

THE PEDIATRIC AIRWAY

Cry, Stridor, and Cough

EDITED BY

Jenő Hirschberg • Tamás Szende
Peter J. Koltai • András Illényi

CO-EDITORS

István Lellei • Zsolt Garay





5521 Ruffin Road
San Diego, CA 92123

e-mail: info@pluralpublishing.com
Web site: <http://www.pluralpublishing.com>

49 Bath Street
Abingdon, Oxfordshire OX14 1EA
United Kingdom

Copyright © by Plural Publishing, Inc. 2008

Designed and typeset in 11½/14 Berkeley by John Reinhardt Book Design
Printed in the United States of America by _____

All rights, including that of translation, reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, recording, or otherwise, including photocopying, recording, taping, Web distribution, or information storage and retrieval systems without the prior written consent of the publisher.

For permission to use material from this text, contact us by
Telephone: (866) 758-7251
Fax: (888) 758-7255
e-mail: permissions@pluralpublishing.com

Every attempt has been made to contact the copyright holders for material originally printed in another source. If any have been inadvertently overlooked, the publishers will gladly make the necessary arrangements at the first opportunity.

ISBN-13: 978-1-59756

ISBN-10: 1-59756-

Library of Congress Cataloging-in-Publication Data:

CONTENTS

Contributors
Preface

Chapter 1. Introduction

J. Hirschberg, T. Szende, P. Koltai, A. Illényi

Chapter 2. The Sound Phenomena Investigated: Cry, Stridor, and Cough

J. Hirschberg, T. Szende, P. Koltai

Cry
Stridor
Cough

Chapter 3. Historical background

J. Hirschberg

The Infant Cry
Stridor
Cough

Chapter 4. Patients

J. Hirschberg, P. Koltai, Zs. Farkas

Chapter 5. Methods

Conventional examination methods, their critical analysis, and sphere of indication

I. Lellei, J. Hirschberg, P. Koltai, Zs. Garay

Examination of cases with pathologic phonation, unusual infant cry

Evaluation of stridor

Evaluation of cough

Basic principles of acoustics, methods of acoustic investigation, sound spectrography *T. Szende, A. Illényi*

The acoustic structure of sound phenomena

Voiced sounds

- Noise
- Aphonia
- Duration (length) of sounds
- Intensity
- Melody of the cry
- Resonance components
- Applied methods for acoustic analysis
 - Sound spectrography
 - Minimal time interval spectrum
 - Measurement of the fundamental frequency
- Analysis of the infant cry with digital signal processing (DSP) *Gy. Várallyay*
 - Why analyze?
 - The infant cry as an acoustic signal
 - Data collect
 - Available techniques to record the infant cry
 - Database
 - Preprocessing of the infant cry
 - Filtering
 - Segmentation
 - Processing of the infant cry
 - Attributes in the time domain
 - Discrete Fourier Transform
 - Acoustic attributes in the spectrum
 - Methods for detecting the fundamental frequency
 - Detecting the melody contour of the infant cry
 - Digital spectrograph
 - Results
 - Duration of cry segments
 - Fundamental frequency
 - Development of the fundamental frequency
 - Melody of the infant cry
 - Evaluation
 - Sound in medicine; noninvasive diagnostic methods
- Nasometry *Zs. Trenovszki, J. Hirschberg*
- Bioinformatics and genomics *Z. Benyó, B. Benyó*

Chapter 6. Characterization and Acoustic Description of the Most Commonly Occurring Sound Signals

T. Szende, J. Hirschberg

Cries

- Clear (pure, regular, normal) cry
- Veiled cry
- Hoarse cry
- Hyperkinetic (tense) cry

Pressed (forced) cry
Raucous cry
Crackling cry
Sharp cry
Shrill (piping, shrieking, screeching) cry
Creaking cry
Very high (high pitched) cry
Bleating (quavering) cry
Sizzling (fizzling, crepitating) cry
Faint (inert, weak, languid) cry
Wan (meagre, low-energy) cry
Bitonal cry
Broken phonation (breaking, breaklike) cry
Aphonic cry
Hollow (cavernous) cry
Dull (colorless) cry

Types of stridor

Pharyngeal-type stridor
Interrupted pharyngeal stridors (with quasiperiodic acoustic structure)
 Sawing (buzzing) stridor
 Rasping stridor
 Croaking stridor
 Snoring stridor
 Bubbling (gurgling) stridor
 Divided pharyngeal stridor
Lump-in-the-throat stridor
Supraglottic stridor (high, sharp, and loud inspiration and expiration)
Cackling (clucking) stridor
Hissing (whistling, sibilant) stridor
Stridor-phonation
Crowing stridor
Stridor of subglottic character
Deep-hollow stridor
Hollow stridor
Tracheal stridor
Spastic (wheezy) expiratory stridor

Types of coughing sound

Nondescript cough
Catarrhal cough
Barking cough
Cough-phonation
Deep cough
Hollow cough
Ringing cough
 Brassy, ringing cough

Metallic, ringing cough
Staccato cough
Suppressed, painful cough

Chapter 7. Airway and Nervous Anomalies Associated with Pathologic Sound Production

Disorders affecting the nose, oral cavity, pharynx, and ears *J. Hirschberg, Zs. Farkas, P. Koltai*

Choanal atresia
Micrognathia
Robin sequence
Cleft palate (CP), velopharyngeal insufficiency (VPI)
Hearing impairment, hearing loss
De Lange syndrome
Hurler's syndrome (multiple dysostosis, gargoylism)
Mental retardation, mental deficiency
Enlarged, hypertrophied tonsils, adenoid vegetation

Disorders affecting the larynx *J. Hirschberg, P. Koltai, I. Lellei, Zs. Garay, G. Katona*

Epiglottitis (supraglottic inflammation)
Acute laryngitis
Laryngeal croup (acute fibrinous laryngitis)
Laryngeal thrush, laryngeal mycosis, fungal laryngitis
Changes following prolonged intubation, acquired laryngeal stenosis
Papilloma of the larynx (upper respiratory papillomatosis)
Vocal cord polyp, laryngeal fibroma
Laryngeal cysts
Laryngocele
Laryngeal cleft
Laryngomalacia (chondromalacia laryngis, soft, flaccid larynx)
Atresia, severe stenosis of the glottis
Laryngeal diaphragm (congenital laryngeal web)
Vocal cord paralysis (abductor [recurrent] and adductor paresis)
Dysphonia
Hyperbilirubinemia
Down syndrome (mongolism)
Cri du chat syndrome (cat's cry disease)
Myasthenia gravis
Amyotonia congenita (congenital muscular atony, Oppenheim's disease)
Polyradiculitis (Guillain-Barré syndrome)
Pseudocroup (subglottic laryngitis)
Subglottic stenosis
Subglottic hemangioma
Contusion (injury) of the larynx

- Tracheal changes *J. Hirschberg, P. Koltai, I. Lellei, K. Hirschberg*
 Congenital goitre
 Vascular anomalies
 Paratracheal or parabronchial lymphadenitis (thoracic lymph node enlargement, lymphadenopathy, bronchial rupture)
 Mediastinal tumors
 Tracheomalacia (functional stenosis of the trachea, soft trachea)
 Circumscribed congenital anomaly of the tracheal cartilages (individual cartilage deformity)
 Tracheal dyskinesia
 Rigid trachea stenosis (congenital fibrous stricture)
 Stenosing laryngotracheobronchitis (sicca maligna)
 Foreign bodies in airways
- Disorders affecting the bronchi and the lungs *J. Hirschberg, G. Katona*
 Wheezy bronchitis, asthma
 Pertussis (whooping cough)
 Pneumonia

Chapter 8. The Diagnostic Value of the Conventional Examination Methods and of Acoustic Analysis

J. Hirschberg, T. Szende, I. Lellei

- Cries
 Classification in terms of the acoustic substrate
 Noise
 Other Structural Changes
 Classification in terms of the location of changes
 Classification on grounds of etiology
 The diagnostic values of clinical (imaging) methods in the evaluation of infant cry
- Stridor
 Pharyngeal stridors
 Laryngeal stridors
 Subglottic and tracheal stridors
 Bronchial stridors
- Cough

Chapter 9. Summary

J. Hirschberg, T. Szende, P. Koltai, A. Illényi

References

Subject Index

DVD Attached

Sound Phenomena (three times played) Corresponding to the Sonagrams *J. Hirschberg, T. Szende, Gy. Várallyay*

Sound Phenomena Characteristic of Diseases *J. Hirschberg, K. Hirschberg, Zs. Garay, Gy. Várallyay*

CONTRIBUTORS

Balázs Benyó, Ph.D., C.Sc. (Chap. 5)

Associate Professor

Electrical Engineer and Information Technology Specialist

Affiliation: Budapest University of Technology and Economics, Hungary

Department of Control Engineering and Information Technology

Zoltán Benyó, Ph.D., D.Sc. Dr. Habil (Techn. Sci.) (Chap. 5)

Professor

Electrical Engineer

Affiliation: Budapest University of Technology and Economics, Hungary

Department of Control Engineering and Information Technology

Zsolt Farkas, M.D., Ph.D. (Chap. 4, 7)

Chief

Otorhinolaryngologist, Audiologist, Phoniatician

Affiliation: Heim Pál Hospital for Sick Children, Budapest, Hungary

Department of Pediatric Oto-rhino-laryngo-bronchology, Phoniatics and Audiology &

Cleft Palate Center

Zsolt Garay, M.D. (Chap. 5, 7, DVD)

Chief

Otorhinolaryngologist, Audiologist, Phoniatician

Affiliation: Budai Children's Hospital, Budapest, Hungary

Department of Pediatric Oto-rhino-laryngo-bronchology, Phoniatics and Audiology &

Cleft Palate Center

Jen Hirschberg, M.D., Ph.D., D.Sc., Chief Editor (Chap. 1, 2, 3, 4, 5, 6, 7, 8, 9, DVD)

Professor, Scientific Consultant

Otorhinolaryngologist, Phoniatician, Audiologist, Cleft Palate Surgeon

Affiliation: Budai Children's Hospital, Budapest, Hungary

Department of Pediatric Oto-rhino-laryngo-bronchology, Phoniatics and Audiology &

Cleft Palate Center

Kristóf Hirschberg, M.D. (*Chap. 7, DVD*)

Ph.D. (doctorate) Student

Affiliation: Institute of Cardiovascular Surgery and
Hungarian National Ambulance and Emergency Service
Budapest, Hungary

András Illényi, M.Sc., Ph.D. (*Chap. 1, 5, 7, 9*)

Professor Em.

Master of Physics and Acoustics

Affiliation: Budapest University of Technology and Economics, Hungary
Department of Telecommunications and Media Informatics

Gábor Katona, M.D., Ph.D. (*Chap. 7*)

Chief and Head

Pediatrician, Otorhinolaryngologist, Audiologist

Affiliation: Heim Pál Hospital for Sick Children, Budapest, Hungary
Department of Pediatric Oto-rhino-laryngo-bronchology, Phoniatics and Audiology &
Cleft Palate Center

Peter J. Koltai, M.D., FACS, FAAP (*Chap. 1, 4, 5, 7, 9*)

Professor and Head

Otolaryngologist

Affiliation: Stanford University School of Medicine
Division of Pediatric Otolaryngology, Stanford, California

István Lellei, M.D. (*Chap. 5, 7, 8*)

Chief and Head

Otorhinolaryngologist

Affiliation: Budai Children's Hospital, Budapest, Hungary
Department of Pediatric Oto-rhino-laryngo-bronchology, Phoniatics and Audiology &
Cleft Palate Center

Tamás Szende, Ph.D., D.Sc. (*Chap. 1, 5, 7, 8, 9, DVD*)

Professor and Head

Linguist-Phonetician

Affiliation: Pázmány Péter Catholic University, Piliscsaba, Hungary
Department of General Linguistics and
Hungarian Academy of Sciences, Institute of Linguistics, Budapest, Hungary

Zsuzsa Trenovszki (*Chap. 5*)

Ph.D. (doctorate) Student

Speech Pathologist

Affiliation: Madarász Children's Hospital, Budapest, Hungary
Department of Otorhinolaryngology, Logopedics & Cleft Palate Center

György Várallyay Jr., M.Sc. (*Chap. 5, DVD*)

Ph.D. (doctorate) Student

Electrical and Biomedical Engineer

Affiliation: Budapest University of Technology and Economics, Hungary
Department of Control Engineering and Information Technology

PREFACE

THIS BOOK is based on a previous publication (cf. J. Hirschberg & T. Szende: *Pathological Cry, Stridor and Cough in Infants. A Clinical-Acoustic Study*, Akadémiai Kiadó, Budapest, 1982). Although the concepts presented in the original work remain valid, the technical advances of the last 25 years in the fields of imaging, endoscopic documentation, computer-aided acoustic measurements, and therapeutic management, have provided us the opportunity to update and expand on the insights detailed in the earlier text. For a measure of continuity, this work retains pertinent citations and data from the original text in order to highlight the evolutionary developments within the discipline. Furthermore, our previous clinical investigations have been continuously enlarged by acoustic evaluation of different respiratory sounds from diseases that were not discussed in the first edition. The present book represents the work of several Hungarian clinicians and scientists from various disciplines, such as pediatric otorhinolaryngology, bronchoesophagology, pediatrics, phoni-

atics, audiology, cardiovascular surgery, linguistics, phonetics, acoustics, speech pathology, electrical and biomedical engineering, and information technology. In this edition we have included contributions from international colleagues in order to open a broader perspective of the field for the reader.

The main goal of our study is to understand the nature of pathologic sound originating in the respiratory tract. Such acoustic phenomenon can be the characteristic symptoms of different diseases, including airway obstruction, neurologic abnormalities, and chromosomal derangements. Unusual airway sounds from a child may furnish important diagnostic clues; therefore, careful analysis can be an important and sometimes vital aspect of the physical examination.

In the course of 45 years of practice in pediatric laryngobronchology, phoniatics, and acoustics we observed and systematically described more than 40 different pathologic sounds, often occurring in different combination with each other, in as many pathologic conditions. Evaluation

of the origin of pathologic phonation and respiratory noises as well as cough sounds relies on the traditional diagnostic modalities of endoscopic visualization, radiologic imaging, and electrophysiologic monitoring, which today remain indispensable. On the other hand, we also emphasize and indeed focus on the value of the perceptive auditory evaluation and objective acoustic analysis of the sound phenomena in question. Our work has consistently demonstrated the value of acoustic measurement as a convenient diagnostic, documentative, and teaching tool.

We begin this book with a description of the acoustic characteristics of the physiologic normal infant cry and then follow with a characterization of pathologic sound phenomena occurring in a wide variety of respiratory and neurologic diseases. In the attached DVD the reader can hear the sounds described in the text,

along with case histories, sonagrams, radiologic imaging, and appropriate endoscopic photographs. We also describe contemporary therapeutical management of the conditions presented. Consequently, the volume encompasses the salient aspects of medical acoustics and pediatric laryngology.

The Editors and Contributors owe a special gratitude to the Plural Publishing Company for their harmonious and professional cooperation that enabled us to publish the book in this form. Also, grateful acknowledgments are due to Judit Szépe, Ph.D. for transforming the material of the book magically into a publication.

Jen Hirschberg

Tamás Szende

Peter J. Koltai

András Illényi

Budapest – Stanford, May, 2007