

# TERMINOLOGY FOR MEASUREMENTS OF VENTILATORY CAPACITY

## A REPORT TO THE THORACIC SOCIETY

PREPARED BY

B. GANDEVIA\* AND P. HUGH-JONES

*" Il faut considérer les mots avec prudence : ils apportent un peu des théories originelles qui les ont fait naître . . . la précision du langage n'est pas qu'un exercice désuet de puriste; elle est un nécessité scientifique " (Cara, 1955).*

The need for uniformity in terminology for measurements commonly used to assess the ventilatory capacity of the lungs has long been apparent. The multiplicity of terms which are in use has undoubtedly confused clinicians and delayed the adoption of simple tests of ventilatory capacity in clinical practice.

There was considerable standardization of terms and symbols among respiratory physiologists following the agreement reached by some workers in the United States (Pappenheimer and others, 1950), but their suggestions did not extend to the ventilatory aspects of lung function, and in this field respiratory physiologists have not only continued to use different terms but have used the same terms with quite different meanings.

In December, 1956, a meeting was held, under the chairmanship of Dr. P. Hugh-Jones, to discuss terms applied to the measurements of maximum ventilation using some notes on alternative terms prepared for the meeting by Dr. B. Gandevia. The meeting was attended by 30 workers interested in clinical respiratory physiology and coming from 14 different centres in Britain. Agreement was reached by a substantial majority of these workers. The definitions of the agreed terms, their abbreviations, and the reasons for rejection of other terms in common use are given below. A number of workers in this field from different centres in the United States have kindly considered these terms and raised no objection to them in relation to the terminology in use there. Some European workers were likewise consulted and with a few exceptions have agreed either in detail or in principle. The terminology

has been considered by the Thoracic Society and recommended for general use in the United Kingdom.

### TERMS AND DEFINITIONS

The recommended terms, their abbreviations, and their equivalents in common use are summarized in the Table. Test conditions, especially subject posture, sitting or standing, should obviously be given.

1. **FORCED VITAL CAPACITY.**—The forced vital capacity is the maximum volume of gas which can be expired following a maximum inspiration, the expiratory phase being accomplished rapidly, and as forcibly as possible. Abbreviation: F.V.C.

2. **FORCED EXPIRATORY VOLUME** (over a stated time interval).—The forced expiratory volume is that volume of gas expired between two stated time intervals during the performance of the forced vital capacity. The abbreviation for this term is F.E.V., the time intervals being indicated by a subscript. It was agreed that where the first time interval is zero, only the second time shall be stated. Thus F.E.V.<sub>0.25-0.75</sub> and F.E.V.<sub>1.0</sub> refer respectively to the volume expired during a forcible expiration from the end of the first 0.25 seconds to the end of 0.75 seconds and to the volume expired in the first second.

**NOTES ON THE USE OF THE TERMS "FORCED VITAL CAPACITY" AND "FORCED EXPIRATORY VOLUME."**—The adoption of the specific term "forced vital capacity" to refer to the vital capacity measured with the subject breathing out as rapidly as possible is justified because the resultant values may differ from those obtained when a full expiration is done slowly as in conventional measurements of the vital capacity. When the vital capacity is measured during an expira-

\*Wunderly Scholar in Diseases of the Chest, Royal Australasian College of Physicians.

TABLE

Description	Recommended Term	Abbreviation	Previous Terms
Spirogram of a forced, complete inspiration or expiration	Forced inspiratory/expiratory spirogram	F.I.S./F.E.S.	Expirogram; fast inspiratory/expiratory vital spirogram
Volume of gas exhaled over a given time interval during a complete forced expiration*	Forced expiratory volume, qualified by time interval used	F.E.V. <sub>T</sub>	Timed vital capacity; fast expiratory capacity; capacity usable on effort (Fr. C.P.U.E.); maximum expiratory volume (Fr. V.E.M.S.)
Volume of gas expired after full inspiration; expiration being as rapid and complete as possible (that is, forced)*	Forced vital capacity	F.V.C.	Timed vital capacity; fast vital capacity; fast maximum expiratory capacity
F.E.V. <sub>T</sub> expressed as percentage of vital capacity	Percentage expired (in T sec.)	F.E.V.%	Timed vital capacity; optimal frequency (Fr.)
Maximum volume of air which subject can breathe per min.	Maximum breathing capacity	M.B.C.	
Volume of air which subject can breathe on voluntary maximum hyperventilation for a given time (direct measurement of the "M.B.C.," usually made during 15 sec.)	Maximum voluntary ventilation (a) no specific qualification (b) qualified by "free" (Frequency to be indicated in both cases)	(a) M.V.V. (b) M.V.V. <sub>F</sub> (Frequency as subscript, e.g., M.V.V. <sub>60</sub> , M.V.V. <sub>40</sub> )	Maximum voluntary ventilation; maximum ventilatory capacity; maximum breathing capacity
(a) frequency controlled (b) frequency uncontrolled			
Volume of air which subject can breathe in one minute (as predicted from F.E.V. <sub>T</sub> )	Indirect maximum breathing capacity	Ind. M.B.C.	—

\* Inspiratory vital capacity, forced inspiratory volume, etc. (I.V.C., F.I.V., etc.), can similarly be used when inspiratory measurements are made.

tion which is not rapid as well as forcible, the term "vital capacity" (unqualified) is applicable.

Since "vital capacity" always refers to the volume of a full expiration, it was agreed that the qualifying term "expiratory" need not be applied to "vital capacity" or "forced vital capacity." However, as the maximum volume measured on inspiration (after a full expiration) may differ from that of expiration, this measurement should be qualified by the word "inspiratory" (thus, "inspiratory V.C." or "forced inspiratory V.C.").

It is a common practice to express the forced expiratory volume as a percentage of the "vital capacity," but it is not usually stated how the vital capacity is measured. It was agreed that whenever this percentage is used, the method of measuring the vital capacity should be indicated by the use of F.V.C. or V.C., as defined above to describe the denominator (thus,  $\frac{F.E.V_{1.0}}{F.V.C.} \%$  or  $\frac{F.E.V_{1.0}}{V.C.} \%$ ).

The abbreviation adopted for either percentage, which must have been defined, is F.E.V.%.

It was not considered desirable to recommend a standard time interval over which the F.E.V. should be measured, particularly as some workers have already adopted the use of a particular time interval (either 0.75 sec. or 1.0 sec.). However, it was generally agreed, without a specific vote, that the F.E.V.<sub>1.0</sub> was appropriate for clinical purposes. Attention was drawn to the wide use of this time interval, not only in this country but also in the United States and on the Continent.

3. MAXIMUM BREATHING CAPACITY.—The "maximum breathing capacity" (M.B.C.) is the maximum volume of air that can be breathed per minute. Since the maximum breathing capacity may be assessed in several ways and under varying conditions, it was agreed that the term should be reserved to indicate a maximum value for a

subject. Although such a maximum is usually attained on voluntary hyperventilation, occasionally exercise provides a greater stimulus and produces larger values. The maximum breathing capacity can be tested either *directly*, under various conditions, or alternatively it can be estimated *indirectly* by prediction from spiographic tracings or from measurements of F.E.V. at certain time intervals.

There are thus two groups of tests for assessing an individual's maximum breathing capacity. These are:

(a) *Maximum Voluntary Ventilation Test (M.V.V.)*, which gives a direct estimate of M.B.C. The maximum voluntary ventilation expressed in litres per minute is the maximum volume of gas which the subject breathes when breathing as deeply and as quickly as possible or when breathing as deeply as possible at a controlled frequency, both tests being performed over a specified period of time. The former variant, when neither frequency nor depth is controlled, is referred to as the maximum voluntary ventilation (free) (M.V.V.<sub>F</sub>), but the frequency adopted by the patient should also be noted (thus M.V.V.<sub>F40</sub>, M.V.V.<sub>F60</sub>). When frequency is controlled, the frequency used is indicated by a subscript, e.g., M.V.V.<sub>40</sub>, M.V.V.<sub>60</sub>.

(b) *Indirect M.B.C.*—The indirect M.B.C. expressed in litres per minute is the maximum volume of air which the subject can breathe per minute, as predicted from measurements of either the inspiratory or expiratory spirogram or both, or from measurements of F.E.V. Since no standard time interval over which to measure the F.E.V. was adopted, no recommendation as to

the detailed procedure in the prediction of the indirect M.B.C. from forced expiratory spiograms was possible. In any event it was considered necessary that the method of arriving at the indirect M.B.C. must always be stated in any paper employing the prediction. It was pointed out that if the prediction was based upon F.E.V.<sub>1.0</sub>, multiplication by 30 gave values for the indirect M.B.C. which were too low. Published data suggest that a factor of 35 is approximately correct and the one most generally used, although the figure of 37.5 has been suggested by French workers on theoretical grounds (Cara, 1953). The difference between using 35 and 37.5 is immaterial in practice. The F.E.V.<sub>0.75</sub> is multiplied by 40 (Kennedy, 1953).

The question of the value and validity of converting measurements of F.E.V. to estimates of the M.B.C. was discussed. It was agreed that no specific recommendation on this subject should be made as it was outside the immediate problem of terminology, but the inaccuracy involved in multiplying F.E.V.<sub>1.0</sub> by the factor 30 was noted. As the predictions from any time interval are approximations, it was felt that the chief value of the conversion probably lay in expressing the results for clinical purposes, where normal values for the M.B.C. are familiar but not those for the F.E.V.

4. FORCED EXPIRATORY SPIROGRAM: FORCED INSPIRATORY SPIROGRAM.—The "forced expiratory spiogram" (F.E.S.) is the spiographic tracing of a forced expiration after a maximal inspiration, and "forced inspiratory spiogram" is the spiographic tracing of a forced inspiration after a maximal inspiration.

#### NOTES ON THE RECOMMENDED TERMINOLOGY WITH REASONS FOR THE ADOPTION OF EACH TERM

1. FORCED VITAL CAPACITY AND FORCED EXPIRATORY VOLUME.—The reason for adopting a special term to describe the vital capacity when estimated during a rapid and forced expiration has already been mentioned, namely, that the value obtained in this way may differ from the value obtained when the vital capacity is measured using slow expiration. The term "forced expiratory volume" was adopted only after considerable discussion of both nomenclature and the significance of the test itself. The word "volume" was preferred because it was considered that the test was basically the measurement of a volume over a certain time rather than a flow, and, secondly, because it is implicit in the American standardized terminology (Pappenheimer and others, 1950) that portions of a capacity (in this case a vital capacity) are referred to as volume. The word "forced" was preferred to

others because the volume of air expired during the first second (for example) of a forcible expiration may in some cases be less than the volume expired in the first second of a more relaxed expiration. If the value obtained for F.E.V.<sub>1.0</sub> during a "relaxed" expiration should prove to be a useful clinical or physiological measurement, it would be embarrassing to have to explain that the "relaxed expiratory volume" at one second was in some cases higher than, for example, the "fast" or "maximum" expiratory volume; the term "forced" leads to no such ambiguity. Since both the "forced expiratory volume" over any period and the "forced vital capacity" were assessed from the same "forced expiratory spiogram," it was considered desirable that the same qualifying term should be used for both expiratory volume and vital capacity.

A number of time intervals from the beginning of expiration have been used as a basis of various "tests" of ventilatory capacity. In seeking a term to describe this type of test it was considered desirable to find a name which would be applicable to the volumes expired over any of these time intervals.

2. MAXIMUM BREATHING CAPACITY.—The term "maximum breathing capacity" has been in use for over 20 years, and for this reason it would be undesirable, if not impossible, to alter it. However, it is known that the values obtained for the M.B.C. vary according to the conditions under which the test is performed, and in particular with the frequency with which it is performed. It was therefore considered desirable to reserve the term M.B.C. for the maximum that one is trying to measure, and to use the term "maximum voluntary ventilation" for one group of tests by which it was assessed. In the circumstances it is apparent that M.V.V. should be qualified by the frequency at which the test was performed, whether or not this is controlled by the observer. If this is done, there is no need for the additional term "maximum ventilatory capacity." The time over which the M.V.V. is measured should also be stated. The result obtained when the test is continued for 15 seconds may differ from that when it is continued for half a minute or longer.

#### ALTERNATIVE TERMS CONSIDERED WITH REASONS FOR THEIR REJECTION

1. ALTERNATIVES TO TERM "FORCED VITAL CAPACITY."—These are "timed vital capacity," "fast or maximum expiratory capacity," "total vital capacity," and "fast vital capacity."

(a) *Timed Vital Capacity*.—This term has been applied to the V.C. when the time taken to expire it is also measured, and it has also been applied to fractions of the V.C. expired in a given time. It is not self-explanatory if used to mean the V.C. estimated from a forced expiration in that the nature of the expiration is not indicated.

(b) *Fast or Maximum Expiratory Capacity*.—Both these terms have been applied to fractions of the vital capacity expired in a given time and are therefore ambiguous.

(c) *Total Vital Capacity*.—This has occasionally been used where the term “timed vital capacity” has been used to denote a portion of the V.C. expired in a given time. It is clearly a contradiction in terms in itself.

(d) *Fast Vital Capacity*.—This term is simple and descriptively accurate, but the first word was altered for the reason previously given.

2. ALTERNATIVES TO TERM “FORCED EXPIRATORY VOLUME.”—These are “timed vital capacity,” “fast or maximal expiratory capacity,” and others.

(a) *Timed Vital Capacity*.—This term is semantically indefensible because the measurement is not one of vital capacity, and the term is likely to lead to confusion with measurements of the vital capacity and of the time taken to expire it. Furthermore, the term has recently been used to denote the *percentage* of the (forced) vital capacity exhaled within the first second.

(b) *Fast or Maximal Expiratory Capacity*.—Comment has already been made in regard to the use of the words “capacity” and “volume.” The word “maximum” was objected to on statistical grounds, and in addition it was thought that “maximum capacity” was inappropriate to a portion of the vital capacity.

(c) Several terms were considered which were based upon the words “expiratory flow rate,” “mean expiratory flow rate,” or “expiratory flow.” The chief argument against these was that most of the measurements were best regarded as those of a volume over any given time, which therefore represented a mean flow only when the time interval happened to be one second. Where the time interval was greater or less than one second, conversion to mean flow required division of the volume by the time interval. This is not usually done, except in the case of the mid-expiratory flow (Leuallen and Fowler, 1955). For this and other reasons terms based on these words were regarded as inappropriate to most of these tests. For some purposes there is no objection to the use of these terms, as for example when referring to inspiratory, expiratory, maximum, or peak flow or when the volume is, in fact, divided by time as in the test of Leuallen and Fowler. The word “rate” was considered superfluous. Measurements of a fixed or specific volume and of the time taken to expire it are necessarily expressed in terms of flow.

3. ALTERNATIVES TO TERM “MAXIMUM BREATHING CAPACITY” AND ESTIMATES OF IT.—Considerable difficulty was encountered in obtaining agreement to appropriate terms, although agreement was easily reached on the principles involved. As the test results depend on the circumstances in which the test is performed, measurements intended to estimate M.B.C. may vary; thus the term M.B.C. was reserved to describe the theoretical maximum for a subject. A term was then sought to cover the various tests

employed in estimating the M.B.C., the circumstances of the test being indicated by appropriate qualifications. The term “maximum ventilation” was favoured by many because it avoided the use of the word “volume”; the concept of volume in this connexion is anomalous, in that the result is expressed in litres per minute. Unfortunately the abbreviation for maximum ventilation (M.V.) is the same as that for minute volume, and this was, therefore, rejected. Objection was taken to the use of “maximum voluntary ventilation” in that, if the circumstances of the test were strictly controlled, the test was in some degree not voluntary. This was, on the whole, overruled and this term was finally adopted. The term “maximum ventilatory capacity” was rejected notably on the grounds of the ambiguity of “capacity,” which may mean either a volume or a quality of “maximum ability.”

4. ALTERNATIVES TO TERM “INDIRECT M.B.C.”—Some of the alternatives were removed because of considerations outlined in the preceding paragraph. It was felt that the term M.B.C. was appropriate to the results obtained, since the procedure was aimed at obtaining a value for this. The term “indirect” was held to imply that no more direct estimation of the M.B.C., such as the M.V.V., was carried out. The term “estimated M.B.C.” was discarded on the grounds that the use of the word “estimated” should be restricted to direct measurements of somewhat less intrinsic accuracy than is implied, for example, by the word “determined.”

5. ALTERNATIVES TO TERM “FORCED EXPIRATORY (OR INSPIRATORY) SPIROGRAM.”—“Forced expiratory (or inspiratory) vital spiogram” was considered too cumbersome; the argument for the inclusion of “vital” was that it implied the recording of a full expiratory or inspiratory phase. “Expiogram” was rejected on the grounds that it did not convey the forced nature of the expiration. It was considered an advantage to retain the same adjective used to qualify “expiratory volume” and “vital capacity” in the same circumstances.

#### SUMMARY

1. Terms and definitions are recommended for the measurements of ventilatory capacity in common use. They are summarized in a table.

2. Reasons are given for their adoption and for the rejection of other terms which have been used in the past.

#### REFERENCES

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