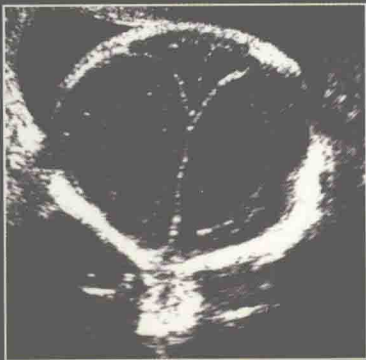


Ultrasonography of the Prenatal and Neonatal Brain

Timor-Tritsch • Monteagudo • Cohen
Second Edition



Ultrasonography of the Prenatal and Neonatal Brain Second Edition

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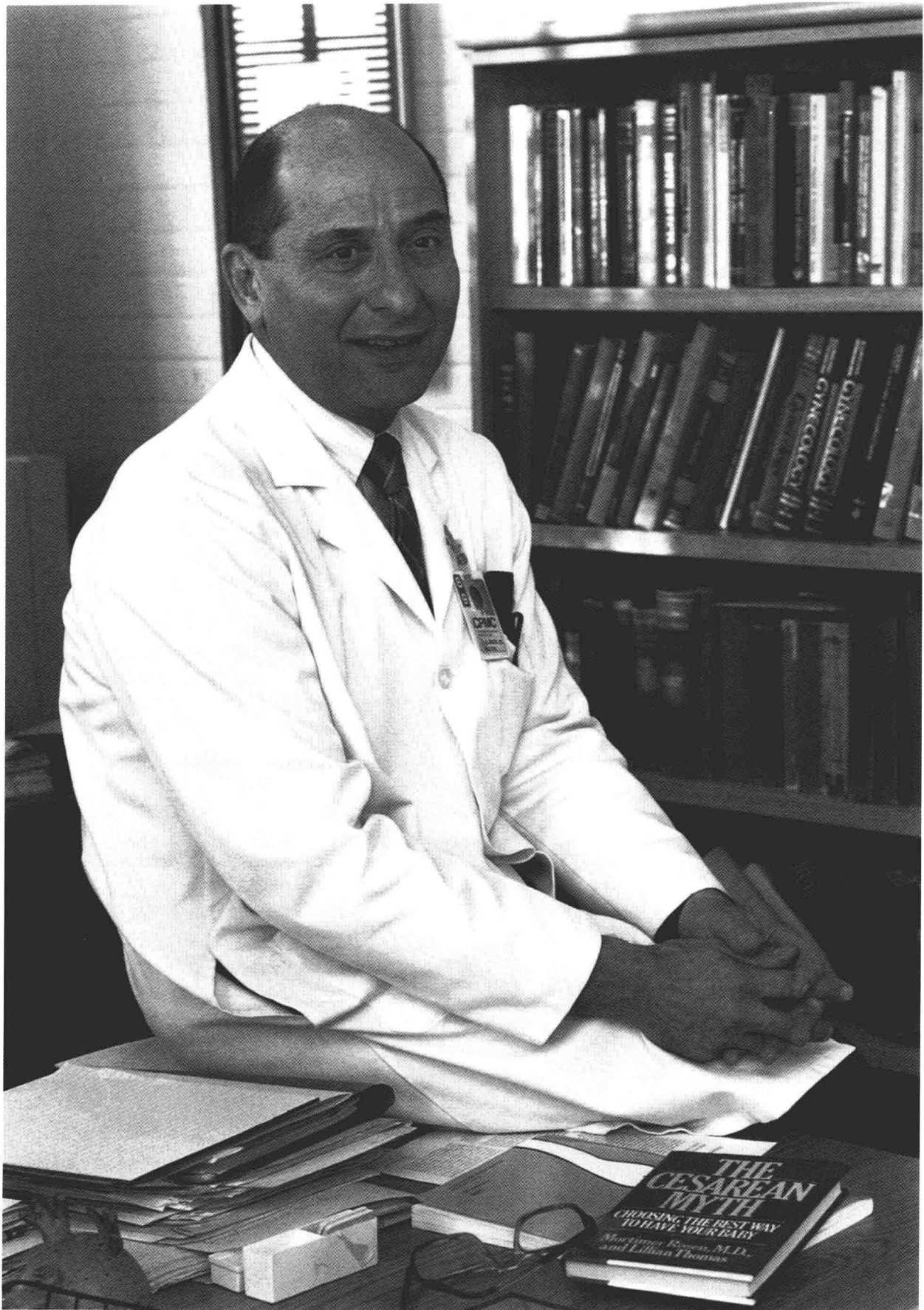
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Notice

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Mortimer G. Rosen, MD, 1931–1992

This book is dedicated to Mortimer G. Rosen, friend and mentor, whose early research on the fetal brain was an inspiration to me and many other young researchers struggling to understand the fetal brain. By creating the necessary clinical and scientific environment for such studies, he became very much a part of its "birth." Many years ago, probably at the beginning of his career as a perinatologist, Dr. Rosen recognized the importance of studying the human fetal brain. Surrounded by a growing group of enthusiastic scholars, including residents, maternal-fetal fellows, biomedical engineers, and biochemists, he pursued his research on one of the most difficult subjects: the physiology and the physiopathology of the fetal central nervous system.

Dr. Rosen believed that the then available systems for monitoring fetal health and well being were inadequate for predicting the intellectual functioning of the neonatal brain. He was always seeking new ways for studying the developing human brain.

When ultrasonography was introduced, Dr. Rosen was among the first to encourage its use in

the study of fetal behavioral studies. When he saw the first detailed, crystal clear pictures of the prenatal central nervous system achieved by high frequency transvaginal imaging, he immediately understood the enormous potential of this laboratory technique.

His scientific integrity and skepticism stimulated us to become experts in our field, and furnish objective results to prove the clinical value of high resolution brain scanning of the fetus.

When I presented him with the outline of this book, he was not only supportive, but promised to contribute a special chapter on cerebral palsy, a subject in which he was extremely interested. This is the only time he let us down. The chapter never got further than its introduction. Mort Rosen—my mentor and friend, as well as enthusiastic supporter of our endeavors—passed away in 1992, not living long enough to see the fruits of his labors.

To you, Mort Rosen, in loving memory. I think you would be proud of this work.

Ilan E. Timor-Tritsch, MD

To my family: my son, Benjamin; my parents, Edith and Miguel; my sister, my niece, and my brother-in-law Edith A, Carolinna and Michael who inspired, supported and encouraged me.

Ana Monteagudo

To my wife, Sandra W. Cohen MD, FACP and to my children David, Lauren and Benjamin, who put up with a lot as I tilt with the windmills of academic radiology. Thanks for your help and patience.

To the memory of my parents Samuel Gozanski Cohen and Lola Esther Cohen (nee Altman) who gave me the background, desire and genes (not Levi's) that help me do what I do.

To my colleagues and mentors in pediatric imaging and diagnostic ultrasound, and to my confreres in Pediatrics, Obstetrics, Pediatric Surgery and Pathology, who have inspired, encouraged and helped me make those all-important diagnoses on those all-important and oh-so-real patients.

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Foreword

Over the past few decades the continued research efforts of basic scientists and clinicians have led to extraordinary advances in the utilization of ultrasound in clinical medicine. Drs. Timor-Tritsch, Monteagudo, and Cohen have continued to explore the fetal and neonatal brain to add to our continuing knowledge to produce yet another landmark textbook. This book adds to our understanding of the role of ultrasound in the evolution of both the fetal and newborn central nervous systems. Normal development as well as central nervous system abnormalities are beautifully illustrated in this second edition. This book synthesizes basic embryology and pathophysiology into a well written and illustrated text while exploiting the latest imaging modalities. This text has further enhanced what they already contributed in the first edition. The editors are clearly the recognized authorities in this field and the contributing authors are recognized experts in the area of their contributions. This beautifully illustrated book is fascinating, concise and essential.

This text is another major contribution to medical science. I am confident it will prove to be essential to every clinician involved in prenatal diagnosis

and neonatal care. This is a book that belongs in every library and clinical site where obstetrics and pediatric patients undergo ultrasound examinations. The addition of new areas and chapters in this edition, such as the role of three-dimensional imaging, both are timely and essential. The authors have already reported on the key and superior role that this modality plays in the diagnosis of many abnormalities heretofore not amenable to prenatal diagnosis by ultrasound. The introduction of topics on fetal therapy also brings new innovations and exciting new approaches that are now being undertaken in this field.

It is clear that Drs. Timor-Tritsch, Monteagudo, and Cohen have advanced their leadership in this field by yet another essential and magnificent text in this most important area of fetal and neonatal development. Along with their contributing authors, they have produced a monumental addition to our literature.

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Preface to the Second Edition

Responding to the positive feedback to the First Edition of our book we decided to update it and expand its content. An additional reason for this decision was the amount of new and pertinent articles which have accumulated in the last 3-4 years. We wanted to review them and add most of them to the more than 1100 references we used in the First Edition.

As far as the chapters are concerned, every previously written chapter was updated and then there are several new chapters. Major changes were made in Chapters 2, 4, 5 and 8 to reflect the new clinical experience in the field of fetal neuroscan and fetal neuro-MRI. New sonographic images of commonly encountered entities were added to the previously published ones. Several rarely seen fetal neuropathologies were also illustrated and were included. All chapters were updated with the newest articles from the literature to justify the term “reference textbook,” a term used by many as they mention the First Edition of the book.

Two new chapters (9 and 14) were added dealing with three-dimensional fetal and neonatal neuroscans. Pediatric neurologists and neurosurgeons rely on neonatal CT and MRI images to study the neonatal brain. So far they seemed hesitant to counsel and to plan postnatal (and prenatal) management of pathologies based upon prenatal ultrasound imaging studies. The reason was, that the prenatal images were obtained at planes unfamiliar to them. They were waiting to see the postnatal imaging studies. Since the introduction of 2D and now of 3D transfontanelle fetal neuroimaging by high frequency, high resolution ultrasound clear images can be generated in the planes which are familiar to pediatric neurologists and neurosurgeons. The expected result of these images is a better understanding of the pathologies leading to an earlier prenatal counseling and planning for postpartum management before the neonatal studies are available. We

predict that the 3D fetal and neonatal brain scan will expand and will be widely employed as effective diagnostic means.

The addition of two new chapters deals with devastating diseases of the fetal brain and attempts for their correction. Chapter 16 summarizes possible causes of cerebral palsy and Chapter 18 is a description of attempts to correct neurological pathologies *in utero*. It seems that after the well known moratorium to treat diseases of the brain, while the fetus is still in the womb, there may be a place for intrauterine treatment for a well selected patient population after adequately researched surgical procedures.

The use of the icons at the side of ultrasound images, to indicate the particular plane or section at which the image was generated, was extended to several more chapters. This ensures a better understanding of the anatomy depicted.

We tried (quite successfully) to standardize the anatomic nomenclature throughout the book and based it on the latest issue of the internationally accepted *Nomina Anatomica*. Correctly or incorrectly, some terms are so deeply “embedded” in the daily use, that it may be impossible to constantly correct them. One such example is the word “hydrocephaly” (the accepted, correct way to use it) which over time was changed to “hydrocephalus” and (probably incorrectly) used in many publications. We selected to use the correct term “hydrocephalus” in all chapters.

We hope that the Second Edition of this book will contribute to the understanding and most importantly the earliest possible detection of neurological diseases of the fetus and the newborn.

Ilan E. Timor-Tritsch, MD
Ana Monteagudo, MD
Harris L. Cohen, MD

Preface to the First Edition

The concept for this book was born many years ago and was preceded by careful acquisition and selection of representative neurosonograms of normal and abnormal cases. The central nervous system is probably the most elaborate and intricate organ or system in the human body. Minute structural abnormalities can, at times, reflect major functional deficiencies. On the other hand, it would appear that at times major anatomic defects do not seem to be associated with significantly deviant function. It is extremely important to study and understand the normal and abnormal fetal and neonatal central nervous system. The central nervous system is one of the common sites of anatomical malformation in the fetus with chromosomal abnormality. The detection of anomalies within the fetal and neonatal brain is feasible using modern imaging techniques, such as ultrasound, computed tomography, and magnetic resonance imaging.

The aim of prenatal ultrasonography is to be able to reassure the pregnant patient as early as possible that fetal development is normal; or if a malformation is detected to counsel the patient about the nature of the problem. Most anomalies of the central nervous system develop early, and we have the tools to detect these as early as 10 to 16 weeks. Early detection of such central nervous system anomalies is probably the most important advance in modern perinatology. Neonatal ultrasound confirms the prenatal diagnosis. In addition, neonatal neurosonography is a powerful tool in diagnosing central nervous system pathology.

The first chapter deals with the development of the human central nervous system. Its authors are the distinguished professors Ronan O'Rahilly and Fabiola Müller, who have a lifetime of professional experience. Professor O'Rahilly not only took time to write about the embryology of the brain, but also invested valuable time in overseeing the correct

anatomical terminology used throughout most of the chapters.

The vast imaging possibilities of ultrasound in general and that of transvaginal sonography in particular regarding the fetal brain, are dealt with at the beginning of our book and lead into the chapters describing the detectable pathology in the fetal and neonatal central nervous system. Because fetal and neonatal neurosonographic scanning is performed using the anterior fontanelle and other calvarial openings, the "classical" axial planes cannot be used to describe the images obtained in the fan-shaped sonographic sections. It was our goal to keep the "classic" planes in use by CT and by MRI imaging of the brain and create a separate and well defined set of planes and sections for the fetal brain imaging. A new nomenclature regarding the scanning planes of the fetal brain is introduced in Chapters 1, 2, 3, and 4.

We felt that a special and dedicated chapter dealing with biometry of the fetal brain should be included. A large number of tables and graphs as well as measurements of the fetal brain are incorporated for reference.

Because the fetal eye and the fetal face are frequently associated with brain pathology, two special chapters are devoted to these structures. Dr. Israel Meizner and Dr. Moshe Bronshtein's group from Israel have the most imaging experience in these two areas and contributed these two important chapters, which we believe are the most detailed in the literature dealing with those subjects.

Neonatal neurosonology is an established diagnostic entity which has earned its well deserved place in the armamentarium of the neuroimager since its introduction in 1979. Chapters concerning imaging of the normal and abnormal neonatal brain, and the chapter by Dr. Madhuri Kirpekar dealing with the spine, are included to form a con-

tinuum as far as the sonographic neuroimaging workup of the prenatal and neonatal CNS.

The chapter written by Gianluigi Pilu and Vincenzo D'Addario and their co-workers from Italy, made a significant contribution to the book by touching on the subject of the midline brain pathologies and the recently introduced attempts to image the fetal brain using MRI.

It is hard and labor intensive to study the physiological aspects of the brain. This was successfully done by recognized authors such as Jan Nijhuis who reviewed the fetal behavioral states coordinated by the brain and by Shimon Degani and Reuven Lewinsky summarizing the clinical uses of measuring the blood flow to the central nervous system.

Finally, the ethical aspects of neurosonography are explored by Frank Chervenak, who over the years has become an authority in the field of medical ethics.

This book was written for the perinatologists, neonatologists, perinatal geneticists, as well as the imaging specialists such as radiologists, obstetricians, and sonographers who see the fetus and neonate in their clinical practice. These specialists scan the fetal and neonatal brain themselves or are directly involved with managing pregnancies with structural malformations or anomalies of the central nervous system. Special emphasis was placed on the creation of an objective and exhaustive updated review of the pertinent literature so that the

reader would have a wide reference base on each subject. As far as the illustrations are concerned, the authors were encouraged to be liberal about including an unrestricted number of cases and their sonographic manifestations in their respective chapters. This may, therefore, lead to some duplication by presenting the same disease or pathology more than once. However, by allowing some deliberate repetition in depicting various cases, we, hopefully, covered the commonly occurring pathologies. We consider such occasional and repetitive presentations as one of the advantages of the text enabling the reader to be educated by the experiences of the different authors and their various points of view.

One of the particular strengths of presenting the sonograms is that we chose to include small body images so that readers could orient themselves as to how an individual sonographic view was obtained. This will, we hope, enable readers to quickly grasp and understand the actual planes used to generate the pictures.

We suggest that neuroimaging of the fetus be included in the structural evaluation of the fetus at any gestational age. We also believe that practitioners involved in fetal and/or neonatal neuroimaging will benefit from using this carefully prepared text.

Ilan E. Timor-Tritsch, MD
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We wish to express our thanks to Christonia Joseph for the secretarial help. The professional help of Barbara Holton and her staff as well as that of Andrea Seils are greatly valued.

*Ilan E. Timor-Tritsch
Ana Monteagudo*

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Harris L. Cohen

Contents

Contributors	xi
Foreward	xv
Preface	xvi
Acknowledgments	xix
1. Prenatal Development of the Brain	1
<i>Ronan O'Rahilly and Fabiola Müller</i>	
2. Normal Two-Dimensional Development of the Prenatal Brain	13
<i>Ilan E. Timor-Tritsch and Ana Monteagudo</i>	
3. Biometry of the Fetal Brain	93
<i>Ana Monteagudo, Nathan Haratz-Rubinstein, and Ilan E. Timor-Tritsch</i>	
4. Fetal Neurosonography of Congenital Brain Anomalies	151
<i>Ana Monteagudo and Ilan E. Timor-Tritsch</i>	
5. Median Anomalies of the Brain	259
<i>Gianluigi Pilu, Antonella Perolo, Pietro Falco, and Antonella Visentin</i>	
6. Ultrasonography of the Fetal Face	277
<i>Israel Meizner</i>	
7. The Fetal Eye	315
<i>Etan Z. Zimmer, Zeev Blumenfeld, and Moshe Bronstein</i>	
8. Magnetic Resonance Imaging of the Fetal Brain	331
<i>Maurizio Resta, Vincenzo D'Addario, Pantaleo Greco, Gilda Caruso, Nicola Medicament, and Nicola Burdi</i>	
9. Three-Dimensional Sonographic of the Fetal Brain	359
<i>Ana Monteagudo, Ilan E. Timor-Tritsch, and Patricia Mayberry</i>	
10. Ethical Dimensions in the Management of Pregnancies Complicated by Fetal Brain Anomalies	393
<i>Frank A. Chervenak and Laurence McCullough</i>	
11. Neurosonography of the Infant: The Normal Examination	403
<i>Harris L. Cohen, Netta M. Blitman, and Julian Sanchez</i>	
12. Neurosonography of the Infant: Diagnosis of Abnormalities	423
<i>Harris L. Cohen and Netta M. Blitman</i>	
13. Ultrasonography of the Neonatal Spine ...	453
<i>Madhuri Kirpekar and Harris L. Cohen</i>	
14. Three-Dimensional Neonatal Neurosonography	467
<i>Michael Manco-Johnson, Gary Thieme, and Darlene Cioffi-Ragan</i>	
15. Neurobehavioral Development of the Fetal Brain	489
<i>Jan J. Nijhuis and Ilse J.M. Nijhuis</i>	
16. The Role of Infection in the Etiology of Cerebral Palsy	497
<i>Luis F. Gonçalves, Eli Maymon, Bo Hyun Yoon, and Roberto Romero</i>	
17. Fetal and Neonatal Cerebral Circulation	509
<i>Shimon Degani</i>	
18. In Utero Surgical Interventions of the Fetal Brain and Spine	527
<i>Andrei Rebarber and Howard Weiner</i>	
Index	539