Principles and Practice of

OBSTETRIC ANAESTHESIA

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Published simultaneously in the United States of America by Charles C Thomas, Publisher, 301-327 *East Lawrence Avenue, Springfield, Illinois.*

Published simultaneously in Canada by The Ryerson Press, Queen Street West, Toronto 2.

First printed 1959

PRINTED IN GREAT BRITAIN FOR BLACKWELL SCIENTIFIC PUBLICATIONS LTD.
BY BILLING AND SONS LIMITED, GUILDFORD AND LONDON
AND BOUND AT THE KEMP HALL BINDERY

To my Mother and Father
with Gratitude
for their Understanding and Sacrifice

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INTRODUCTION

THE adding of a new title to the catalogue of medical works is a responsibility which may be justifiably undertaken on one of only two counts: if the aim is to fill a gap in the literature, or if the author feels capable of presenting in a more palatable manner, facts and ideas which have already reached the library shelves. In the present case the plea is based on the former indication.

At the time of writing, no British textbook of obstetric anaesthesia remains in print. Although the subject is dealt with in textbooks of both obstetrics and anaesthetics, discussion necessarily tends to be somewhat cursory. It is axiomatic that sound practice stems from knowledge wedded to experience, and an attempt has been made here to gather together the facts, and many of the theories, which must be understood by an anaesthetist before he can intelligently apply himself to the management of an obstetric patient. The days of empiricism in anaesthesia for general surgery are fast passing, for obstetric anaesthesia they still flourish. The pages which follow reveal that we remain ignorant of many aspects of the subject, notably regarding the problems of placental transmission and of neonatal respiration. However, there is much known which is immediately applicable to sound obstetric anaesthetic procedure, and it is surely time that the principles were put into more general use.

Repeatedly throughout this decade the pages of the *Lancet* and the *British Medical Journal* have revealed that there is considerable disquiet regarding our standards of anaesthesia for obstetrics. The criticisms may be resolved into two categories, the one concerned with method and the other with service. The primary aim of this book is to present an evaluation of the range of methods of anaesthesia and analgesia, with reference to physiological and pharmacological processes. Some mention must also be made, however, of the deficiencies in our anaesthesia service.

Despite the fact that we have a large, and still growing, population of anaesthetists, whose work is confined almost entirely to hospital practice, in recent years obstetric needs have been met by an increase in neither quantity nor quality of attention. Obstetric anaesthesia remains the

Cinderella of the speciality in most hospitals—including those of considerable repute—and all too frequently anaesthesia for forceps delivery is left in the hands of the junior resident, unsupervised, and with only the smatterings of experience in the general theatre. That most obstetric operations are emergencies, occurring at awkward hours, is the basic cause of this administrative failure, but it is also the very reason why increased skill and attention are called for in these cases.

The national maternal and infant mortality rates have been falling in a gratifying manner during the past twenty years. These declines have resulted from improvement in many lines of therapy, notably in the combating of sepsis and of shock, but not from improvement in standards of anaesthesia. The latter is now, by contrast, becoming a prominent cause of maternal mortality and must thus be indicted as a major factor in infant mortality and morbidity. In 1955 there were 667,811 live births, 439 maternal deaths, and a maternal mortality rate of 0·66 per 1,000 in England and Wales.[1] Of the maternal deaths, 251 were associated with complications of pregnancy (excluding urinary tract infection and ectopic pregnancy) or with delivery (Brews p. 713).[2] One hundred and twenty of these were associated with actual delivery, and failure of complete anaesthetic management must have played a significant part in many of these tragedies. The Report just quoted indicated that in the three-year period 1952-54 in England and Wales, 49 maternal deaths were directly attributable to complications of anaesthesia, and in another 20 cases anaesthesia was a contributing factor. To this total of 69 must be added an unspecified number in which the anaesthetist was at fault in his rôle as resuscitator. Comparable figures will certainly apply to the whole of the United Kingdom.

Dinnick[3] has shown that in England and Wales in 1954, general anaesthesia was administered for 67,600 of the 432,000 deliveries occurring in hospitals and regional methods were used in a further 19,000 cases. When considered in relation to the round total of two million anaesthetics (excluding 'dental gases')[4] administered annually in the United Kingdom, these figures speak for themselves. If we relegate to a position of neglect one patient out of every twenty-five requiring anaesthesia, we are failing in our professional duty. This is the very least of the matter, for no mention has been made of the 900,000 deliveries occurring each year in the United Kingdom, during the course of which techniques and drugs of direct concern to the anaesthetist are regularly used. The negligence of British anaesthetists in this regard ill-becomes the country in which was first demonstrated a rationally controlled method for the relief of pain in childbirth.

Anaesthetists must also bear considerable responsibility for the current failure to reduce the perinatal mortality and morbidity rates, but the analysis of the factors concerned is difficult.

The United States has similar problems. In 1955 the maternal mortality was 0·47 per 1,000 live births, with a total of about four million deliveries.[5] Referring to a somewhat earlier period (1944-53), Matson and Jacoby[6] have indicated that surveys reveal 3-10 per cent of the deaths to be the result of anaesthesia. In response to this situation, leading American anaesthetists, notably Hingson[5] and Apgar,[7] have urged a 24-hour anaesthetic service for obstetrics, combined with a closer collaboration between anaesthetists, obstetricians, and paediatricians in both routine work and in the investigation of the problems involved. That such proposals can be advanced for immediate adoption in a country which still suffers from a serious shortage of anaesthetists, delineates even more sharply the poverty of our own efforts.

Obstetric anaesthesia and analgesia cannot be satisfactorily undertaken merely by transposing to the labour ward the methods learned in the general operating theatre. Further specialized knowledge and techniques are needed.

The welfare of the child, also, is a direct responsibility of the obstetric anaesthetist. By virtue of his special training, the anaesthetist has a unique contribution to make towards the problems of ensuring an adequate oxygen supply for the foetus, of avoiding centrally-induced neonatal depression, of resuscitating the newborn, and of preventing or treating regressing pulmonary efficiency in the newborn. As in the case of maternal morbidity, these problems become of increasing concern as the previous major causes of perinatal death are reduced in importance. On a national scale, anaesthetists are not yet facing their responsibilities in this field. The problems, in terms of both research and of day-to-day application, can be attacked satisfactorily only by the concerted action of obstetricians, paediatricians, and anaesthetists (physiologists and other laboratory workers have, of course, a great part to play in the special centres), each of whom is willing to work under the direction of the others, depending upon the shifting requirements of the situation.

This is no place in which to discuss the larger questions involved in an expansion of the anaesthetic service fully to meet these requirements. It might be suggested, however, that the urgent demands of obstetrics are likely to be met to a greater extent by a reorganization than by a reinforcement of each anaesthetic department.

The common function of an Introduction is to survey the environment —both historical and contemporary—of the subject to be dissected in the

body of the book. In this respect it is felt that two further matters must be presented, one a warning and the other a tribute.

Most hospital practitioners regularly consult the leading journals concerned with their speciality and published in other lands. In the English-speaking communities, reading is probably confined to the journals from the Commonwealth, the United States and Scandinavia. Interpretation of the views expressed, and of the results reported, in these articles must to some extent be based upon an appreciation of the medico-social background of the community under investigation. In the field with which this book is concerned, the point assumes great importance when attention is directed to the literature of the United States and Canada. Readers on the eastern shores of the Atlantic would do well to bear in mind the following facts:

The midwife system is virtually non-existent in North America, almost all deliveries being conducted by the attending physician or obstetrician (in the U.S.A. 85 per cent of the total occur in hospitals). Outside of the renowned institutions, this not infrequently leads to a call to delay the progress of delivery in order that the accoucheur may reach his patient in time.[8, 9] The vast majority of deliveries are instrumental, the practice being founded upon well-engrained views on saving the perineum and avoiding prolonged pressure on the foetal head. Consequently, the very large numbers of forceps deliveries often quoted are, in effect, biased by the inclusion of many cases of normal women undergoing normal pregnancies and having normal infants. In North America, active participation by the mother in her labour is not generally observed, and there is a vociferous demand for the obliteration of all awareness of the birth process, for sedation and for, if possible, amnesia. Hingson's introduction of the régime of continuous caudal analgesia has to some extent offset the latter two requirements.

It is important that these factors be borne in mind whenever articles from Canada or the U.S.A. are consulted, just as it is necessary for North American readers to appreciate the working conditions in Britain and Scandinavia when assessing the results published in these countries.

As was said earlier, this book was conceived mainly because there appeared to be a need to collect and to analyse the plethora of pronouncements and observations on the subjects of obstetric analgesia and anaesthesia, and of neonatal resuscitation. Inevitably, therefore, it is founded upon the work of many people who have been prominent in this field during the past century. A very personal call is felt to pay tribute to the following inspiring workers: Sir James Young Simpson; John Snow; Carl Gauss; Sir James Barcroft; R. J. Minnitt; Stewart H. Clifford;

Bert B. Hershenson; Robert A. Hingson; Clement A. Smith; Virginia Apgar; E. H. Seward; Hilda Roberts; Ian Donald; and R. Bryce-Smith. It is largely due to the initiative of these men and women that ease of pain in childbirth has been, and continues to be, rendered more efficient and more safe for both mother and child.

Finally my thanks go to Miss Marjorie Kuck, M.R.C.O.G., in Toronto, and to Dr. R. E. Molloy, F.F.A., R.C.S., now returned to London from Pittsburgh, for reading the draft text with the aim of discovering any gross errors of fact in obstetric and anaesthetic matters. They are not to be held responsible for any of the opinions, assessments, or recommendations expressed.

J.S.C.

September, 1958.

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CHAPTER I

THE MOTHER

EVERY anaesthetist is a doctor. It is to be expected, therefore, that obstetric anaesthetics will be administered always by practitioners having some knowledge of the significant changes accompanying pregnancy. Furthermore, the anaesthetist will be aware of the general mechanics and physiology of labour and of how these might vary. It is only by weaving his specialized skill into the framework of this basic knowledge that he is able to offer maximum aid to both the patient and the obstetrician.

As in all medicine, co-operation is the key-word. The anaesthetist must be able to anticipate the difficulties which the obstetrician might encounter during delivery, and must be prepared to allow him the best operating conditions compatible with the safety of his two patients. Reciprocity is, of course, implicit in co-operation. A good obstetrician appreciates the limitations of anaesthesia, and the dangers which it presents to mother and child. In addition, in any good team, each doctor will know the individual adequacies of the other, and will modify his technique accordingly.

In the years of his training and—in the case of the occasional obstetric anaesthetist—during the long summer of his consultancy, recollections of his undergraduate tuition in obstetrics will fade in the mind of the anaesthetist. This chapter is an attempt to present a *résumé* of the important anatomical and physiological considerations of pregnancy and labour relative to the practice of anaesthesia. In emphasis and approach it is a considerable distortion of the obstetric viewpoint; this is natural enough, as obstetrician and anaesthetist contemplate the patient from opposite poles.

Normal Pregnancy and Labour

1. VARIATIONS IN BLOOD AND BODY FLUID

Water retention is a normal concomitant of pregnancy. There is general retention throughout the tissues, but the proportions held in the intra- and extra-vascular compartments vary in each trimester. The extra-vascular fluid increases gradually during the first six months, and

the gain is notably accelerated during the course of the third trimester, reversal of the process being initiated only after delivery. The intravascular water retention increases only slightly during the first trimester, the gradient steepens thereafter until just before the onset of labour, when there is a sharp and significant fall.

Salt retention closely accompanies water retention throughout pregnancy. Both processes are probably related to the secretion of steroids by the placenta. In the post-partum period following a normal pregnancy, on the average about 5 gm. sodium is 'shed' by the mother.

The other components of the blood also follow a pattern of volumetric change during pregnancy. Total blood volume decreases during the first two months, and thereafter rises gradually until the time of delivery. Plasma volume increases steadily throughout pregnancy until just before the onset of labour, when there is a significant fall. Red cell volume, after an initial fall during the first two months, rises with the progress of pregnancy until the time of delivery. However, the increasing hypervolaemia outstrips the rise in red cell volume and haemoglobin mass, leading to haemodilution and an apparent anaemia as term approaches. A red cell count of 3·75 million per c.cm., a haemoglobin of 11–12 gm. per cent, and a haematocrit of 35 per cent have been suggested as the lower levels of normal at term. Because of foetal demands made upon the maternal iron supplies, there is always a tendency for a true anaemia to develop. It is almost always necessary to supplement a normal good diet with iron throughout pregnancy, in order to build a store with which the heavy demands of the final trimester may be met. It is the duty of the anaesthetist, in co-operation with the obstetrician, to watch for anaemia and to treat it should it occur in a patient under his care. It is generally accepted that the maternal blood loss during a normal delivery might reach 500–600 ml.

The platelets, which remain fairly constant in concentration during pregnancy, increase abruptly in number during the late stages of labour. There is in addition a total increase and a relative increase in the fibrinogen content of the plasma, the total amount being 40 per cent greater than normal—despite a diminution of plasma protein concentration, there is actually a gain of about 18 per cent in the total circulating mass near term. Although these two factors are important in curbing haemorrhage, they might also lead to an increased liability to thrombo-embolic phenomena during the puerperium, and should spur the anaesthetist to increased care in the matters of foot-stirrups, leg-rests and general positioning of the patient.

2. Cardiovascular Changes

The dynamics of the circulation undergo important changes during pregnancy. The size of the heart increases slightly, but only in proportion to the general weight gain. Its position changes as might be deduced from the mechanics of a rapidly growing tumour causing upward displacement of the diaphragm. Cardiac output is increased considerably during the middle trimester, and thereafter gradually falls, reaching a rate a little above normal just before term. During the first stage of labour, cardiac output rises again, increasing markedly when strong uterine contractions occur. At no time, however, is the myocardial reserve of the pregnant woman without heart disease demonstrably depleted.

During pregnancy the resting pulse-rate increases on the average by 12-20 beats per minute. Various changes of rhythm in otherwise normal hearts have been observed: they invariably disappear following delivery, and are probably of no significance.

Systolic blood pressure is unchanged by normal pregnancy. The diastolic pressure falls slightly during the greater part of the gestation period, with a resultant increase in pulse pressure, but it returns to the pre-pregnancy level during the final month.

As would be expected, uterine blood flow increased vastly with the progress of pregnancy. It has been computed that, towards term, blood reaches the uterus at the rate of 500 ml. per minute.[1] Due to the demands of the foetus, oxygen consumption is extremely high (see Chapter II). Furthermore, there are during labour greatly significant changes in the continuity of uterine blood flow. It has been shown that, in the course of a normal contraction, the pressure within the uterine muscle rises to about 50 mm. Hg. As the venous pressure is only about 4 mm. Hg, there is a temporary interference with the venous return from the uterus, and consequently, by retrograde resistance, with the arterial supply. It has been suggested that this period of relative ischaemia during each contraction is compensated for by a local hyperaemia—induced by the accumulated metabolites—whilst the uterine muscle is at rest. The changes in uterine blood flow are said to be accompanied by similar variations in placental blood flow, leading to a tidal variation in the amount of oxygen available to the foetus. The second of these propositions has not yet been satisfactorily demonstrated, and it is interesting to speculate upon the significance of the large blood-filled intervillous spaces in this respect. Possibly, in normal labour, the intervillous blood acts as a reservoir from which the foetus can draw an adequate amount of oxygen during a

contraction. The subject will be further discussed in this and subsequent chapters.

Although the general venous pressure remains relatively unchanged, the increasing size of the gravid uterus leads to a gradual rise in the femoral venous pressure, continuing through the second and third trimesters. At term the pressure reaches about 18 mm. Hg, compared with the normal 6 mm. Hg. It should be noted that when the patient is supine, as in operative obstetrics, the inferior vena cava—which receives the uterine venous outflow—is directly subject to these pressure changes.

3. Alterations in the Mechanics of Respiration

Despite the encroachment of the diaphragm into the thoracic cavity, pulmonary ventilation is actually increased during pregnancy. This increase is initiated in the first trimester, and continues gradually throughout pregnancy. It is a result of a rise in both respiratory rate and tidal volume. The rate is increased to the point of dyspnoea in about 60 per cent of women during the final trimester. Broadening of the chest and a change from abdominal to thoracic breathing contribute to the physiological compensation for a decreased thoracic height, and the tidal volume increases by an average of about 25 per cent during the months from early pregnancy to term. Vital capacity and inspiratory reserve remain unchanged, and thus the expiratory reserve is inevitably decreased.

The respiratory mucosa exhibits a generalized hyperaemia due to capillary engorgement. This is to be accepted as increasing, however slightly, the hazard of intubation, especially if the nasal route is used. It also tends to increase the discomfort of the dyspnoea of late pregnancy—an increase which is emphasized in the presence of even minor upper respiratory infection. These points are of some importance in regard to the application of a face-mask, as nose-breathing becomes extremely difficult for some women at term.

4. Biochemical Changes

As pregnancy advances, both the oxygen and the carbon dioxide dissociation curves of the mother's blood are shifted slightly to the right. This means that during late pregnancy, in a low oxygen-tension environment, oxygen is more readily released and carbon dioxide more readily taken up by the blood than is the case in the non-pregnant state. Oxygen consumption is increased, having by term risen to a level about 10 per cent higher than that obtaining prior to pregnancy. Carbon dioxide tension

and carbon dioxide content are both diminished. The carbon dioxide combining power of the blood decreases from the normal of about 52 volumes per cent to approximately 45 volumes per cent. This reduction in alkali reserve is accompanied by a reduction in total buffer base. It does not, however, represent a true acidosis. The serum *p*H remains constant. The condition is apparently one of compensated carbon dioxide deficit, a deficit resulting from the increased pulmonary ventilation referred to above. These factors are of considerable importance in the understanding of questions concerning neonatal respiration.

In relation to the foregoing, it is as well to remember that during normal pregnancy the basal metabolic rate rises gradually, and that at term it might be more than 10 per cent above that obtaining in the non-pregnant state. In addition, there is an increased fat absorption and a rise in plasma fats concentration. Ketosis is not a normal accompaniment of pregnancy, but these two shifts, together with the fall in alkali-reserve, make the pregnant woman increasingly liable to drift into a ketotic state.

Glycosuria, persistent or intermittent, is a not unusual feature of many pregnancies. It is related to a lowered renal threshold, and to a decreased ability on the part of the liver to store glycogen.

Non-protein nitrogen and blood urea levels are significantly reduced during normal pregnancy.

5. Digestive Disturbance

The only disturbance of digestion which is of interest to the anaesthetist occurs during labour. It has long been held that there is a considerable reduction in the rate of emptying of the stomach during labour. This tenet is based almost entirely on clinical impression, and is said to hold for both fluid and solid stomach-contents. Radiographic investigation[2] has tended to throw some doubt on the correctness of the view as far as fluid contents are concerned, but it would still serve the anaesthetist well not to take chances in this respect.

6. Renal Tract

Of some importance to the anaesthetist is the fact that during pregnancy a slight degree of hydroureter and hydronephrosis develop—especially on the right side. This effect tends to be accentuated during labour, due to mechanical factors, and can be a prominent cause of pain early in labour. The pain is referred to the tenth and eleventh thoracic segments. If, as in protracted labour, this process of damming back the flow of urine

is prolonged, the use of drugs which are excreted unchanged by the kidney must be limited.

7. Mechanics and Pain Labour

Towards the end of a normal pregnancy the uterus is an extra-pelvic structure. The onset of labour may be heralded by the phenomenon of 'lightening', in which the presenting part descends into the pelvis. Prior to this, although the well-known contractions of Braxton-Hicks occur with considerable frequency, there is no pain of any significance associated with normal pregnancy.

The nerve-pathways involved in labour are now well-recognized, their final identification being based largely on the results of Cleland's[3] original work. The propulsive efforts of the uterus, contributed largely by the longitudinal muscle fibres of the corpus and fundus, are initiated by stimuli travelling via sympathetic fibres whose central origins lie above the level of the sixth thoracic segment. The oncoming foetus is accommodated by active dilatation of the lower segment of the uterus, that is, by the circular fibres of the lower third of the corpus uteri and those of the cervix. The motor pathways by which this is effected are contained in the parasympathetic outflow from S2, 3, and 4. In addition to the neural element, there is a hormonal factor of possibly equal importance in the control of myometrial activity. It is understood that a pituitary derivative, closely related to pitocin, plays an important part in the initiation of uterine contraction.

The sensory nerve supply is best described in conjunction with an account of the course of labour. The initial contractions are felt as a tightening in the lower abdomen and the lower part of the back.[4] Such sensations are not to be construed as evidence of true labour unless each is accompanied by a palpable uterine contraction. The lower abdominal discomfort is reflexly produced by stimuli arising in the body of the uterus. Afferent nerves from the latter pass via various plexuses of intervening fibres to their cell stations in the eleventh and twelfth thoracic ganglia of each sympathetic chain. From these the associated white rami communicantes travel with the appropriate dorsal nerve root to synapse in the eleventh and twelfth thoracic segments of the spinal cord. In accordance with the general findings regarding visceral sensation, pain is therefore referred to the areas supplied by the somatic afferent nerves arising from these segments. Under some circumstances the first lumbar segment might also become involved.

The low backache component of early labour is associated with the start of cervical dilatation. Stimuli from the cervix are transmitted via

the second, third, and fourth sacral components of the parasympathetic system. Sensation is appreciated as coming from the sites of distribution of the appropriate somatic afferent fibres.

As labour progresses, contractions assume a greater regularity, and increase in strength and frequency. Pain is likely to supercede discomfort when the degree of cervical dilatation has reached about two fingers in the primipara and about three fingers in the multipara. From this time, and until the end of the first stage of labour, each contraction is characteristically accompanied by a waxing-peak-waning pattern of pain. The waxing and waning components take the form of a dull ache—respectively increasingly and decreasingly severe—felt in the lower abdomen, the low back area, and the front and inner aspects of the upper thighs: in effect, over the area of distribution of T11, T12, L1, S2, S3, and S4. At the peak period there is in addition a severe griping pain which is usually referred to the areas supplied by T11 and T12. When the foetal lie is occipito-posterior, the most severe pain in the first stage is nearly always felt in the back; often, under such circumstances, backache persists even between contractions.

Classically, contractions during the latter-half of the first stage of labour occur about every 3-5 minutes and last for about 1 minute. Pain or discomfort is felt during approximately the last 40 seconds of each contraction, and thus there is about a 20-second warning period. The remembrance of this fact is of great importance in the successful conduction of inhalational analgesia.

At the end of the first stage the mother becomes a much more active participant in her labour. In many cases this change from the era of passivity quickens the interest of the patient, and in so doing helps to diminish her appreciation of the pain involved. At the same time, both the character and the source of pain are somewhat changed. Contractions occur more frequently, and give only about 5 seconds warning of the start of pain. Hence, to provide adequate inhalation analgesia, reliance must be placed upon the regularity with which the contractions occur.[4] Although the pain of uterine propulsion—transmitted via T11 and T12—persists, that due to dilatation of the lower segment is, of course, ended. In place of the latter, stimuli arise from the pelvic floor area, upon which the head descends with some force following full dilatation of the cervix. The afferent fibres here concerned likewise have their central connections situated in the second, third, and fourth sacral segments, but are somatic rather than parasympathetic. Stimulation of the pelvic floor leads reflexly to an increase in the strength of uterine contractions; it also provokes the mother into making voluntary bearing-down efforts. The latter