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Volume 10

Respiration

Editors

I. HUTÁS

L. A. DEBRECZENI

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PHYSIOLOGICAL SCIENCES

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FOREWORD

This volume is one of the series published by Akadémiai Kiadó, the Publishing House of the Hungarian Academy of Sciences in coedition with Pergamon Press, containing the proceedings of the symposia of the 28th International Congress of Physiology held in Budapest between 13 and 19 July, 1980. In view of the diversity of the material and the "taxonomic" difficulties encountered whenever an attempt is made to put the various subdisciplines and major themes of modern physiology into the semblance of some systematic order, the organizers of the Congress had to settle for 14 sections and for 127 symposia, with a considerable number of free communications presented either orally or as posters.

The Congress could boast of an unusually bright galaxy of top names among the invited lecturers and participants and, naturally, the ideal would have been to include all the invited lectures and symposia papers into the volumes. We are most grateful for all the material received and truly regret that a fraction of the manuscripts were not submitted in time. We were forced to set rigid deadlines, and top priority was given to speedy publication even at the price of sacrifices and compromises. It will be for the readers to judge whether or not such an editorial policy is justifiable, for we strongly believe that the value of congress proceedings declines proportionally with the gap between the time of the meeting and the date of publication. For the same reason, instead of giving exact transcriptions of the discussions, we had to rely on the introductions of the Symposia Chairmen who knew the material beforehand and on their concluding remarks summing up the highlights of the discussions.

Evidently, such publications cannot and should not be compared with papers that have gone through the ordinary scrupulous editorial process of the international periodicals with their strict reviewing policy and high rejection rates or suggestions for major changes. However, it may be refreshing to read these more spontaneous presentations written without having to watch the "shibboleths" of the scientific establishment.

September 1, 1980 J. Szentágothai

President of the
Hungarian Academy of Sciences

PREFACE

All members of the Commission on Respiratory Physiology of IUPS have helped to organise the scientific programme of the Section 05 on Respiration of the 28th International Congress of Physiological Sciences (Budapest, July 13–19, 1980). We kindly thank for the help of Prof. E. Agostini (Milan), chairman of the Commission and Prof. J. Piiper (Göttingen), a member of the Commission.

The chairmen of the Congress Symposia were given suggested topics. They have chosen the participating lecturers as well as the titles of the papers. We are grateful for their devoted assistance.

The invited lecturers, beside presenting the latest results of their investigations had the chance to give a review of a given subject-matter. This is usually not an especially rewarding task as such a review might even surpass the size of a volume. They were the representatives of different branches and largely contributed to the maintaining of the level of the symposia. We thank all of them for accepting our invitation.

The number of congress symposia as well as the number of invited lectures were limited by the time given for the programme. We think that during the Congress new trends in different fields of respiratory research have evolved, described by the lectures of the Selected Papers Section.

Of course, a congress proceeding can never aim at completeness, however we believe that the most important papers dealing with newest trends in respiratory physiology have been included. As the authors of this volume are experts in giving lectures as well as due to the shortness of time the papers will be published in unchanged forms.

Finally we should like to express our thanks to the members of the staff of the Akadémiai Kiadó, Publishing House of the Hungarian Academy of Sciences, for editing the volume.

I. Hutás and L. A. Debreczeni

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TRENDS IN RESPIRATORY RESEARCH

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I. Hutás and L. A. Debreczeni (eds)

MECHANICS OF THE CHEST WALL

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Rohrer (8) and later Fenn and his associates (7), started modern respiratory mechanics on its way by a process of simplification: they integrated the complexity of respiratory movements into a single variable, volume, and force into a single variable, pressure. Their respiratory system had just two parts: the lungs and chest wall, operating in series. Thus, two pressures, transthoracic and transpulmonary, and one volume, sufficed to describe the system.

Agostoni and Rahn (2) divided transthoracic pressure into transdiaphragmatic and transabdominal components, and Agostoni and Mead (1) applied these to diagrams of the respiratory system which showed the lungs in series with a two-pathway chest wall: the rib-cage providing one pathway and the diaphragm-abdomen the other, the two pathways operating parallel. But the volume scales on these diagrams were largely hypothetical and this stimulated Konno and myself (5) to seek some way to measure them. We displayed the anterior-posterior diameters of the rib-cage and abdomen X-Y, and found that when we held lung volume constant, the two diameters were tightly coupled: we could readily increase the A-P diameter of the rib-cage, if we simultaneously decreased that of the abdomen, and vice versa. When these iso-volume maneuvers were done at different volumes essentially parallel lines were developed, which, by suitable gain adjustments, could be made to have a negative slope of unity. We interpreted the tight coupling at constant volume as indicating that the chest wall had just two ways to change volume--i.e. by rib-cage or by abdominal expansion. Indeed, we found that if we were careful to maintain a constant spinal attitude it was possible to recover lung volume changes by appropriate sums of these two signals over a wide range of ventilations.

We had set out to provide Agostoni and Mead's two pathway model of the chest wall with better measurement of the pathway volume displacements. For several years I thought we had succeeded. I thought that our estimates of the volume displacements of the rib-cage and abdomen at the body surface were all that were needed. I now appreciate that they were not sufficient. Abdominal displacements, as we measured them, did not give an adequate measure of diaphragmatic displacements.

I will show you that diaphragmatic displacements can, indeed, be estimated from abdominal volume displacements, but our idea of what constitutes the abdomen has to be extended. The wall of the abdomen includes a portion that we ordinarily do not regard as abdominal at all. This is part of the rib-cage beginning at its costal margin and extending cephelad to the diaphragmatic reflection. In this region the diaphragm is directly apposed to the rib-cage interior, and beneath lies not lung, but abdominal contents. I refer to this region as the "area of apposition" (6). At residual volume it covers approximately 1/2 of the internal surface of the rib-cage, decreasing to become a narrow ring at Total Lung Capacity. That is, as the diaphragm shortens the area of apposition decreases, and, finally, virtually disappears. As it decreases it expands outward and moves upward (i.e. toward the head), and both of these motions need to be taken into account in estimating abdominal displacements. The area of apposition forms a truncated cone--rather like a somewhat bent lampshade--which, as the diaphragm contracts, and the rib-cage expands, becomes shorter and wider, and tips up slightly in front. In terms of volume displacement it behaves like an expanding Krogh spirometer. The walls of the spirometer are formed by the rib-cage and hence are constrained to move with it, and this provides a way to measure it: We can estimate the total volumetric expansion of the rib-cage by the method of Konno and Mead. The fraction of its surface taken up by the area of apposition times this displacement is an estimate of the outward displacement of the area of apposition. For example, at FRC, in the upright posture, the area of apposition makes up about 1/4 of the rib-cage surface, and approximately 1/4 of its volume expansion should be reassigned to the abdomen.

The axial component can be estimated as the product of the cross-section at the level of the costal margin and a fraction (between 0.5 and 1.0 depending on the location of the hinge point) of the change in the xiphi-pubic distance. The axial component (at fixed spinal attitude) is totally dependent on the rib-cage motion and hence may also be represented as a fraction of the rib-cage excursion.

The sum of the fractions related to the "upward" and "outward" components times the rib-cage volume changes gives the total that should be assigned to rib-cage abdominal wall expansion. Next I relate this to the other abdominal displacements.

Since the abdominal contents are essentially incompressible, the sum of all abdominal wall volume displacements must be 0, and any single displacement must be equal and opposite to the sum of the others. Thus, displacement of the diaphragm dome--the pathway displacement we are seeking--is equal (and opposite) to the sum of the rib-cage and anterior-wall displacements. In terms of the Konno-Mead measurements, then, the diaphragm volume displacement is the abdominal volume displacement plus a fraction of the rib-cage volume displacement.

Let us see where we stand relative to our original objective. We set out to make better measurements of volume displacement for the Agostoni-Mead model--which we did--but then found that the model needed modification. The Konno-Mead measurements were correct for the rib-cage and the anterior abdominal wall--but, as we have seen, not for the diaphragm. Only at TLC, when the area of apposition virtually disappears, is the original model approximately correct. At all other volumes, the rib-cage forms part of the abdominal wall and has the potential for sharing diaphragmatic