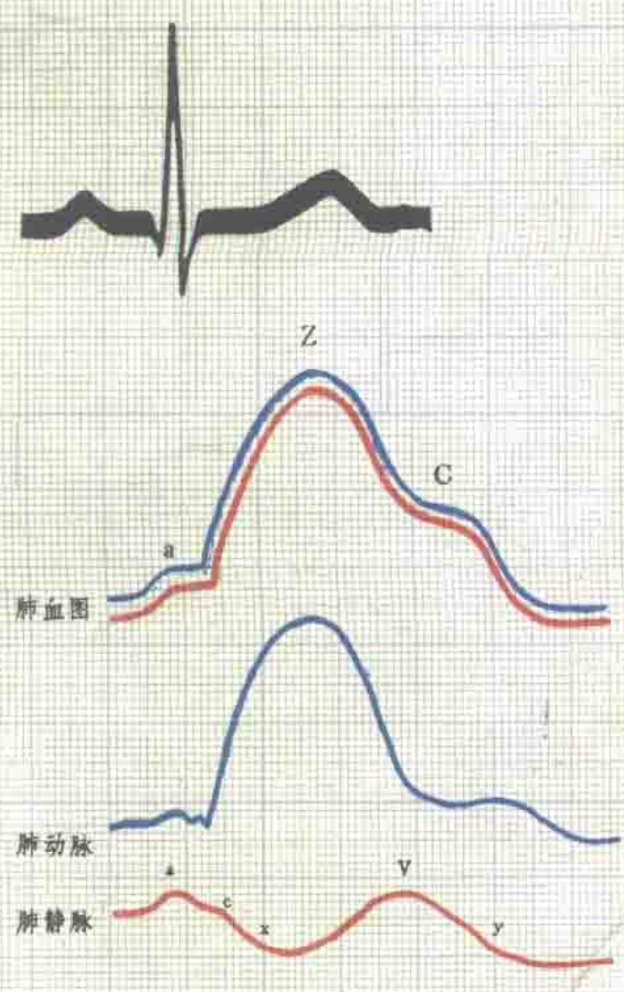
Clinical Impedance Rheography of the Lung

临床肺血图

李希臻 著



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李 希 璨 著

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内 容 简 介

肺血图是采用生物电阻抗方法从人体外部观察到的肺循环波动情况的波形。肺血图方法是了解肺循环状况的一种新的辅助诊断技术。它具有无损伤、简便易行、可反复进行等优点。不仅可提供肺动脉的情况，还能反映肺静脉的许多情况。

本书系作者根据从事肺血图研究获得的成果，系统地介绍了肺血图的理论和实践经验，集中地反映了肺血图应用于临床的意义，适当地介绍了国内外的进展情况。

书中以肺动、静脉综合波动观点和优势波动的理论，全面地阐述了肺血图的概念、原理、操作方法和干扰、伪差、变异的种类及识别，以及正常波形及其组成，各波的病理生理意义等。还详细地按肺循环疾病的分类，分别叙述了肺动脉、肺静脉容量变动和部分肺循环等四十余种疾病的波形特点、规律及形成原理等。

本书对各种心、肺疾病的辅助诊断，疗效观察，开展肺循环监护，以及对高山、宇航、潜水等人员的生理实验研究都有重要的参考价值。可供循环、呼吸系及有关医师、医学院校进修生、研究生、物理诊断人员及从事生理、病理生理研究人员阅读和参考。

Publisher's Brief Comment

Lung rheography records the wave form which shows the status of pulmonary blood pulsation from outside the body with the method of bioimpedance. The "Rheography" mothod is an non-inuasive ancillary diagnostic method for evaluating the status of pulmonary circulation. As seen from this book, lung rheogram not only can give information on the condition of pulmonary artery but also can reflect many aspects of the condition of pulmonary vein.

In this book, the author, on the basis of his experiences in doing research work and in giving lectures on lung rheography, systematically discussed the theories and practice of lung rheography, emphatically reflecting the recent achievements both in research work and in clinical usage. The author appropriately mentioned the advancement already made and questions not yet answered both in our country and abroad. This book may be used as important reference book for clinicians and for those who are engaged in experimental researches.

In this book, the auther always observed the theory of "blood volume composite wave" and" dominant pulsation".

There are fifteen chapters in this book. The first three chapters deal with the concept, principle and method of operation. In chapters four and five,

interference, false error, and the type and identification of variations are discussed. In chapters eight and nine the normal wave form and its composition and the pathophysiological significance of the different waves are highlighted. From chapter ten to chapter thirteen, according to the classification of pulmonary circulatory diseases, the author separately discussed the features, regularity and the principles governing the origination of the waves seen in fourty-five different entities of diseases and conditions, which are associated with changes in pulmonary arteria and venous volume and changes of partial pulmonary circulation. Chapter fourteen describes how to read lung rheogram and how to write report. Chapter fifteen concisely numerates some problems still present and certain progressions.

This book is of great value to the diagnosis of cardiopulmonary diseases, to the assessment of results of treatment, to the monitoring of pulmonary circulation, to the laboratory study on the pathophysiology of mountain disease, of space aviation and of caisson disease, and to the examination of the pulmonary circulation no matter for what reason it is needed.

This book may serve as reading material and as reference book for clinicians of cardiac, chest and other related department; for fellows and research men working in medical college; for physical diagnosticians and for those engaging in physiology and pathophysiology researches.

前　言

肺血图是采用无损伤性方法，观察肺动、静脉波动状态，检查由于心脏、血管、肺等器官疾病所引起的肺循环血液容积波动改变而产生的波形。肺血图检查法是在生物电阻抗领域内"血流图"基础上发展起来的一种新的生物物理学的辅助诊断技术。

"血流图"（Rheogram）又称电阻图（Impedance Rheogram）、阻抗式容积描记图（Impedance Plethysmogram）等等。它是被检区域总的或综合的血液容积波动状态的反映和记录，是动脉波动曲线与静脉波动曲线的综合波。肺血图主要不是显示肺的"血液流动"的情况，加上在名称上容易和观察"血流"的方法相混，常造成临床认识上的误解等原因，还因它观察的是肺循环，所以去掉了"流"字，称"肺血图"。

对于肺血图，国外自1961年开始有人进行探讨，苏、日、美、捷、意等国的学者做了许多工作，并取得一定成就。

我国自1975年开始，采用扩大的右肺区域性（右全肺）"血流图"法，通过对6只狗阻断肺循环前后的实验观察，对多例人的单侧肺动脉发育不全和单侧肺全切后的健、患两侧对比等，证明了所描图象主要反映的是肺循环。先后观察了正常人、肺气肿、肺心病、胸膜炎、肺炎、肺内占位性病变、风湿性心脏病、冠心病、心肌炎、心肌病，以及四十几种可导致肺循环改变的先天性心脏病、大血管疾病（畸型）等共2000余例。其中做了500余例心脏手术（包括人造瓣膜替换、心脏起搏器安装）的前后对照及300余例的心导管资料对照，见到了不同的波形特点，进一步证明了肺血图主要反映的是肺循环的波动情况。对这些疾病的不同血流动力学状态的图象进行了研究，并得到了初步规律性的认识。

在此基础上，于1978年4月又对肺血图曲线的组成进行了研究，使"血容综合波"和"优势波动"的理论得到了初步证明。实践表明，它能够比较满意地解释上述所见到的各种疾病的图形特点。现已初步形成了一套基础理论和规律性的检查方法，它可从观察肺循环动、静脉波动的角度上对各种导致肺循环改变的心、肺疾病做无损伤的辅助检查。同时，还可给其它"血流图"以新的认识和发展。为了这一新技术的推广和应用，现将这些主要内容汇集成册，以供参考。由于这是一项很年轻的和正在发展的检查技术，加之水平有限，难免有许多缺点甚至错误，望读者给予批评指正，以便使这项新的检查技术逐步得到发展。

在这项研究工作中，得到上级领导、二一一医院及有关同志的大力支持。受到了沈阳部队科技经验交流大会和全国科学大会的奖励。在第五届国际生物电阻抗会议上，受到许多专家、国际友人的热情赞许。在实验中还得到哈尔滨市慢性气管炎研究所、哈尔滨医科大学、上海市卫生局、上海市胸科医院、上海复旦大学数学研究所郑祖康同志、沈阳部队总医院有关领导和科室的大力支持和协作。本书撰写过程中，还得到《解放军医学杂志》、沈阳部队医学科学委员会、沈阳部队总医院胸科钱武杨主任、哈尔滨医科大学傅世英教授、黑龙江大学赵辛而副教授、二一一医院林之虎主任的指导与审阅。在资料收集整理中曾得到顾菊康、张加华、瞿忠杰、周都红、冯玉妹、成淑英、韩兵、宫毅臣、李颜珍、李辽昌、李红等医师的热情帮助，在此一并表示衷心的感谢。

1981年9月

Preface

Lung rheography is a non-invasive biophysical method used to observe the pulmonary arterial and venous pulsation status and to examine the wave form produced by the changes of blood volume pulsation of pulmonary circulation, these changes being caused by various diseases of heart, blood vessels, and lungs. It is a new ancillary diagnostic technigue developed on the basis of "Rheography" within the sphere of EBI.

"Rheography" is also called impedance rheography and plethysmography. It reflects and records the total or composite status of the blood volume pulsation of the examined area and its tracings represent the composite wave of arterial pulsation curve as well as venous pulsation curve. Since it does not principally denote the status of "blood flow" and terminologically it may be confused with the method used to observe blood flow, and, furthermore, on clinical practice it frequently causes misunderstanding, here we omit the word "flow" from the Chinese term. Because it is used to observe the pulmonary circulation, it is thus termed "lung rheography".

Researchos in this subject commenced abroad in 1961, and since then authorities in Soviet Union, Japan, America, Czechoslovakia and Italy have done large amount of work concerning this subject and have made contributions to it.

In our country, beginning in 1975 and using the technique of enlarged regional "rheography" of rt. lung (total rt. lung), we performed animal experiment on 6 dogs and carried out clinical studies. Through analysing the rheograms taken both before and after pulmonary circulation obliteration in the 6 dogs and through comparing the rheograms taken on the sound side with those taken on the diseased side of the chest in many patients suffering from unilateral pulmonary artery agenesis or subjected to unilateral pneumonectomy, we consistently proved that the waves traced principally reflect the condition of pulmonary circulation. We have successively made observations on healthy persons and on patients with emphysema, cor-pulmonale, pleurisy, pneumonia, space occupying lesions of the lung, rheumatic heart disease, coronary artery disease, myocarditis and about fourty entities of congenital heart diseases and great blood vessel diseases (anomalies) which may lead to pulmonary circulation changes, the tatal number of patients being more than 2000 cases. Among these patients, in more than 500 cases, who under-

went cardiac operations (including artificial valve replacement and cardiac pacemaker implantation), we compared their rheographic results obtained both before and after operation, and in more than 300 cases we also made comparisons between the data obtained by catheterization. By these methods we could identify different wave patterns and thus further proved that the waves traced could certainly, from body surface, reflect the status of the pulsation of pulmonary circulation. We also studied the graphic tracings representing different hemodynamic status of these disease conditions and gained preliminary recognition concerning their regularity.

On this basis, we studied the composition of the waves of lung rheogram in April 1978 and obtained preliminary evidence in proof of the theory of "blood volume composite wave"and"dominant pulsation". Our practice had shown this theory could comparatively satisfactoryly explain the graphic features recorded during the various diseases as stated above. Furthermore, under the guidance of this basis, we worked out a tentative basic theory and established a routine operative technique and method of examination to gain preliminary recognition of its regularity. By meams of observing the pulmonary arterial and venous pulsation, lung rheogram, in aid of clinical and other methods of examination, may be used in clinical practice as non-invasive ancillary method for examining various cardio-pulmonary diseases which may cause pulmonary circulatory changes and, furthermore, it can aid to gain new knowledge and promote further development of rheography of other parts of the body. In the hope that this newly developed method may be pushed forward to wider application and more usage, the author collected and analysed his expermental results and clinical observations and complied this book, which, the author hopes, may be useful as a reference book for those who are interested in this subject.

At present time, owing to the lack of generally accepted equipment together with the limited number of cases studied, it is only possible to discuss the natural rules about the sequential changes of lung rheogram but impossible to work out any quantitative or qualitative data for diagnostic criterion. The latter is one of the important aspects of the subject which should be brought into faster progress in the future with great effort.

In view of the fact that lung rheography is a new and developing diagnostic technique which is still in its early stage and the experiences of the author are rather limited, it is probably inevitable that there may be many defects or even errors in this book. Criticisms from the readers are warmly expected by the author so as to put this new diagnostic technique into advance step by step.

In this research work, from the beginning to end, the author always got firm

support and warm encouragement from his seniority, 211 Hospital and many comrades concerned. He was rewarded for good work on the Technological Experience Exchange Conference held by the P. L. A. Shenyang Unit and on the National Conference of Science. On the Vth International Conference on Electrical Bioimpedance the author received hearty praise from many specialists and friends who attended the meeting. During the experiment the author also got firm support and cooperation from Harbin Chronic Bronchitis Research Institute, Harbin Medical College, Shanghai Municipal Hygienic Bureau, Shanghai Chest Disease Hospital, Comrade Zheng Zu-kang (郑祖康) of the Mathematics Research Institute of Shanghai Fu-Dan University and the concerned heads and departments of the General Hospital of Shenyang Unit of the P. L. A.. During preparation of the book the author also received instructions from and had the manuscript critically reviewed by the Editorial Board of the "P. L. A. Medical Journal"; members of Medical Science Committe of Shenyang Unit of the P. L. A.; Dr. Qian Wu-yang (钱武杨), head of chest department of General Hospital of Shenyang Uuit of the P. L. A.; Prof. Fu Shi-ying (付世英) of Harbin Medical College; Prof. Zhao Xin-er (赵辛而) of Heilongjiang University, and Dr. Lin Zhi-hu (林之虎) of 211 Hospital. Dr. Gu Ju-kang (顾菊康), Dr. Zhang Jia-hua (张加华), Dr. Qu Zhong-jie (瞿忠杰), Dr. Zhou Du-hong (周都红), Dr. Feng Yu-mei (冯玉妹), Dr. Cheng Shu-ying (成淑英), Dr. Han Bing (韩兵), Dr. Gong Yi-chen (宫毅臣), Dr. Li Yan-zhen (李颜珍), Dr. Li Liao-chang(李辽昌)and Dr. Li Hong (李红) gave the author great assistance in collecting and arranging the material. To them, together with all mentioned above, the author wishes to express his sincere thanks.

September 1981

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Contents

肺血图发展简史

(Brief Historical Review of the Development of Impedance Rheography of the Lung)

肺血图是在"血流图"(Rheography)基础上发展起来的一项新检查技术，是"血流图"领域的一个分支和组成部分。1907年克里默(H.Cormer)首先在电荷电场内使跳动的离体蛙心显示了生物的电阻抗变动。二十年代后相继有人用1.8～200千赫的交流电观察机体的导电性，均发现有随心脏舒缩相一致的电阻抗变化。1932年阿茨勒(E.Arzler)和莱曼(G.Lehman)用交流电容积记录仪记录了人体的脉博。1937年由曼(H.Man)使用交流电桥记录了四肢的电容积阻抗，实际上形成了现用的电桥式(两极法)肢体血流图。

1939年美国奈波尔(J.Nyboer)发明直接式机(四极法)。1945年已有人将其应用于四肢、躯干及某些脏器的观察研究。1950年用于研究大脑的血管功能状态。Nyboer与Kubicek等于1950～1955年用四极法做血流的定量分析，研究并设计了计算式。1959年由J.Nyboer主编了"电阻抗容积描计法"一书，推动了这一方法的进展。十年后，1969年9月由美国纽约科学院马尔科维奇(S.F.Markvich)任主席召开了首届国际生物电阻抗会议，会后出版了专刊，发表了许多国家的代表性文章30余篇。1966年Kubicek对宇航员的心排量进行了研究，认为有一定价值。此后英、法、德、意各国均相继开展了生物电阻抗的研究工作。日本开展了一系列的实验，多数是使用四电极法对全胸部的观察，所反映的内容以体循环占较大比重。苏联、东欧等国多用桥式机研究肺、脑、肝等器官。

我国自1964年引进阻抗技术时，主要是观察脑循环的。首先由北京神经外科研究所杨林报道了"脑电阻图在大脑肿瘤诊断上的应用"。1965年陈光达又发表了在诊断脑动脉硬化上的研究。此后各地相继开展了对脑血管功能的观察和应用，并称谓"脑血流图"。1974年中国医学科学院阜外医院介绍了用自制的双道直接式机做肢体血流的定量研究，开始了我国肢体血流图的工作。该院高血压病研究小组发表了在心血管疾病的应用。上海中医学院曙光医院沈幼棠、上海第一医学院等、河北省人民医院邓开伯相继发表了四极法对心排量和测定收缩时间间期等方面的文章。上海第一医学院、上海劳动卫生及职业病防治研究所顾菊康介绍了肝血流图的观察等等，受到了国内外有关人士的重视。这些观察的许多事实表明，阻抗法做为一项无损伤的观察血流动力情况的方法，是有价值的。但是还广泛存在着对波形的组成、病理生理意义、影响因素等认识上的不足和分歧。尤其"脑血流图"，由于在理论上受"单纯局部动脉血流"观点的限制，产生了许多与临床不符的结果，给这类技术的发展带来严重影响。

对以肺循环为重点的观察，主要始于1961年Пушкарь对肺动脉和主动脉的观察。1967年Пешковии观察了慢性肺部疾患。1970年Новиков研究室间隔缺损的肺血图特点，报

道了肺动脉压力与肺血图的右心射血前期的相互关系，并推导了计算式。近年来，苏联及东欧也开始应用四极法，捷克的 Sava 还将桥式机加以改良做定量研究。日本、美国学者也对肺循环的观察方法、电场分布、波形分析等进行一系列的实验，取得不少有意义的成果。

我国自 1975 年开始这项研究。作者使用桥式机采用扩大的右肺区域性法，在哈尔滨市慢性气管炎研究所、哈尔滨医科大学协助下，观察了 230 例各种心、肺疾病，得到了与肺循环改变相关的所见。又经 6 条狗的动物实验，一致证明了这种方法主要反映的是肺循环情况。初步认定了它的作用、前途和意义并提出了它的“波”是由肺动脉波和肺静脉波两个“波”共同组成的“血容综合波动”观点。对其中 150 例慢性气管炎肺气肿、肺心病的观察研究及部分动物实验于1976 年发表，1977 年1月《医学研究通讯》予以转载。之后，得到上海市卫生局的支持和上海市胸科医院的协作，观察了各种导致肺循环改变的心血管疾病 1100 例，并于 1977 年 9 月将其中 208 例心脏手术前后的观察文章，在全国心血管外科经验交流（长春）会议上进行宣读。同时在第二次全国肺心病（大连）会上宣读了上述对肺心病的观察和动物实验结果。于此同时温州医学院介绍了矽肺肺心病的血流图观察，洛阳第二人民医院陈颜发表了肺血图 100 例正常人观察，上海第六人民医院、广西医学院等也相继通过动物实验证明了与肺循环的密切关系，武汉医学院王迪寻发表了对肺血管反映的观察。以后温州医学院又进行了一系列的实验研究，南昌市医科所、武汉医学院、医师进修学院和中南、华东、西北、西南地区的许多单位广泛开展了对肺心病的临床观察和调查，上海市胸科医院等继续对先心病做观察等等。

1978 年 4 月作者对肺血图曲线的组成进行了研究并得到证明，它和“优势波动”理论的提出比较满意地解释了上述所见到的各种波形，纠正了长期以来“单纯局部动脉血流”观点造成的错误认识，使“血容综合波动观念”的理论有了实际的依据，并得到应用和发展。同时还给其它“血流图”曲线以新的认识和发展。至此，它已初步形成了一整套基础理论和初步规律性认识的新检查方法，为临床观察肺循环波动状态提供了一项新的辅助诊断技术。之后，又做了肺循环监护的尝试，也获得初步成功。这些成果，在 1979 年 5 月中华医学会上海分会阻抗式血流图经验交流会及同年 9 月在有十八省市代表参加的血流图科研应用协作网学术交流（宝鸡）会上，做了全面介绍，受到与会代表的好评。此后，又在沈阳部队总医院进行重复验证，使观察总数达到 1500 例以上，丰富和发展了上述认识。1980 年 7 月沈阳部队医学科学委员会对这些成果做了全面的鉴定。部分论文在《中华结核和呼吸系疾病杂志》、《解放军医学杂志》、《中华医学杂志》、《医学文选》等刊物发表后，得到国内外学术界的重视与好评。1981 年 8 月在日本东京召开的第五届国际生物电阻抗会议上发表了其中的一部分。目前，这项工作已在苏、法、意、日、美等许多国家相继开展起来。

总　论

(General Consideration)

一　肺循环疾病和肺血图

(Pulmonary Circulatory Diseases and Impedance Rheography of the Lung)

(一)　肺循环疾病的概念

(General Concept of Pulmonary Circulatory Diseases)

许多心、肺疾病往往主要或首先引起肺循环的改变而不大影响体循环，对于这一类疾病称谓“肺循环疾病”。这类疾病包括有：多种的先天性心脏病、风湿性心脏病、肺原性心脏病、冠心病、心肌病、心包疾病、左心衰竭、左房粘液瘤、胸腔的积液、积血、积气、肿物、畸型等，以及各种肺的疾病和血管畸型、梗塞、胸廓的明显畸型等等。

(二)　肺血图的概念

(General Concept of Impedance Rheography of the Lung)

对于上述疾病所造成的肺循环改变，常不能在反映体循环的方法中得到明显或灵敏的显示，但却可以在观察肺循环的方法上获得丰富所见。可是长期以来，由于临床上缺少这方面的无损伤性观察方法，限制了人们的眼界，对肺循环改变的情况了解很少。

肺血图是从体外观察肺循环波动状态的无损伤性检查方法。在心脏病方面，心电图反映的是心脏的生物电及传导情况；X线、超声检查是从解剖上反映心血管改变；肺血图则是从心脏的机械效能和肺循环血流动力角度反映心血管的功能状态，特别是它能够无损伤地反映肺静脉情况，目前尚没有其它方法可以做到这一点。而临床上又在许多情况下产生这方面的改变，这就使得此种新的检查技术有着特殊的意义和前途。肺血图的出现，为无损伤观察肺循环的动态开辟了一条新途径，把这个长期闭塞于胸腔内的领域暴露在人们眼前。并提出了许多新的值得研究的课题：如这个波形在多大程度上反映了肺循环；正常波形是什么样，以及它可有哪些变异；这个曲线是怎样组成的，各波的生理、病理意义如何；各种不同病变及不同的情况有哪些改变以及它们的形成机理，如何应用这些规律为临床服务等等。