liters/minute; *i.e.*, their pulmonary reserve is limited. Furthermore, patients with pulmonary emphysema and an MBC of less than 40 liters/minute will usually have resting arterial oxygen saturations below 92 per cent and P_{CO_2} values above 48 mm. of mercury.[7] On the other hand, it is unlikely for patients with MBC values greater than 40 liters/minute to develop increasing respiratory acidosis during inhalation of 100 per cent oxygen.[8] Therefore, most patients who can extinguish the match easily can be expected to respond effectively to normal demands for gas exchange.

The match test requires (1) no excessive patient or physician effort, (2) takes minimal time for performance, (3) is reproducible, (4) requires no expensive or bulky equipment and (5) correlates well with the MBC, an established test of pulmonary insufficiency.

The match test serves three purposes: (1) It aids in the selection of patients whose pulmonary vulnerability is great enough to justify careful preoperative preparation. (2) It adds a quantitative value to the many clinical impressions that the physician must weigh in deciding for or against operation in every patient. (3) By repeating the test, the patient's progress may be followed.

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Influence of Gas Velocities and Concentrations on Match-Blowing-Out Time

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The ability to blow out a paper match held 3 inches from the widely opened mouth has long been used as a simple method for assessing and demonstrating ventilatory dysfunction. This rough index correlates well with the maximum breathing capacity and the one second vital capacity.[1-3] However, none of the previous writers on the match test seems to have studied the effect of measured air velocity in blowing out matches. It is the purpose of this communication to measure the expiratory gas velocity necessary to extinguish a match.

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METHOD

In the present study a 120 liter Tissot spirometer with varying weights on the bell was used to produce exactly measured volume flow rates during descent of the bell. The gas was ejected into the room through smooth, straight tubes three feet long to reduce turbulence. Their cross sectional area varied in different studies. A newly lighted match was held 3 inches from the end of the tube. A stopwatch with a scale reading fifths of a second was started at the moment when flow was initiated by turn[illegible]g a stopcock, and was stopped when the ma[illegible]h went out. Velocity of gas flow in cm./sec[illegible]nd is the relevant parameter in blowing ou[illegible] matches, not the volume flow in liters/minute which is used in bellows function tests of the lung. This velocity was calculated, in meters/second, from the ratio (volume flow in liters/second)/(cross sectional area of tube in cm.^{2}).

Results

Data on tubes of different diameter are given in figure 1, where black circles, triangles and squares indicate tubes with cross sectional areas of 7.54, 3.80 and 3.46 square centimeters, respectively. The x axis shows the linear velocity. The y axis is the mean time in seconds taken to blow out groups of 10 matches. The standard deviation of each mean is indicated by vertical lines through each point.

The volume flow needed to give the same linear velocity through the widest of the three tubes is 2.18 times that needed wtih the narrowest tube. The data presented in figure 1 by the coincidence of circles, squares and triangles on the same line shows that linear velocity and not volume flow is what determines the time taken to blow out a match.

The position in which the match is held effects the time taken to blow it out. In these studies cardboard matches were held vertically in the air stream with their narrowest edge facing into the stream. When the broader surface of the match faced into the stream the time needed to blow out the match was reduced by 30 per cent. Matches from several different manufacturers were tested and were blown out in the same time.

Obviously the composition of the gas also affects blowing out time since this is longer in 100 per cent oxygen and is zero irrespective of flow rate in 0 per cent oxygen. We have, therefore, tested the match blowing effectiveness of two different gases other than air, *i.e.*, 15 per cent O_2, 5 per cent CO_2, 80 per cent N_2, and 30 per cent O_2, 5 per cent CO_2, 65 per cent N_2. The results are given in figure 1 as open circles and open triangles. It is seen that a 5 per cent reduction in oxygen concentration decreases the match blowing time by about 30 per cent.

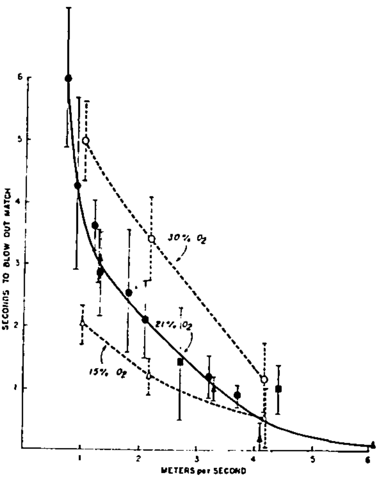

FIG. 1. The time taken to blow out matches (seconds) at varying gas velocities (meters/sec.) with gases containing 15 per cent O_2—5 per cent CO_2—80 per cent N_2, 21 per cent O_2—5 per cent CO_2—74 per cent N_2, and 30 per cent O_2—5 per cent CO_2—65 per cent N_2. Circles, triangles and squares indicate tubes with cross sectional area of 7.54, 3.80 and 3.46, respectively. The standard deviation of each mean is indicated by vertical lines through each point.

Discussion

How does this match blowing time relate to the match blowing effort of patients? This time factor depends on the velocity profile of the forced expiration. In normal people there is a high flow rate lasting about one second, *i.e.*, 84 per cent or more of the vital capacity is expired in that time.[4] The match is blown out in the first second. In patients with airway obstruction the flow is slower and lasts longer, and furthermore it decreases in each successive second of forced expiration. The flow which has most effect on success or failure in match blowing is the peak flow in the first second. However, it is possible in patients to have velocity profiles in which the match is blown out in the second or even the third second when a relatively low velocity is maintained for a long time during the performance of the vital capacity. Since N_2 concentration rises and O_2 concentration falls as expiration continues in such patients, the extinguishing of the flame is facilitated by the changing gas composition. In such patients the time taken to blow out the match is a sign of impaired function. Indeed the time taken to blow out a match might be a better index to use than success or failure. In order that a match be blown out in one second it is necessary, as can be seen from figure 1, that the gas velocity exceeds about 4 meters/second with room air or 3 meters/second with 15 per cent O_2, 5 per cent CO_2, 80 per cent N_2 which approximates expired gas.

The volume flow corresponding to any velocity depends on the cross sectional area of the open mouth. In 10 randomly selected young men this was found to average 8.9 cm.[2] At a velocity of 3 m./second, through a mouth of this size, volume flow is 2.66 liters/second. This is in general agreement with the published estimates. Thus Snider[2] found that the mean value for the one second vital capacity of those subjects who could extinguish the match was 2.49 liters with a standard deviation of ± 0.57 liters. The mean value of the one second vital capacity for those who could not blow out the match was 0.97 liter with a standard deviation of ± 0.47 liters, *i.e.*, about one third as much. Olsen[1] found subjects with maximum breathing capacities less than 40 liters/second, *i.e.*, about one-third normal failed to blow out matches.

It is apparent from the standard deviations in figure 1 that the match blowing time varies considerable even under the standardized conditions used here. The match blowing performance of patients seems to be somewhat more variable and assessments should be based on the average performance with several matches. Despite these limitations, the match blowing test seems to be a useful, simple, rough test of ventilatory functions.

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Anesthesia Data Sheet

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A summary sheet for the tabulation of anesthesia clinical work, departmental or individual, is herein submitted. This sheet provides a ready reference for data pertaining to number of cases done, number of times various agents or techniques are employed, and number and type of complications.

As can be seen from the illustration, the principal vertical column is the one labelled "Agent and Technique." The initial entry is recorded, once only, to the left beside the respective agent or technique in the "Number" column. Other vertical columns are for the listing of complications, specific and by systems, in the appropriate boxes. Particular complications for each agent can be totalled in the individual spaces. The total number of times each agent or technique is used can be obtained by adding the entries in the "Number" column and recording in the proper box in the "Totals" column at the right side. The number of complications by type and system are added vertically and listed in the respective blocks at the bottom of the sheet.

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