SECOND EDITION

Best Practice in Labour and Delivery

Edited by Sir Sabaratnam Arulkumaran

CAMBRIDGE

Medicine

Best Practice in Labour and Delivery

Second Edition

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Edited by

Sir Sabaratnam Arulkumaran

St George's University of London, UK, University of Nicosia, Cyprus, and Institute of Global Health, Imperial College, London, UK

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I dedicate this book to mothers, babies, their families and care givers who have helped us to understand the process of labour and delivery. The advanced scientific knowledge gained from studying labour and delivery has helped us to improve the safety and quality of the care we provide.

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Preface to the Second Edition

Best Practice in Labour and Delivery is a comprehensive textbook of 33 chapters that cover most topics of importance that one should know in labour and delivery. Starting from basic anatomy and physiology, the book covers the entire spectrum of problems encountered in labour and delivery. Special attention is paid to topics of importance that result in maternal and fetal morbidity and mortality. The layout and rational arrangement of chapters makes the book easy to navigate and read; this is made more simple by use of easy-to-assimilate tables, care pathways, suitable illustrations and pictures.

Each chapter has been contributed by nationally and internationally recognized experts. In addition to the latest evidence from guidelines published by various colleges from the UK and other countries, and the Cochrane Database, the authors have distilled the recommendations from the NICE guidelines on intrapartum care published in December 2014 and the recommendations from the UK Confidential Enquiries into Maternal Deaths, released in January 2015. Most authors have carried out original research into the topics chosen and their work blends into the respective chapters. In addition to technical aspects of labour and delivery, the important aspects of non-technical skills needed for good practice, prioritization to give care, clinical governance, risk management and objective structured assessment of technical skills are dealt with in detail. These chapters will help each and every consultant and trainee, especially those who have opted to train in advanced labour ward practice.

I am grateful to the contributors, who have sacrificed a lot of their time to provide us with the excellent chapters. Even with scrupulous proofreading there may be mistakes, and some facts may be wrong or controversial. I would be most grateful to the readers for writing to me as the editor, or to the publisher, so that we can rectify any problems in the next reprint.

Yours sincerely,

Sir Sabaratnam Arulkumaran

Preface to the First Edition

Those privileged to look after women during their labours and deliveries have a duty to practise to the highest standards. A clear understanding of what constitutes best practice will help to ensure the safety and health of mothers and babies through parturition.

Whilst the encouragement of normality is implicit, abnormality in labour must be recognized promptly and, when necessary, must be appropriately managed to ensure best outcome.

An understanding of normality and when and how to intervene are the keys to good clinical care. This textbook is an encompassing reference covering all the essential information relating to childbirth; it offers clear practical guidance across the width of labour and delivery.

We are very grateful to those well-known leading experts who, despite their busy lives, have made such excellent contributions to this definitive text. Each chapter offers a modern authoritative review of best practice with the evidence base for good clinical care necessary to optimize outcome through appropriate clinical management and justifiable intervention.

Whilst this is an ideal textbook for those training or taking examinations in labour ward practice, it offers all those professionals caring for the labouring woman a modern, evidence-based approach, which will help them understand and deliver the best possible clinical care. The importance of team working, prioritizing and the organization of maternity care receive appropriate emphasis with clear guidance and practical advice.

Guided by appropriate, clearly defined management pathways, based on national guidance, attending professionals will be best placed to improve safety and the quality of the labour process for both mother and baby.

The auditing and monitoring of standards and outcomes are vital to the organization and improvement of maternity services. The recent introduction of Clinical Dashboards (Appendix A) promises to be a major advance by facilitating the monitoring through traffic light recording of performance and governance (including clinical activity, workforce, outcomes risk incidents, complaints/women's feedback about care) against locally or nationally agreed benchmarked standards.

This book contains the most up-to-date references and evidence base, including from the Guidelines and Standards of the Royal College of Obstetricians and Gynaecologists (www.rcog.org.uk) and the National Institute for Health and Clinical Excellence (www.nice.org.uk). We believe that this textbook will be of great value for all midwives and doctors overseeing and managing childbirth.

Richard Warren
Sir Sabaratnam Arulkumaran

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The editor would like to sincerely thank the authors for their excellent contributions to the second edition of the book. I thank Mrs Sue Cunningham for inviting and reminding the authors and for collating and finalizing the edited chapters. I am most grateful to Nick Dunton and Kirsten Bot of Cambridge University Press for their constant support and for their patience in producing this book.

I am indebted to Gayatri, Shankari, Nishkantha and Kailash for their kind understanding of my time away from them in doing all the writing and editing.

Chapter 1

Pelvic and Fetal Cranial Anatomy and the Stages and Mechanism of Labour

K. Muhunthan

Introduction

Labour or parturition is the culmination of a period of pregnancy whereby the expulsion of fetus, amniotic fluid, placenta and membranes takes place from the gravid uterus of a pregnant woman. In a woman with a regular 28-day cycle, labour is said to take place 280 days after the onset of the last menstrual period. However, the length of human gestation varies considerably among healthy pregnancies, even when ovulation is accurately measured in naturally conceiving women [1].

Successful labour passes through three stages: the shortening and dilatation of the cervix; descent and birth of the fetus; and the expulsion of the placenta and membranes. Efficient uterine contractions (power), an adequate roomy pelvis (passage) and an appropriate fetal size (passenger) are key factors in this process.

Anatomy of the Female Pelvis

The bony pelvis consists of the two innominate bones, or hipbones, which are fused to the sacrum posteriorly and to each other anteriorly at the pubic symphysis. Each innominate bone is composed of the ilium, ischium and pubis, which are connected by cartilage in youth but fused in the adult (Figure 1.1). The pelvis has two basins: the major (or greater) pelvis and the minor (or lesser) pelvis. The abdominal viscera occupy the major pelvis and the minor pelvis is the narrower continuation of the major pelvis. Inferiorly, the pelvic outlet is closed by the pelvic floor.

The female pelvis has a wider diameter and a more circular shape than that of the male. The wider inlet facilitates engagement of the fetal head and parturition. Numerous projections and contours provide attachment sites for ligaments, muscles and fascial layers. This distinctive shape of the human pelvis is probably not only the result of an adaptation to a bipedal gait, but also a result of the need for a larger birth canal for a human fetus with a large brain [2].

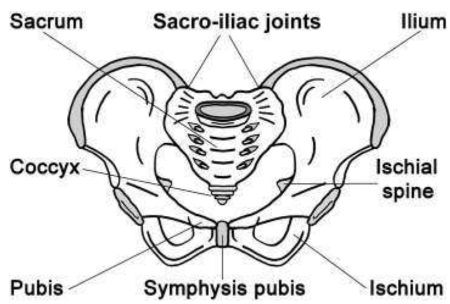

Figure 1.1 Bony female pelvis.

The female pelvis is tilted forwards relative to the spine and described as the deviation of the pelvic inlet from the horizontal in the sagittal plane. The pelvic 'tilt' or angle of inclination is measured as an angle between the line from the top of the sacrum to the top of the pubis, and a horizontal line in a standing radiograph (Figure 1.2).

The pelvic tilt is variable between different individuals and between different races; in adult Caucasian females the pelvis is usually about 55° to the horizontal plane. It is also position-dependent and increases with growth into adulthood [3].

Based on the characteristic of the pelvic inlet, it is classified into four basic shapes: the round (gynaecoid), the wedge-shaped (android), the longitudinal oval (anthropoid) and the transverse oval (platypelloid) type of inlet (Figure 1.3). However, a large

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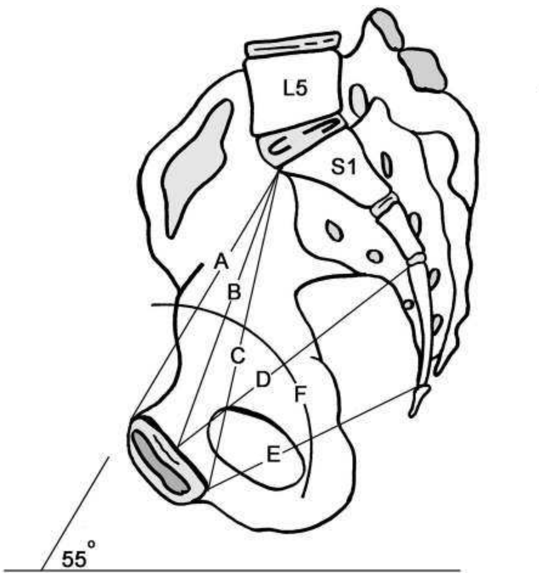

Figure 1.2 Sagittal section of the pelvis with 55° inclination. A: anatomical conjugate, B: obstetric conjugate; C: diagonal conjugate; D: mid-cavity; E: outlet; F: pelvic axis.

number of pelves appear to conform to intermediate shapes between these extreme types [4].

The true pelvis is a bony canal, through which the fetus must pass, and has three parts: the inlet, the pelvic cavity and the outlet. The pelvic inlet is bounded anteriorly by the pubic crest and spine; posteriorly by the promontory of the sacrum and ala; and laterally by the ilio pectineal line. In an adequately sized pelvis the inlet's diameter antero-posteriorly is usually more than 12 cm, and the transverse diameter is 13.5 cm.

The antero-posterior diameter of the pelvic *inlet* is also known as the true or anatomical conjugate. However, clinically the fetus must pass through the obstetric conjugate, which is the line between the promontory of the sacrum and the innermost part of the symphysis pubis, which is usually more than 10 cm. The conjugate that can be measured clinically is the diagonal conjugate, which is the line between the sacral promontory and the lowermost point of the symphysis pubis. This is about 1.5–2 cm greater than the obstetric conjugate (Figure 1.2).

The *mid-cavity* is a curved canal with a straight and shallow anterior wall which is the pubis. The posterior wall is bounded by the deep and concave sacrum and laterally by the ischium and part of the ilium. In the mid-cavity both antero-posterior (AP) and transverse diameters are usually approximately 12.5 cm.

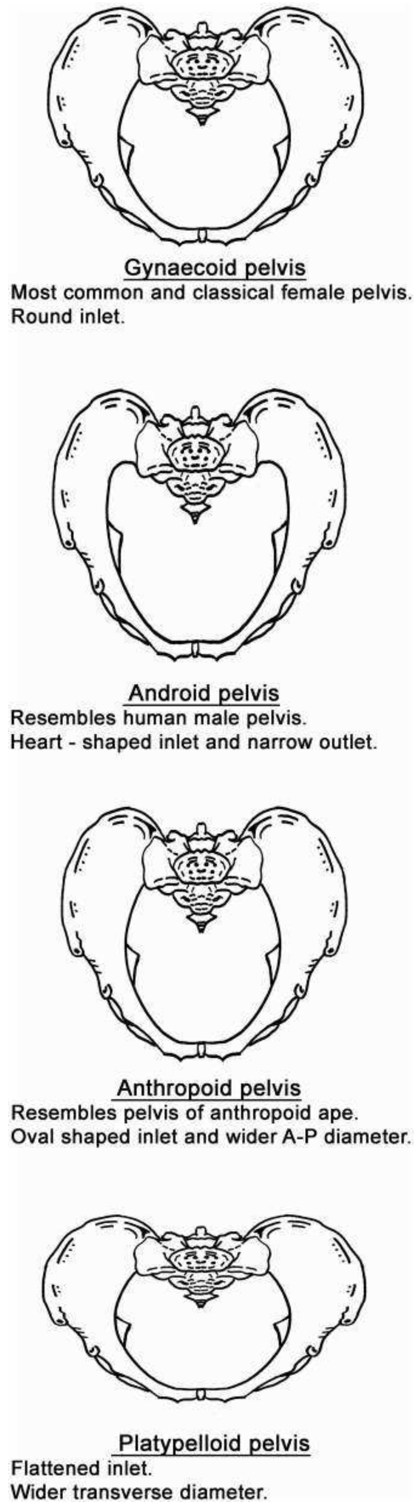

Figure 1.3 Four basic shapes of pelvis.

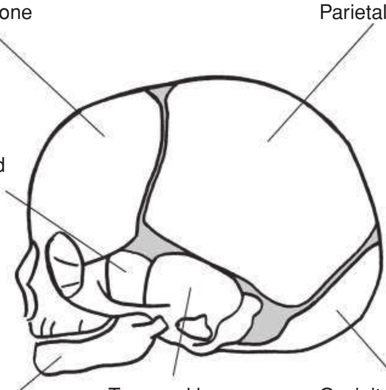

Figure 1.4 Fetal skull bones.

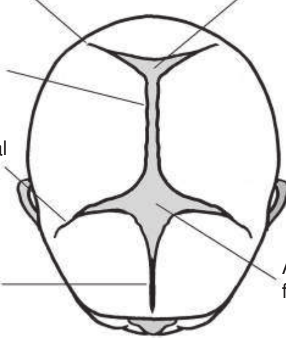

Figure 1.5 Sutures and fontanelles of the fetal skull.

The pelvic *outlet* is the lower circumference of the lesser pelvis. It is very irregular and bounded by the pubic arch anteriorly, ischial tuberosities laterally and sacrotuberous ligament and the tip of the coccyx posteriorly.

In order to have a successful delivery the fetus has to pass through this bony canal; the axis through which the fetus travels is an imaginary line joining the centre points of the planes of the inlet, cavity and outlet.

Anatomy of the Fetal Skull

The human fetal skull is considered to be the largest compared to the pelvic size of all other living primates and the most difficult part of the fetus to pass through the mother's pelvic canal, due to its hard, bony nature [5].

The skull bones encase and protect the brain, which is very delicate and subjected to pressure when the fetal head passes down the birth canal. The fetal cranium is composed of nine bones (occipital, two parietal, two frontal, two temporal, sphenoid and ethmoid). Of these, the bones that compose the skull are of clinical importance during birth (Figure 1.4).

The fetal skull bones are as follows:

1. The *frontal bone*, which forms the forehead. In the fetus, the frontal bone is in two halves which fuse (join) into a single bone after the age of eight years.
2. The two *parietal bones*, which lie on either side of the skull and occupy most of the skull.
3. The *occipital bone*, which forms the back of the skull and part of its base. It joins with the cervical vertebrae.
4. The two *temporal bones*, one on each side of the head, closest to the ear.

Sutures are joints between these bones of the skull. The *lambdoid suture* forms the junction between the occipital and the parietal bones; the *sagittal suture* joins the two parietal bones together; the *coronal suture* joins the frontal bones to the two parietal bones; and the *frontal suture* joins the two frontal bones together.

A fontanelle is the space created by the joining of two or more sutures. It is covered by thick membranes and the skin on the fetal head, protecting the brain underneath. The anterior fontanelle (also known as the bregma) is a diamond-shaped space towards the front of the fetal head, at the junction of the sagittal, coronal and frontal sutures. The posterior fontanelle (or lambda) has a triangular shape, and is found towards the back of the fetal skull. It is formed by the junction of the lambdoid and sagittal sutures.

In the fetus they permit their movement and overlap during labour under the pressure on the fetal head as it passes down the birth canal. This process, called *moulding*, can decrease the diameters of the fetal skull. The suboccipito-bregmatic diameter is more sensitive to the changes of labour force than other fetal skull diameters [6]. Significant moulding with caput can be a sign of cephalo-pelvic disproportion and this should be ruled out before attempting an instrumental vaginal delivery [7]. During early childhood, these sutures

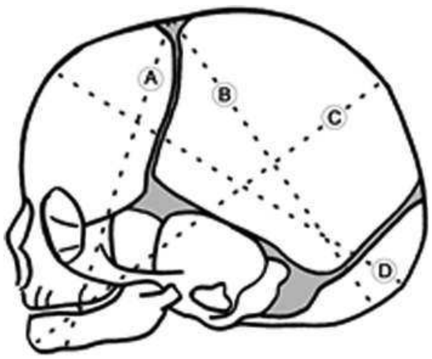

Figure 1.6 Fetal skull diameters. A: submento-bregmatic (9.5 cm); B: suboccipito-bregmatic (9.5 cm); C: mento-vertical (13.5 cm); D: occipito-frontal (11.5 cm).

harden and the skull bones can no longer move relative to one another, as they can to a small extent in the fetus and newborn.

The widest transverse diameter of the fetal skull is the biparietal diameter, which is 9.5 cm. The AP diameter of the fetal head is determined by the degree of flexion of the fetal head. This also determines which region of the fetal skull is presenting during labour, and it is described as lines that correspond to the diameter of the presenting region of the head (Figure 1.6). The suboccipito-bregmatic (fully flexed vertex) and the submento-bregmatic (face) are the narrowest AP diameters at 9.5 cm each. The widest AP diameter is 13.5 cm, and is with the fully extended head which is the mento-vertical of a brow presentation. The occipito-frontal (11.5 cm) diameter is seen with deflexed vertex presentation.

Identification of these regions and landmarks on the top of the fetal skull has particular importance for obstetric care when vaginal assessments are made during labour.

The Uterus During Pregnancy

After conception, the uterus provides a nutritive and safe environment for the embryo to develop as a fetus until delivery. The uterus undergoes extensive adaptations mainly with regards to size, shape, position, vasculature and its ability to contract.

Uterine Size

In an uncomplicated pregnancy by term, approximately the weight of the uterus increases 20-fold (from 70 g to 1000 g) and the volume by 500-fold (10 cc to 5000 cc). This increase of capacity can be expected to accommodate the fetus, placenta and amniotic fluid.

Early in gestation, uterine hypertrophy probably is stimulated by the action of mainly estrogen and also of progesterone. Later in pregnancy hypertrophy of cells of the uterus is due to response to the biological mechanical stretching of uterine walls by the growing fetus and placenta [8]. In this process of hypertrophy, stretching of muscle cells along with accumulation of fibrous and elastic tissue plays a major role, and the production of new myocytes is limited.

Uterine Shape and Position

From its original pear shape, the uterus assumes a globular shape as the pregnancy advances. It becomes palpable abdominally by 12 weeks as it is too large to remain totally within the pelvis. From this point onwards it can be measured and palpated as it is in contact with the anterior abdominal wall (Figure 1.7). By term it almost reaches the liver and this exponential enlargement of the uterus displaces the bowels laterally and superiorly. In supine position it rests on the vertebral column and the adjacent great vessels, especially the inferior vena cava and aorta. It also undergoes *dextrorotation*, which is likely caused by the recto-sigmoid

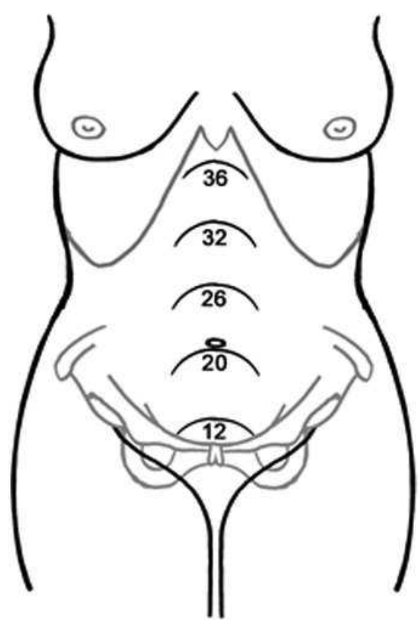

Figure 1.7 Height of the uterus at various weeks of pregnancy.

colon on the left side of the pelvis. As the uterus rises, tension is exerted on the broad and round ligaments.

Uterine Vascular Adaptations

The regulation of uterine vascular remodelling during pregnancy is part of the larger set of adaptive physiological processes required for a successful pregnancy outcome.

A multitude of physiological adaptations of the cardiovascular system takes place during pregnancy; the most notable changes are the increase in intravascular volume and cardiac output. Cardiac output increases from 3.5 to 6.0 l/min at rest, a rise of close to 40%. These changes begin as early as the first trimester of pregnancy.

The greatest changes, however, are those occurring in the uteroplacental circulation.

Haemochorial placentation in humans results in decreased downstream resistance and secretion of molecular signals. The former results in increased upstream flow velocity and initiates nitric oxide (NO) secretion as well as other effects that lead to changes in cell and matrix properties. The combination of vasodilation, changes in matrix enzymes and cellular architecture leads to an increase in lumen diameter without any change in wall thickness, decreased resistance and increased uteroplacental flow [9]. As a result, an even greater fall in vascular resistance preferentially directs some 20% of total cardiac output to this vascular bed by term, amounting to a 10-fold or greater increase over levels present in the non-pregnant state, such that, by term, uteroplacental flow may approach 1 l/min [10].

Uterine Contractility

Adaptations of human myometrium during pregnancy include cellular mechanisms that preclude the development of high levels of myosin light chain phosphorylation during contraction and an increase in the stress-generating capacity for any given level of myosin light chain phosphorylation. This process is said to be mediated through Ca^{2+} [11]. From the first trimester onward, the uterus undergoes irregular painless contraction that becomes manually detectable during the mid-trimester. These contractions vary in intensity and timing and are called *Braxton Hicks contractions* [12]. Gradually they increase in intensity and frequency during the last week or two and may cause some discomfort late in pregnancy.

Length of Pregnancy and Initiation of Labour

Length of Pregnancy

Length of pregnancy in humans averages 40 weeks. Little is known about the factors determining length of pregnancy, but it has been thought to be controlled by events occurring in late pregnancy that influence timing of parturition. Thus, preterm birth is a consequence of premature activation of parturition by a pathological process. In humans, timing of birth is associated with expression of the gene responsible for corticotrophin-releasing hormone (CRH) by the placenta. Maternal plasma concentration of CRH is a potential marker of this process. It has been postulated that a placental clock determines the timing of delivery [13].

Initiation of Labour

During pregnancy, the uterus is maintained in a state of functional quiescence through the integrated action of one or more of a series of inhibitors. Cervical ripening and myometrial contraction are main contributing factors for the initiation of labour, and they start a few weeks before the true labour. It is considered that there is an interaction between maternal and fetal factors that initiate labour in humans. Maternal endocrine and genetic factors and the influence of fetal factors play an important role.

Maternal Endocrine and Genetic Influence

The functional quiescence during pregnancy is maintained by the integrated action of one or more of a series of inhibitors, including progesterone, prostacyclin, relaxin, nitric oxide, parathyroid hormone-related peptide, calcitonin gene-related peptide, adrenomedullin and vasoactive intestinal peptide.

Change in the oestrogen:progesterone ratio, CRH, prostaglandins, oxytocin and contraction-associated proteins are some of the other factors that influence onset of labour [14]. Also it is noted that women who carried polymorphic tumour necrosis factor (*TNF* α-*308*) gene have a tendency to deliver preterm [15].

Fetal Influence

Initiation of labour at term or even preterm is also influenced by signals from the fetus. Its growth, resulting in uterine stretch, increased surfactant protein-A

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