Alessandra Piontelli

Development of Normal Fetal Movements

The First 25 Weeks of Gestation

Springer

Development of Normal Fetal Movements

Alessandra Piontelli

Development of Normal Fetal Movements

The First 25 Weeks of Gestation

Springer

ALESSANDRA PIONTELLI
Department of Maternal/Fetal Medicine
Clinica Mangiagalli
University of Milan
Milan, Italy
E-mail: alessandra.piontelli@fastwebnet.it

With the assistance of:

Luisa Bocconi, Chiara Boschetto, Elena Caravelli, Florinda Ceriani, Isabella Fabietti, Roberto Fogliani, Alessandra Kustermann, Umberto Nicolini†, Sarah Salmona, Beatrice Tassis, Laura Villa, Cinzia Zoppini.

Department of Maternal/Fetal Medicine, University of Milan, Clinica Mangiagalli - Fondazione IRCCS Ca' Granda, Ospedale Maggiore, Policlinico di Milano, Italy

ISBN 978 88 470 1401 5 e ISBN 978 88 470 1402 2

DOI 10.1007/978 88 470 1402 2
Library of Congress Control Number: 2010923295

Cover illustration: Ikona S.r.l., Milan, Italy

Typesetting: Ikona S.r.l., Milan, Italy
Printing and binding: Grafiche Porpora S.r.l., Segrate, Milano

Printed in Italy

Springer Verlag Italia S.r.l. Via Decembrio 28 I 20137 Milan
Springer is a part of Springer Science+Business Media

To my mother
and
to all our mothers

Preface

This work sees the light for various reasons. There is a general lack of detailed information about the earliest stages of human motor development. The reasons for this are explained more fully in the Introduction; here we may simply state that, apart from their intrinsic interest, earlier phenomena are fundamental to the comprehension of later phenomena rooted in them, whether pathological or normal. This is especially so in the rapidly developing young organism.

At birth the neonate is catapulted into a profoundly different physical and social environment requiring extremely diverse functioning: suffice it to mention aerial respiration, no longer being fed through the placenta and the cord, and the full impact of gravity on neonatal movements. The neonate generally adapts smoothly to the transition, as it has been equipped to do so during the 9 months of pregnancy. However, the study of the early stages of fetal motor development should not be exclusively directed towards the understanding of functioning in the neonate.

Fetuses undergo constant and very rapid changes throughout pregnancy. Equally, the intrauterine environment varies continuously. The young organism is continually reshaped in more or less subtle ways and its functions modify, develop, become redundant or are incorporated almost beyond recognition into subsequent ones. Fetuses are perfectly adapted to each step of their rapid development. Only some functions are fully and wholly anticipatory and uniquely geared toward postnatal life. In other words, at any given gestational age fetuses are to be considered *in themselves* and in relation to their environmental conditions. On this basis, preparatory or mixed functions and their evolution can be teased out.

Besides trying to bring to light a severely neglected topic, some other reasons motivated me to write this work. Relatively recent technologies such as 4D ultrasonography once seemed to hold the promise to revolutionize fetal studies; however, 4D ultrasound produces not real-time images, but computerized reconstructions of the fetus in motion. As such, it fails to capture essential features of most fetal movements. On the other hand, 4D ultrasound does offer some sensational and easily readable images. Researchers with little or no experience in the field are increasingly drawn to the 4D technique by its deceptive accessibility and apparent ease of interpretation. This often results in far-fetched conclusions being reached over very thin ice. In a few years' time new technologies will certainly bring about a true revolution in fetal studies. However, future studies will also always require a thorough basic knowledge of fetal functioning and how it changes. For the moment this basic knowledge can only be acquired by dipping into a mixture of techniques, using the best each has to offer.

With the recent invasion of ultrasound pictures, and 'special effects' images which have been totally artificially constructed, fetuses and their behaviour and development are often referred to as 'wonders of nature'. Almost nothing makes us feel that we are witnessing

a miracle of nature like watching a new life unfold. Others regard the miracle of life as a gift from God. This latter stance, legitimate as it may be, belongs to religion, not to the study of nature. The sense of wonder, whether based upon compelling religious beliefs or sentimental and emotional reactions, impinges strongly on society's attitudes, on decisions about the fetus, and ultimately on the lives of many women deemed to be mere containers of the 'miraculously' unfolding life.

Fetal behaviour is fascinating, but it can be analysed. By relying on observational data, this work hopes to re-establish a balance in favour of evidence. Having spent many years working in this field I felt that the time had come to gather together all the accumulated knowledge about the first 25 weeks of pregnancy, the time span on which I have always focused my attention.

My professional background is somewhat multi-faceted. After graduating in medicine I specialized in psychiatry and neurology, trained amongst other things as a 'baby-watcher' following the principles of ethology in England, but then went back to medicine and, albeit not formally, became an expert in obstetrics and fetal behaviour by pursuing my research in the main maternity hospital in Italy, my native country, for almost 20 years.

By propounding a fresh look at our first movements and the rapid changes they undergo, I hope to elicit renewed interest in the reader in this vastly unexplored but fascinating field. I also hope this will result in further research bringing about true advances in our still rudimentary understanding of this neglected area of knowledge.

Milan, April 2010 *Alessandra Piontelli*

Acknowledgements

The help and support of many individuals were critical in making this work a reality. These include former and current staff, students, and nurses of the Department of Maternal Fetal Medicine at the Clinica Mangiagalli of the University of Milan. I am greatly indebted to Professor Fedele for allowing me full access to the Clinic. This book could not have seen the light of day without the help and the teachings of the late Umberto Nicolini, of Alessandra Kustermann, and of, in alphabetical order: Stefano Acerboni, Luisa Bocconi, Chiara Boschetto, Elena Caravelli, Florinda Ceriani, Isabella Fabietti, Roberto Fogliani, Leo Gallo, Sarah Salmona, Beatrice Tassis, Laura Villa, and Cinzia Zoppini. Most of these persons will be further acknowledged in each chapter for helping me collect the material and for independently reviewing it. Thank you Lucy for always being so available and kind. The pregnant mothers who so generously agreed to be part of all these studies have obviously been essential to this work. I am greatly indebted to all of them.

This work could not have been made possible without the help of Carlo Castellano and his enormous generosity in allowing Esaote S.p.A. (Genoa, Italy) to lend me the equipment specifically chosen for the various requirements of this work. Carlo and Ileana, you have been marvellous friends. All the technicians and local directors of Esaote have been excellent in solving the many problems of ultrasonographic research. A special thank to Dr Testa and Dr Schiavi, and to Emilio Busato for technical help.

In their special training courses, Heinz Prechtl, Christa Einspieler, Giovanni Cioni, and Paolo Ferrari have been fundamental teachers for learning to observe fetal and neonatal motions. Heinz and Christa were so kind as to ask me to speak at to two meetings in Graz. These symposia were invaluable for meeting extraordinary people, and for learning and testing out some of my thoughts. I am particularly grateful to Peter Wolff for some long discussions in Graz, Boston, and Milan.

Many other special colleagues and friends have been at my side at various stages of my work. Particular thanks go to Antonio d'Elia, Daniel Stern, Colwyn Trevarthen, Elizabeth Spillius, Jerry Bruner, the late Mauro Mancia and the late Elizabeth Bryan, and to Diane Garcia and all my friends in Los Angeles. Giannis Kougioumouzakis in Crete has always provided a wonderful arena to test out my ideas and share them with him and with an exceptional audience. I am also grateful to the anonymous reviewers of the manuscript for their valuable suggestions.

A very special thank you goes to my editor Donatella Rizza for being so accessible, helpful, and encouraging. Working with her and with all the staff at Springer-Verlag Italia has been a real pleasure.

Chris Benton as usual has carefully and patiently revised my English. Andrea Sommaruga

has helped me with figures and computer work, and Sergio Belfiore with photographic material.
Luigi with Filippo and Roberto have been always lovingly and unfailingly by my side.
Ultimately, of course, the responsibility for what I say in this book remains mine alone.

Contents

Introduction

Keywords Fetus • Neonate • Movements • Gestation • Premature • Ultrasound

Normal human fetal movements during the first 25 weeks of gestation have generally been overlooked. The beginnings of fetal activities have in the main been regarded as chaotic and disorganized, and as such not worthy of detailed investigation. In reality, fetal movements during the first 25 weeks of pregnancy are simply organized differently to those in later periods, and are in any case functional to the various stages of development of that time span. However, quite apart from the neglect suffered by this specific period, *all* research on human fetal movements seems to have come to a standstill in recent years, whilst myths surrounding our first movements have flourished.

Our origins have always fascinated us, and the origins of our movements are particularly fascinating as they initiate many vital phenomena. Historically, Aristotle can be considered the father of embryology. He was the first scholar to challenge the traditional view of existence as beginning only at birth; his investigations began at or soon after conception and were always grounded in direct observation. Based as it is on the observation of movements from their very beginning, in this particular sense this work could be regarded as 'Aristotelian'. Aristotle dissected many animals, possibly including human embryos, and observed their changes throughout the various stages of pregnancy. He attributed increasing degrees of animation to the growing embryo. According to his theories, the embryo started its development in a 'vegetative' state. A 'sentient' phase then followed until 16 20 weeks, when 'quickening', the stage of pregnancy at which the mother begins to sense fetal movements, began and the embryo was thought to have irrevocably achieved a 'rational soul'. Following Aristotle, many scholars continued to regard quickening as the sign that the fetus had finally emerged from the chain of its former vegetable and animal hazy states and attained 'ensoulment' or 'animation', a term derived from the Latin *anima* (soul). Other scholars, mainly basing their interpretations on analysis of the Old Testament, considered the first breath as the true beginning of human life. Still others regarded viability as the indication that the fetus had fully entered the human world. Opponents of all these theories of 'delayed ensoulment' contended that the embryo possessed a soul from conception and was fully human long before it quickened and long before it took its first aerial breath. These concepts were debated for centuries amongst various religious communities, and similar arguments, though refined and updated, are still largely at the basis of pro-choice and pro-life debates.

When the fetus attains a 'rational soul' or, as we would call now it, 'awareness' and 'consciousness', continues to be an unanswered question which will not be touched upon in this book. The very concepts of consciousness and awareness are far from being clarified and still await both differentiation and convincing consensual definitions. Furthermore, the attainment of consciousness is not an *either/or* phenomenon, but one that is built gradually and takes on different gradations and shades during its development. It may possibly be easier to state when a fetus *cannot* sustain consciousness than when it can.

It was only when scientists stopped looking for the 'soul' that a truly observational and scientific interest in the fetus began. Towards the turn of the nineteenth century, several disciplines split from philosophy, making it

A. Piontelli, *Development of Normal Fetal Movements*.

possible for proper fetal research grounded in reality to start. William Preyer, a German embryologist and physiologist, can be considered the true father of fetal studies. Preyer wrote in 1885 a seminal treatise, *'Spezielle Physiologie des Embryo'('Special Physiology of the Embryo'*), in which he dealt with the sensorimotor functions of the human fetus, giving expression to many far-reaching intuitions [1]. However, the means available to early scientists were very limited. They could only observe the excursions of the maternal abdominal wall or try to infer the behaviour of the fetus from that of premature infants.

After Preyer's pioneering work, the subject stagnated for about 50 years, and it was only between the 1920s and the 1940s that fetal studies saw a remarkable resurgence. Several scholars observed fetuses after spontaneous miscarriage or abortion by caesarean section. Significant contributions were made by the Swiss neurologist and psychiatrist Myeczyslaw Minkowski [2], who observed the behaviour of surgically removed fetuses; by Davenport Hooker [3], an American anatomist, who added cinematic documentation and tactile stimulation to the observation of moribund human aborted fetuses; and by Hooker's collaborator Tryphena Humphrey [4]. Their investigations, pursued by testing and directly observing the early human fetus, provided numerous basic concepts, many of which are still fundamental today. Another historical classic is Arnold Gesell's *The Embryology of Behavior*, published in 1945, which describes and illustrates the physical and behavioural development in the human from embryo to fetus, and from fetus to neonate [5]. Other relevant contributions came from scientists observing and experimenting with various animals. However, the majority of the studies performed in these years were strongly influenced by the otherwise remarkable work of Sherrington and Pavlov centring on reflexes, and as a consequence of this, a 'reflexogenic' view of fetal motions became prevalent whereby they were considered to be invariably generated by unidentified stimuli.

After this extraordinary blossoming, the subject was largely abandoned until the introduction of ultrasound in the mid-late 1970s. Ultrasound, by offering the unprecedented possibility of observing the undisturbed and unharmed fetus in its natural environment, opened a completely new era for the study of fetal activities, which not surprisingly underwent an unparalleled renaissance. The belief in the reflexogenic nature of human fetal movements was promptly and fully dispelled. Ultrasonographic investigations of human fetal motor development were pioneered by Birnholz and colleagues [6], Ianniruberto and Tajani [7], and deVries, Visser and Prechtl [8 10].

The studies of Prechtl and his followers have been particularly influential. Prechtl, a developmental neurologist, was initially a student of Konrad Lorenz, one of the founders of ethology. Ethology is the branch of zoology studying animal behaviour within its natural environment as well as in the laboratory. The pictures of Lorenz immersed in a pond observing the greylag goose or walking about followed by a young 'imprinted' duck have become icons of naturalistic studies. Prechtl applied many of the principles of ethology to fetal studies. Amongst other things, he furnished an accurate account of the evolution of fetal movements throughout pregnancy and a so-called 'ethogram', the description and definition of various fetal movements. This classification, based as it was on terminology used for the premature and the neonate, has been almost universally adopted, fostering mutual understanding amongst researchers in the field. Grounded as they are in the observation of the human fetus within its natural milieu, studies of fetal movements, including the present volume, are largely rooted in ethology.

Niko Tinbergen, the other founder of ethology, who won the Nobel Prize for Medicine in 1974 together with Konrad Lorenz and Karl von Frisch, also had a significant influence on fetal studies. Tinbergen thought that scientists always needed to pay attention to four fundamental kinds of explanation when faced with any behaviour: function, causation, development, and evolutionary history [11]. These questions are still of primary relevance for those attempting to study human fetal behaviour. Whenever feasible each motor phenomenon described in this book will be examined in the light of Tinbergen's four queries.

However, to return to where we started: despite the importance of Prechtl's leading work and perhaps because of its intimidating significance except for a few valuable additions, the study of human fetal motor functioning, in particular during the first 25 weeks of pregnancy, seems to have come to a halt. According to deVries, one of the pioneers in the field, human fetal motor research peaked between 1980 and 1990 and declined thereafter [12]. Even during this 'golden age' the first half of pregnancy was usually overlooked. Out of 109 relevant articles examined by deVries, 83% dealt with the second half of pregnancy only. As a result of this stagnation, the same data are quoted repeatedly and fairly uncritically, and our knowledge of the origins of fetal movements can be said to be still at the embryonic stage.

Apparently contrasting with this stagnation in fetal