

# Hypertension in Children and Adolescents

Editors

Giorgio Giovannelli, M.D.    Maria I. New, M.D.

Sergio Gorini, M.D.

# Hypertension in Children and Adolescents

## Editors

**Giorgio Giovannelli, M.D.**

*Professor of Pediatrics  
Chairman, Department of  
Pediatrics  
University of Parma  
Parma, Italy*

**Maria I. New, M.D.**

*Professor and Chairman, Department  
of Pediatrics  
Division Head, Pediatric  
Endocrinology  
Cornell University  
New York, New York*

**Sergio Gorini, M.D.**

*President  
International Foundation Menarini  
Florence, Italy*

Raven Press ■ New York

Raven Press, 1140 Avenue of the Americas, New York, New York 10036

---

© 1981 by Raven Press Books, Ltd. All rights reserved. This book is protected by copyright. No part of it may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the publishers.

Made in the United States of America

---

Great care has been taken to maintain the accuracy of the information contained in the volume. However, Raven Press cannot be held responsible for errors or for any consequences arising from the use of the information contained herein.

Materials appearing in this book prepared by individuals as part of their official duties as U.S. Government employees are not covered by the above-mentioned copyright.

#### **Library of Congress Cataloging in Publication Data**

Main entry under title:

Hypertension in children and adolescents.

Derived from presentations made at the International Symposium on Juvenile Hypertension held in Parma, Italy, June 4–6, 1979, sponsored by the International Pediatric Association and the International Society of Hypertension.

Includes bibliographical references and index.

1. Hypertension in children—Congresses.

I. Giovannelli, Giorgio. II. New, Maria I.

III. Gorini, S. IV. International Symposium on Juvenile Hypertension, Parma, 1979. V. International Pediatric Association. VI. International Society of Hypertension.

[DNLM: 1. Hypertension—In infancy and childhood—Congresses. 2. Hypertension—In adolescence—Congresses. WG340 I5887h 1979]

RJ426.H9H96 618.92'132 80-5068

ISBN 0-89004-523-2

# Preface

Hypertension in the young must be studied in the young. The following statements indicate why the study of hypertension in children is necessary and will provide information not obtainable in the adult.

1. Antecedents of essential hypertension in adults must be looked for in the young. Investigation of the young will make it possible to seek markers and risk factors for the development of hypertension.

2. There is evidence that essential hypertension is a hereditary disorder. The genetics of the disorder are best studied at the earliest stage of life, before some environmental forces that may affect blood pressure are superimposed.

3. Since essential hypertension is asymptomatic in its earliest stages, vascular changes may have already occurred at the time of detection. Prevention of complications may be possible if children with high blood pressure are studied.

4. Prenatal influences on blood pressure can best be investigated in the newborn and very young infant.

5. Some forms of hypertension are more frequently diagnosed in the child than in the adult, for example, high blood pressure occurring with acute glomerulonephritis and congenital adrenal hyperplasia. Therefore, pediatric groups may provide the necessary study populations.

6. Some forms of hypertension are reversible in the child but not in the adult. "Dexamethasone-suppressible hyperaldosteronism" is associated with high blood pressure in children and in adults. This disorder has recently been described in three children and in their mother. Although the children's blood pressure levels decreased promptly with dexamethasone treatment, the mother remained hypertensive. Thus, failure to diagnose the syndrome in childhood, when hypertension responds to treatment, penalizes the adults as well as the child. Further research is required to determine why the child responds to treatment while the adult does not.

7. The long-term pharmacologic benefits and risks of treating children with hypertension are not known. Studies must be conducted to determine the effect of antihypertensive drugs on growth and puberty.

This volume touches on all these aspects and brings the reader up to date on the current status of hypertension in the developmental age.

Understanding the pathophysiology of childhood hypertension offers the best hope of reversing the hypertensive process before severe vascular complications intervene. Thus, research into childhood hypertension constitutes a form of preventive medicine to which this book, by summarizing the present knowledge on the subject, brings a valuable contribution.

The Editors

# Contributors

**Raymond D. Adelman**

*Department of Pediatrics  
University of California, Davis  
Sacramento, California 95819*

**A. Ammenti**

*Department of Pediatrics  
University of Parma  
Parma, Italy*

**J. L. Andre**

*Centre de Médecine Préventive  
Vandoeuvre Les Nancy, France*

**Jean-Louis Bacri**

*Service de Néphrologie  
Pédiatrique Hôpital des  
Enfants Malades  
75730 Paris Cedex 15  
France*

**C. Barlassina**

*Istituto di Clinica Medica I  
Università di Milano  
20122 Milano, Italy*

**J. D. Baxter**

*Endocrine Research Division  
University of California, San Francisco  
San Francisco, California 94143*

**S. Bernasconi**

*Department of Pediatrics  
University of Parma  
Parma, Italy*

**G. Bianchi**

*Istituto di Clinica Medica I  
Università di Milano  
20122 Milano, Italy*

**Carlo Bianchini**

*Istituto di Ricerche Cardiovascolari  
"G. Sisini"  
Università di Milano  
20122 Milano, Italy*

**Edward G. Biglieri**

*Department of Medicine  
Metabolic Research Unit  
University of California, San Francisco  
San Francisco, California 94143*

**Pierre Biron**

*Department of Pediatrics and  
Pharmacology  
University of Montreal  
Montreal, Canada H3T 1C5*

**Hans George Bodmer**

*Department of Pediatrics  
and Internal Medicine  
University of Zurich  
Zurich, Switzerland*

**Alfred M. Bongiovanni**

*Catholic University of Puerto Rico  
and  
Department of Pediatrics  
University of Pennsylvania  
Philadelphia, Pennsylvania*

**L. Boschi**

*I Patologia Medica  
Policlinico Umberto I  
University of Rome  
00100 Roma, Italy*

**J. J. Brown**

*MRC Blood Pressure Unit  
Western Infirmary  
Glasgow G11 6NT, Scotland*

**Michel Broyer**

*Hôpital des Enfants Malades  
75730 Paris Cedex 15  
France*

**Maria Letizia Caccamo**

*Cattedra di Patologia Neonatale  
dell'Università di Milano  
Milan, Italy*

**Vito Cagli**

*V. delle Isole 10  
00198 Roma, Italy*

**A. M. Caravaggi**

*Centro Ricerche Farmitalia  
Carlo Erba  
Nerviano-Milano  
Italy*

**A. Castrucci**

*Service of Cardiovascular  
Radiology  
Sam Camillo Hospital  
Rome, Italy*

**Pasqualina Cazzaniga**

*Cattedra di Patologia Neonatale  
dell'Università di Milano  
Milano, Italy*

**M. Csukás**

*Hungarian Institute of Cardiology  
H-1450 Budapest, Hungary*

**P. Cugini**

*1 Patologia Medica  
Policlinico Umberto I  
00100 Roma, Italy*

**A. M. M. Cumming**

*MRC Blood Pressure Unit  
Western Infirmary  
Glasgow G11 6NT, Scotland*

**D. Cusi**

*Istituto di Clinica Medica I  
Università di Milano  
20122 Milano, Italy*

**Sidney L. Dale**

*Section of Endocrinology and  
Metabolism  
Department of Medicine and Physiology  
Boston University School of Medicine  
Boston, Massachusetts 02118*

**André Davignon**

*Service of Cardiology  
Department of Pediatrics  
Hôpital Sainte-Justine  
Montreal, Canada*

**Jacques de Champlain**

*Department of Physiology  
University of Montreal  
Montreal, Canada*

**L. De Medici**

*Service of Cardiovascular  
Radiology  
Sam Camillo Hospital  
Rome, Italy*

**J. P. Deschamps**

*Centre de Médecine Préventive  
Vandoeuvre Les Nancy, France*

**Michael de Swiet**

*Cardiothoracic Institute  
Brompton Hospital  
London SW3 6HP, England*

**Michael J. Dillon**

*The Hospital for Sick Children  
London WC1N 1EH, England*

**Angelika Dumbs**

*Medizinische Klinik Innenstadt  
der Universität München  
D-8 München 2, West Germany*

**L. Duzzi**

*Centro Ricerche Farmitalia  
Carlo Erba  
Milano, Italy*

**Alison Earley**

*Department of Paediatrics  
Cardiothoracic Institute  
Brompton Hospital  
London SW3 6HP, England*

**Frederick H. Epstein**

*Department of Pediatrics  
and Internal Medicine  
University of Zurich  
Zurich, Switzerland*

**Peter Fayers**

*Medical Research Council  
Tuberculosis and Chest Diseases Unit  
Brompton Hospital  
London SW3 6HP, England*

**P. Ferrari**

*Centro Ricerche Farmitalia  
Carlo Erba  
Milano, Italy*

**Henry Fink**

*Chronobiology Laboratories  
Department of Laboratory Medicine  
and Pathology  
University of Minnesota  
Minneapolis, Minnesota 55455*

**Barbara Friedmann**

*Medizinische Klinik Innenstadt  
der Universität München  
D-8 München 2, West Germany*

**M. Gatti**

*Istituto di Clinica Medica I  
Università di Milano  
20122 Milano, Italy*

**G. Giovannelli**

*Department of Pediatrics  
University of Parma  
Parma, Italy*

**David Goldring**

*Washington University School of  
Medicine  
Edward Mallinckrodt Department of  
Pediatrics  
and  
Division of Cardiology  
St. Louis Children's Hospital  
St. Louis, Missouri 63110*

**Margit Grønbaek**

*Children Hospital, Fuglebakken  
DK-2000 Copenhagen F  
Denmark*

**R. Gueguen**

*Centre de Médecine Préventive  
Vandoeuvre Les Nancy, France*

**I. Gyárfás**

*Hungarian Institute of  
Cardiology  
H-1450 Budapest, Hungary*

**Franz Halberg**

*Chronobiology Laboratories  
Department of Laboratory Medicine  
and Pathology  
Minneapolis, Minnesota 55455*

**Antonio Hernandez**

*Washington University School of  
Medicine  
Edward Mallinckrodt Department of  
Pediatrics  
and  
Division of Cardiology  
St. Louis Children's Hospital  
St. Louis, Missouri 63110*

**Bert Hofman**

*Department of Epidemiology  
Erasmus University  
Rotterdam, The Netherlands*

**Karsten Kaas Ibsen**

*Children Hospital, Fuglebakken  
DK-2000 Copenhagen F, Denmark*

**I. Kamaras**

*Institute of Hygiene of  
Children and Adolescents  
H-1054 Budapest, Hungary*

**Margaret M. Kilcoyne**

*Department of Medicine  
The College of Physicians  
and Surgeons of Columbia  
University  
Division of Cardiology  
New York, New York 10032*

**Rudolf König**

*Children's Hospital  
University of Berne  
CH-3010 Berne, Switzerland*

**Nancy C. Lan**

*Department of Medicine and  
Metabolic Research Unit  
University of California, San Francisco  
San Francisco, California 94143*

**Gastone Leonetti**

*Istituto di Ricerche  
Cardiovascolari "G. Sisini"  
Milano, Italy*

**Ernst P. Leumann**

*Kinderspital Zürich  
8032 Zurich, Switzerland*

**A. F. Lever**

*MRC Blood Pressure Unit  
Western Infirmary  
Glasgow G11 6NT, Scotland*

**L. S. Levine**

*Department of Pediatrics  
Cornell University Medical College  
New York, New York 10021*

**Jennifer M. H. Loggie**

*Department of Pediatrics  
University of Cincinnati  
and  
The Children's Hospital  
Research Center  
Cincinnati, Ohio 45229*

**Sol Londe**

*2855 Roscomere Rd.  
Bel Air, California 90024*

**G. P. Lupi**

*Istituto di Clinica Medica I  
Università di Milano  
20122 Milano, Italy*

**Fabio Magrini**

*Istituto di Ricerche Cardiovascolari  
CNR  
Università di Milano  
20122 Milano, Italy*

**A. Mancini**

*I Patologia Medica  
Policlinico Umberto I  
University of Rome  
00100 Roma, Italy*

**W. Thomas Manders**

*Department of Medicine  
Harvard Medical School  
Peter Bent Brigham Hospital  
and  
New England Regional Primate  
Research Center  
Southboro, Massachusetts 01772*

**Emanuela Marcato**

*Cattedra di Patologia Neonatale  
dell'Università di Milano  
Milano, Italy*

**Franco Mantero**

*Istituto di Semeiotica Medica  
35100 Padova, Italy*

**Juana Rey Márquez**

*V. dei Meli 64  
00172 Roma, Italy*

**P. Masarotto**

*Istituto di Semeiotica Medica  
Università di Padova  
Padova, Italy*

**Daniel T. Matulich**

*Department of Medicine and  
Metabolic Research Unit  
University of California, San Francisco  
San Francisco, California 94143*

**James C. Melby**

*University Hospital  
Boston, Massachusetts 02118*

**T. Meucci**

*I Patologia Medica  
Policlinico Umberto I  
University of Rome  
Rome, Italy*

**Bernard L. Mirkin**

*Division of Clinical Pharmacology  
Departments of Pediatrics and  
Pharmacology  
University of Minnesota  
Minneapolis, Minnesota 55455*

**Israel Mirsky**

*Department of Medicine  
Harvard Medical School  
Peter Bent Brigham Hospital  
and  
New England Primate Research Center  
Southboro, Massachusetts 01772*

**Jean-Guy Mongeau**

*Service of Nephrology  
Hôpital Sainte-Justine  
Montreal, Canada H3T 1C5*



**M. I. New**

*Department of Pediatrics  
Cornell University Medical College  
New York, New York 10021*

**G. Nori**

*Department of Pediatrics  
University of Parma  
Parma, Italy*

**P. Ofner**

*Hungarian Institute of Cardiology  
H-1450 Budapest, Hungary*

**Massimo Pagani**

*Istituto di Ricerche Cardiovascolari  
CNR  
Universita di Milano  
20122 Milano, Italy*

**M. Pierson**

*Centre de Médecine Préventive  
Vandoeuvre Les Nancy, France*

**H. Poulizac**

*Centre de Médecine Préventive  
Vandoeuvre Les Nancy, France*

**W. Rauh**

*University Children's Hospital  
D-6900 Heidelberg, West Germany*

**P. Ridolfi**

*Istituto di Semeiotica Medica  
Università di Padova  
Padova, Italy*

**Giorgio Rizzato**

*Cattedra di Patologia Neonatale  
dell'Università di Milano  
Milano, Italy*

**J. I. S. Robertson**

*MRC Blood Pressure Unit  
Western Infirmary  
Glasgow G11 6NT, Scotland*

**M. Rocca**

*Department of Pediatrics  
University of Parma  
Parma, Italy*

**Ettore Rossi**

*Children's Hospital  
University of Berne  
CH-3010 Berne, Switzerland*

**Pierre Royer**

*Service de Néphrologie Pédiatrique  
Hôpital des Enfants Malades  
75730 Paris Cedex 15, France*

**Carla Sala**

*Istituto di Ricerche Cardiovascolari  
"G. Sisini"  
Milano, Italy*

**Daniela Sanguigni**

*V. Stamira 15  
00162 Roma, Italy*

**C. Scaroni**

*Istituto di Semeiotica Medica  
Università di Padova  
Padova, Italy*

**D. Scavo**

*I Patologia Medica  
Policlinico Umberto I  
University of Rome  
00100 Rome, Italy*

**K. Schärer**

*Division of Pediatric Nephrology  
University Children's Hospital  
D-6900 Heidelberg, West Germany*

**Burkhard Scherer**

*Medizinische Klinik Innenstadt  
der Universität München  
D-8 München 2, West Germany*

**Adriana Segrè**

*Cattedra di Patologia Neonatale  
dell'Università di Milano  
Milano, Italy*

**R. Senault**

*Centre de Médecine Préventive  
Vandoeuvre Les Nancy, France*

**Elliot Anthony Shinebourne**

*Department of Paediatrics  
Cardiothoracic Institute  
Brompton Hospital  
London SW3 6HP, England*

**N. Sonino**

*Istituto di Semeiotica Medica  
Università di Padova  
Padova, Italy*

**Jan R. Stockigt**

*Ewen Downie Metabolic Unit  
Alfred Hospital  
Melbourne, Australia 3181*

**Zs. Tarján**

*Hungarian Institute of Cardiology  
H-1450 Budapest, Hungary*

**Laura Terzoli**

*Istituto di Ricerche  
Cardiovascolari "G. Sisini"  
Milano, Italy*

**Eija Timonen**

*Department of Pediatrics  
University of Oulu  
SF-90220 Oulu 22, Finland*

**E. Török**

*Hungarian Institute of Cardiology  
H-1450 Budapest, Hungary*

**Matti Uhari**

*Department of Pediatrics  
University of Oulu  
SF-90220 Oulu 22, Finland*

**H. E. Ulmer**

*University Children's Hospital  
D-6900 Heidelberg, West Germany*

**Hans A. Valkenburg**

*Department of Epidemiology  
Erasmus University  
Rotterdam, The Netherlands*

**Stephen F. Vatner**

*Department of Medicine  
Harvard Medical School  
Peter Bent Brigham Hospital  
and  
New England Primate Research Center  
Southboro, Massachusetts 01772*

**O. Velis**

*Istituto di Clinica Medica I  
Università di Milano  
20122 Milano, Italy*

**Willy Vetter**

*Department of Pediatrics and  
Internal Medicine  
University of Zurich  
Zurich, Switzerland*

**R. Virdis**

*Department of Pediatrics  
University of Parma  
Parma, Italy*

**Peter C. Weber**

*Medizinische Klinik Innenstadt  
der Universität München  
D-8 München 2, West Germany*

**Alberto Zanchetti**

*Istituto di Patologia Medica I  
Istituto di Ricerche  
Cardiovascolari  
Università di Milano  
Milano, Italy*

# Contents

## Magnitude of Problem

- 1 Studies in Blood Pressure and Hypertension in General Pediatric Practice  
*S. Londe*
- 9 Epidemiology of Childhood Hypertension  
*Jennifer M. H. Loggie*
- 15 Adolescent Hypertension  
*Margaret M. Kilcoyne*
- 21 The Epidemiology of Neonatal Hypertension  
*Raymond D. Adelman*

## Blood Pressure in Childhood and Some Related Aspects

- 31 Variance Analysis of Genetic and Environmental Components of Blood Pressure  
*Jean-Guy Mongeau and Pierre Biron*
- 35 The Role of Dietary Salt in Juvenile Hypertension  
*W. Rauh, L. S. Levine, and M. I. New*
- 45 Juvenile Human Blood Pressure: Need for a Chronobiologic Approach  
*Franz Halberg and Henry Fink*

## Pathophysiology of Juvenile Hypertension

### *Hypothesis*

- 75 Is an Abnormal Kidney Development Involved in the Pathogenesis of Essential Hypertension?  
*G. Bianchi, A. M. Caravaggi, D. Cusi, C. Barlassina, G. P. Lupi, L. Duzzi, M. Gatti, P. Ferrari, and O. Velis*

### *Hemodynamic Aspects*

- 89 Hemodynamics of Juvenile Hypertension  
*Alberto Zanchetti*
- 91 Age-Related Changes in the Elastic Properties of the Thoracic Aorta of Conscious Sheep  
*Massimo Pagani, Israel Mirsky, W. Thomas Manders, and Stephen F. Vatner*

- 101 Systemic Hemodynamic Changes During Growth in the Dog  
*Fabio Magrini*
- 113 Blood Pressure Studies of a High School Population: Clinical Profile  
of the Juvenile Hypertensive  
*David Goldring and Antonio Hernandez*

*Plasma Renin Activity and Sympathetic Nervous System*

- 129 Plasma Renin Activity (PRA) in the Pediatric Age  
*G. Giovannelli, A. Ammenti, R. Viridis, S. Bernasconi, G. Nori, and M. Rocca*
- 137 Application of Study of the Renin-Angiotensin System to Pediatric Pa-  
thology  
*Michael J. Dillon*
- 147 The Development of the Sympathetic Nervous System and Its Role in  
Blood Pressure Control  
*Jennifer M. H. Loggie*
- 151 Study of Sympathetic Activity in Adolescents Suffering from Essential  
Hypertension: Preliminary Data on Plasma Catecholamines  
*Jean-Guy Mongeau, Jacques de Champlain, and André Davignon*

*Special Aspects*

- 157 Investigation of New Forms of Hypertension in Childhood  
*Maria I. New*
- 161 New Studies of the 11-Hydroxylase and the 18-Hydroxylase Enzymes  
in Hypertensive Form of Congenital Adrenal Hyperplasia  
*Lenore S. Levine*
- 165 Role of Steroids in Various States of Mineralocorticoid-Excess Hyperten-  
sion: Analysis by Mineralocorticoid Receptor Assay  
*Nancy C. Lan, Daniel T. Matulich, Jan R. Stockigt, Edward G. Biglieri,  
Maria I. New, and John D. Baxter*
- 177 Adrenocorticosteroids in Experimental and Human Hypertension  
*James C. Melby and Sidney L. Dale*

**Clinical Aspects of Juvenile Hypertension**

- 195 Hypertension in Children: Clinical Aspects  
*Ettore Rossi and Rudolf König*
- 201 Renal Forms of Hypertension in Children: Report on 238 Cases  
*Michel Broyer, Jean-Louis Bacri, and Pierre Royer*

- 209 Cardiovascular Form of Hypertension: Coarctation of the Aorta in the Infant and Child  
*David Goldring*
- 217 The Adrenal and Other Hormones in Human Hypertension  
*Alfred M. Bongiovanni*

### Therapy

- 223 Antihypertensive Drugs: Mechanisms of Action and Therapeutic Application in Children  
*Bernard L. Mirkin*
- 239 The Management of Hypertension in Children with Chronic Renal Failure  
*K. Schärer, W. Rauh, and H. E. Ulmer*
- 251 The Evaluation and Nonsurgical Management of Renovascular Hypertension in the Neonate  
*Raymond D. Adelman*

### Brief Communications

- 265 Juvenile Hypertension due to Excess of Mineralocorticoids Other than Aldosterone  
*F. Mantero, N. Sonino, C. Scaroni, P. Ridolfi, and P. Masarotto*
- 271 Renal Prostaglandins and Blood Pressure During the First Week of Life in Man  
*Burkhard Scherer, Barbara Friedmann, Angelika Dumbs, and Peter C. Weber*
- 277 Studies of Blood Pressures in School Children in Zurich, Switzerland  
*Ernst P. Leumann, Hans Georg Bodmer, Willy Vetter, and Frederick H. Epstein*
- 283 Epidemiological Study of Blood Pressure in Infancy  
*Michael de Swiet, Alison Earley, Peter Fayers, and Elliot Anthony Shinebourne*
- 287 Dietary Salt and Blood Pressure During the First Four Months of Life  
*Matti Uhari and Eija Timonen*
- 293 Plasma Renin Activity, Urine Aldosterone, Renal Function and Water Electrolytes Homeostasis in Full-Term and Pre-Term Newborn Infants  
*Maria Letizia Caccamo, Carlo Bianchini, Adriana Segré, Pasqualina Cazzaniga, Emanuela Marcato, Giorgio Rizzato, Laura Terzoli, Carla Sala, and Gastone Leonetti*

- 301 International Study on Juvenile Hypertension: Screening Data from the Budapest Center  
*E. Török, I. Gyarfas, M. Csukás, I. Kamaras, Z. Tarjan, and P. Ofner*
- 307 Elevated Blood Pressure in Childhood: Determinants and Prognosis in a Prospective Open Population Study  
*Bert Hofman and Hans A. Valkenburg*
- 313 Distribution of Arterial Blood Pressure Measurements in Children and Adolescents Between 4 and 18 Years of Age: Influence of the Measuring Techniques on the Results  
*J. L. Andre, J. P. Deschamps, R. Gueguen, M. Pierson, H. Poulizac, and R. Senault*
- 319 Evidence of an Angiotensinogenic Mechanism for Generalized Hypertension Associated with Coarctation of the Aorta  
*P. Cugini, A. Mancini, T. Meucci, D. Scavo, A. Castrucci, L. Boschi, and L. De Medici*
- 325 Severe Hypertension in Juvenile Patients  
*A. M. M. Cumming, J. J. Brown, A. F. Lever, J. I. S. Robertson*
- 329 Familial Aggregation of Blood Pressure Levels in Newborn Infants and Their Mothers  
*Karstén Kaas Ibsen and Margit Grønkaek*
- 333 Juvenile Arterial Hypertension and Hyperkinetic Heart Syndrome: Results of Therapy with Beta-Blocking Agents  
*Vito Cagli, Juana Rey Márquez, and Daniela Sanguigni*
- 337 *Subject Index*

# Studies of Blood Pressure and Hypertension in General Pediatric Practice

Sol Londe

*Edward Mallinckrodt Department of Pediatrics, Division of Cardiology, Washington  
University School of Medicine, St. Louis, Missouri*

The studies to be described were begun about 18 years ago. They were performed on asymptomatic children attending a private pediatrician's office and two pediatric clinics, and on students in five high schools in the metropolitan area of St. Louis, Missouri. At the beginning, a satisfactory definition of juvenile hypertension presented a problem, because our experience had already indicated that the frequently mentioned arbitrary values of 130/85 to 140/85-90 mm Hg were not appropriate for children of every age (1,5,8,9,16,18-21,23,26). Furthermore, the published data derived from blood pressure measurements in population samples of normal children were obtained under varying conditions and showed a considerable degree of variation (2,4,6,7,22,24,25,27).

Normal standards for office practice were therefore established. The means, standard deviations, and 90th and 95th percentiles for systolic and diastolic blood pressure were calculated for 795 boys and 798 girls, 3 to 15 years of age (Figs. 1 and 2) (10). The subjects were children brought to the pediatrician's office for routine physical examinations. Measurements were taken in the right arm, in the supine position, at the end of the examination and before any painful procedures. Cuffs with widths of approximately two-thirds of arm length and the mercury manometer were used. The fifth Korotkoff phase was considered to be diastolic pressure. Only one reading was recorded unless it seemed unusually high, in which case the lowest of three readings was used.

According to the suggestion of Master et al. for adults (17) systolic and/or diastolic blood pressures persistently above the 90th percentile for age and sex are considered to be suspicious, and those above the 95th percentile are regarded as hypertensive. The 95th percentile as the upper limit of normal is now accepted by many in the United States. In our practice, patients whose blood pressures remain above the 90th percentile and occasionally above the 95th percentile for more than one year are classified as being hypertensive.

One hundred and thirty-one such patients were followed for 2 to 9 years (13). Hypertension was found in patients as young as 3 years and in 29 children under the age of 6. The greatest number of hypertensive readings was detected

## HYPERTENSION IN PEDIATRIC PRACTICE

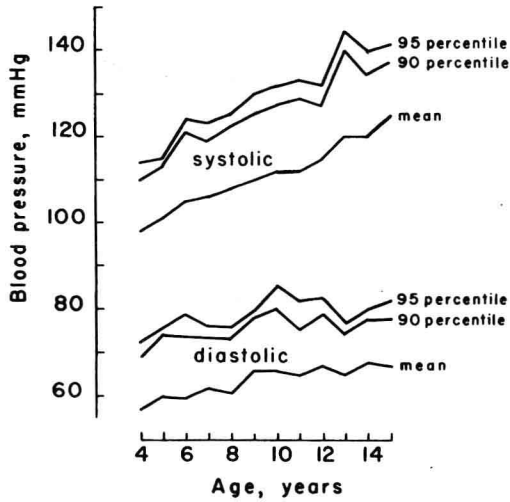


FIG. 1. Blood pressure for age in boys. (From ref. 9a, with permission.)

at age 5 and ages 8 to 12 years. Forty-one percent displayed systolic, 42% systolic and diastolic, and 17% diastolic hypertension. Thirty percent had normal blood pressure before they became hypertensive. One-half of 98 patients on whom three or more readings were taken showed an occasional normal reading, suggesting that they had labile hypertension. Sixty-five percent of 81 children

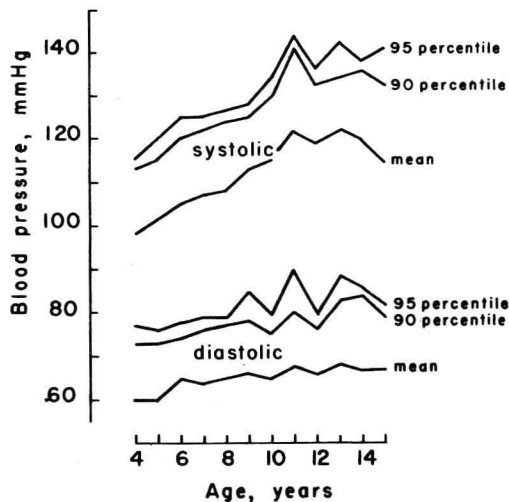


FIG. 2. Blood pressure for age in girls. (From ref. 9a, with permission.)



observed from 3 to 9 years still exhibited elevated pressure at their last examination. Hypertension was present in one or both parents of 51%, and 5% of the families had more than one hypertensive child. Obesity was present in 55%. The incidence of parental hypertension for normotensive children was 18%, and 15% were obese.

The first 74 hypertensive children, 4 to 18 years of age, were reported in 1971 (11). Initially, 33 subjects were investigated on an outpatient basis, using the following laboratory studies: serum sodium and potassium levels, urea clearance, 24-hour urinary catecholamine excretion, electrocardiogram, chest roentgenogram, and intravenous pyelogram when indicated. Because of the paucity of findings in this group, more extensive inpatient investigations were performed on the next 41 patients in the clinical research unit of St. Louis Children's Hospital. Laboratory determinations included serum sodium, potassium, chloride, creatinine, urea nitrogen, and plasma renin activity. The latter study was performed after the children had been ambulatory for 30 to 60 min. Twenty-four-hour urinary excretion of aldosterone, sodium, and creatinine was determined, as well as creatinine clearance. In addition, catecholamines were measured in two urine specimens obtained on successive days, and rapid-sequence intravenous pyelograms, chest roentgenograms, and electrocardiograms were performed.

With one exception, our last 57 patients were investigated on an outpatient basis. Creatinine clearance, serum potassium, creatinine, and urea nitrogen determinations, as well as rapid-scan intravenous pyelograms, chest roentgenograms, and electrocardiograms, were performed on 32 of these. Rapid-scan intravenous pyelogram was performed on only one of the remaining 25 patients.

A possible cause for hypertension was found in only 5% of patients studied. All of these had disease of the urinary tract, one patient with decreased maximum urea clearance and elevated nonprotein nitrogen, one with ureteral reflux, one with renal bleeding associated with sickle-cell trait, and three with pyelonephritis. Thus, 95% of children in whom high blood pressure was an incidental finding seemed to have primary hypertension. Because of our experience, we do not believe that extensive investigations are necessary in the absence of suspicious history, symptoms, or findings.

Although the observations described above indicate that the suggested definition of juvenile hypertension is a useful one, the ultimate answer will be found when we examine those of our patients who are now young adults. However, several points suggest that the concept is probably valid. The first is the significantly high incidence of parental hypertension and of obesity. Second, 60% of 48 patients considered to be hypertensive before the age of 10 had blood pressure readings  $>140$  systolic and/or 90 mm Hg diastolic at one time or another.

The incidence of hypertension among black adults is nearly twice that of the general population in the United States, and the incidence of hypertensive heart disease almost triple that in white persons. For this reason, blood pressure studies were made in 2481 black and white children 3 to 14 years of age and