachea with labelled albumin in normal subjects.

Age/Sex	Smoking	Spirometry	Distance (cms)	Time (min)	speed cm/min
22/M	Nil	Normal	6.2	6.82	1.1
40/M	Nil	Normal	5.7	5.13	0.9
31/F	Nil	Normal	8.3	8.0	1.04
43/F	Nil	Normal	6.5	5.59	0.86

Fourteen patients (12 males and 2 females) were studied. Their ages ranged from 20 to 70 years (mean 41). Ten patients had COPD, 3 bronchiectasis and 1 pulmonary tuberculosis. The radio-pharmaceutical used for this study was human serum albumin labelled with technitium-99m. The kit was prepared at Inmol. 15 to 20 mCi of technetium pertechnetate was added to the solution of albumin and incubated in a water bath for 10 min. at 45 to 50°C. The solution was filtered through a 0.um millipore filter. The labelled albumin was placed in the modified BARC aerosol generation system providedby the InternationalAtomicEnergyAgency(IAEA). The patients inhaled the particles for 3-5 minutes before imaging was started. A computerised gamma camera (Scintiview II, Gammasonics, Siemens) was used for ten patients while the rest were studied on an analogue gamma camera system. Imaging was done in the supine position. One hundred pictures of 32 sec interval each, were acquired. Discrete boll of radioactivity, trapped in the mucous of the tracheobronchial tree were seen moving towards the larynx. The position of the bolus was marked at the start of the study taking carina as a reference point. A second point was marked if the bolus was still in the trachea. In cases the bolus readily passed . into the larynx, full tracheal length was measured with the help of a laryngeal marker. Four regions of interest were drawn on the trachea and the time activity curves were plotted (Figure).

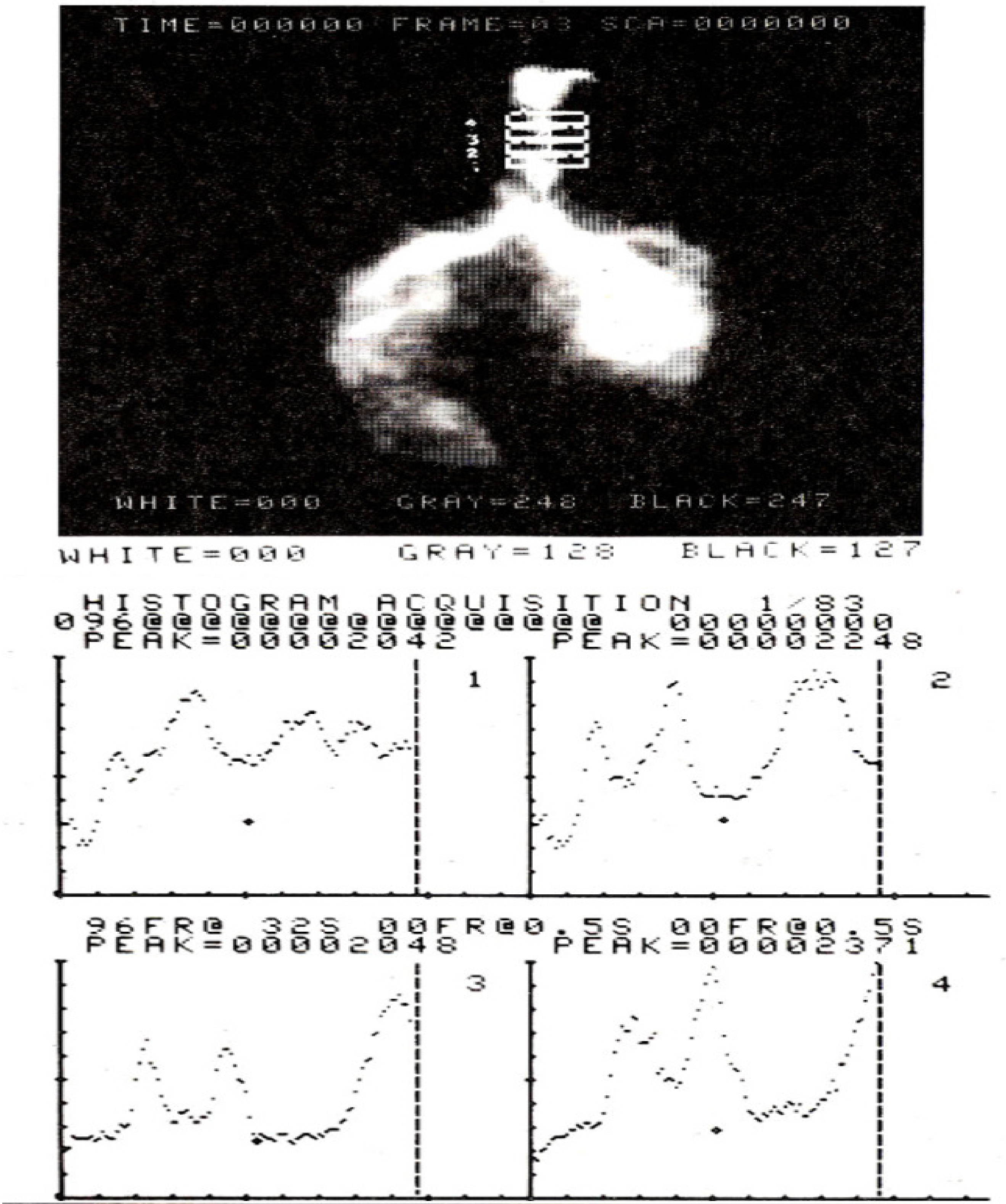

Figure. 4 Regions of interest marked on the trachea and time activity curves plotted.

The velocity of movement was calculated by the following formula:

$V = S/T$

where V= velocity, S= distance, T= time.

The rest of the five cases, one normal and four abnormal subjects were studied on an analogue gamma camera system and the images acquired every two minutes for one hour. The speed of movement of the bolus was calculated by using the above formula.

RESULTS

The movement of the bolus of radioactivity was observed in the cine mode on a colour display. The isotope travelled from the lung hila to the larynx from where it was swallowed[7]. Different speeds of movement of bolus were obtained ranging from absolute stasis to near normal speeds (0.1 cm/mm to 0.9 cm/mm). One patient with bronchiectasis showed complete stasis. The rate of ciliary movement in other diseases of the lung is shown in Table II.

TABLE I. Transit time and rate of mucociliary activity of trachea with labelled albumin in normal subjects.

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The values obtained by spot imaging technique are shown in Table III.

TABLE III. Transit time and rate of mucociliary activity of trachea by spot images.

Diagnosis	Smoking	Distance (cm)	Time (min)	Speed V=S/T
Emphysema	Yes	8.32	28	0.297
Normal	No	9.36	22	0.425
Ch. bronchitis				
left bronchiectasis	Yes	1.56	50	0.312
Bronchiectasis, asthma	No	6.76	40	0.169
Asthmata	No	3.64	20	0.182

Maximum speed obtained by the technique was 0.42 cm/mm. It was also observed that the pattern of transport mucus varied from patient to patient. Different patterns obtained in this group of patients were linear, spiral or regurgitative.

DISCUSSION

The epithelium that lines the respiratory passages from nose to the terminal bronchioles is ciliated columnar epithelium. The cilia move in a layer of mucus which is produced by the sub-mucus glands and other epithelial cells. This mucus is in a constant phase of movement which is cephalad in direction and hence serves as an effective and constant clearing mechanism. Because of the sticky property of this mucus any pollutant in the inspired air is trapped by it. Inhalation of the aerosol results in deposition of particles in the mouth, pharynx, larynx, trachea, proximal bronchi and alveoli depending upon the size of the particles (Table IV)

Table IV. Particle-traping by air passages.

Size of particle	Size of trapping
>2 microns	Nasal passages and trachea.
102 microns	From large bronchi upto terminal brochioles
0.4-1 microns	Alveoli
<0.4 microns	Don't settle - are exhaled

After a few minutes of inhalation boli of tracheal mucus are formed which begin to travel upwards. The comparison of the results obtained by two techniques could not accurately be performed because of a small number of patients and controls. The major purpose of this study was to standardise the technique for the study of mucociliary clearance. Only one control, studied by analogue imaging technique, showed slow velocity of ciliary transport which may have been due to an undiagnosed disease of the lungs. The velocity of transport of isotope can be used as an index of ciliary function. The velocity of mucus transport in normal individuals is close to 1 cm/min. However, different velocities are observed in patients with respiratory diseases. The correlation of ciliary function and the velocity of transport holds only where the pattern of transport is linear. In spiral and regurgitative mode of transport the actual velocity may be normal, but since the bolus has to travel a longer distance in a spiral course this correlation does not remain valid. In other words, the velocity measurement in such patients is inaccurate. It may however, be mentioned that the linear mode of transport is considered as normal. Extremely low velocities of transport of mucus are seen in bronchiectasis. The technique for in vivo monitoring of ciliary function is simple, non-invasive and inexpensive. It is felt that the number of normal individuals in this study is rather small and more studies should be carried out so as to formulate normal ranges of velocity of ciiary transport valid for both rural and urban population. Further studies to correlate mucociliary function with the degree of environmental pollution may also give interesting information. The mucociliary damage caused by smoking can also be assessed by using this simple technique.

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