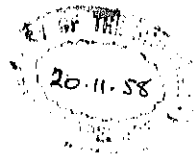
STUDIES OF LUNG FUNCTION BY ALVEOLAR GAS ANALYSIS



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INTRODUCTION

The chief aim of this thesis is to present a new method of measuring the degree to which gas and blood are unevenly distributed throughout the lungs by analysing the gas contents of a single expiration.

The clinical value of measuring the regional inequality of alveolar gas flow (or ventilation) has been accepted for several years. However, the gas exchange which takes place in any part of the lung is determined by the ratio of gas flow to blood flow (ventilation-perfusion ratio). An inequality of the ventilation-perfusion ratio throughout the lung is the chief defect of gas exchange in emphysema and the commonest clinical cause of respiratory failure. Yet no simple method of measuring the ventilation-perfusion ratio inequality has hitherto been available.

In chapter I, previous knowledge about alveolar gas is traced to the present day. Chapter II is devoted to theoretical relations between alveolar gas measurements and ventilation or the ventilation-perfusion ratio. In chapter III a series of experiments to determine whether these theoretical relations form a basis for a practical test is described, and the results are discussed in chapter IV. Final modifications of the test are presented in chapter V.

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CHAPTER II

B. 2. (iv) Effect of solubility of nitrogen and argon

(v) Variation in the nitrogen partial pressure of the pre-inspiratory alveolar gas

(vi) Difference in water vapour pressure between inspirate and expirate.

C. THE DERIVATION OF ALVEOLAR PERFUSION FROM ALVEOLAR GAS MEASUREMENTS.

CHAPTER III. FIRST SERIES OF EXPERIMENTS - DESIGN, APPARATUS AND METHODS.

1. Purpose of the experiments

(i) Introduction

(ii) The questions to be answered

(iii) The experimental plan

2. Respiratory mass spectrometer

(i) Description

(ii) Operation

(iii) Calibration

(iv) Accuracy

(v) Response time

CHAPTER III.

3. Other apparatus

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(ii) Flow and volume meters

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(iv) Apparatus for blood analysis

(v) Apparatus for measurement of forced expiratory volume

4. Subjects.

(i) Normal subjects

(ii) Subjects with diseases affecting chiefly ventilation

(iii) Subjects with emphysema

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(ii) Derivation of ventilation-perfusion ratio from respiratory quotient

(iii) Calculation of the inequality of ventilation-perfusion ratio

CHAPTER III.

6. (iv) Calculation of the inequality of ventilation

(v) Calculation of the inequality of perfusion

CHAPTER IV. FIRST SERIES OF EXPERIMENTS - RESULTS AND DISCUSSION

1. The feasibility of the single breath method of measuring the inequality of ventilation, ventilation-perfusion ratio and perfusion.

(i) Results

(ii) Discussion

a. Magnitude of the inequality

b. Sensitivity of the indices of ventilation-perfusion ratio and perfusion inequality to changes in the gas tensions of mixed venous blood

c. Sensitivity of the indices of ventilation-perfusion ratio and perfusion inequality to anaemia

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CHAPTER IV.

2. (ii) Distribution of anatomical dead space gas

3. Synchrony and its measurement

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(ii) Effect of synchrony on measurements of inequality

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b. Comparison of ventilatory inequality from single breath and multibreath methods

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(v) Relation between the indices of ventilatory and ventilation-perfusion ratio inequality

(vi) Mechanical factors affecting alveolar emptying

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CHAPTER V. SECOND SERIES OF EXPERIMENTS

1. Purpose of the experiments.

   (i) Measurement of both inequality of ventilation and ventilation-perfusion ratio in one expiration

   (ii) Use of an inspiratory mixture containing the same oxygen content as air

   (iii) Use of a large inspiratory volume

   (iv) Use of a different expired volume for analysis

   (v) Comparison of slow and fast expirations

   (vi) Comparison of changes in asthma and emphysema

2. Methods

   (i) Apparatus

   (ii) Subjects

   (iii) Procedures

   (iv) Calculations

3. Results

4. Discussion

   (i) Repeatability and discrimination

CHAPTER V.

4. (ii) Justification of the modified technique

a. Use of a large inspiratory volume

b. Use of a large expired volume for analysis

(iii) Comparison of slow and fast inspirations

(iv) Comparison of the results in emphysema and asthma.

SUMMARY

SYMBOLS AND ABBREVIATIONS

ACKNOWLEDGEMENTS

BIBLIOGRAPHY