UTERINE ACTIVITY IN LABOUR

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Declaration:

This thesis is based on original work initiated and performed by me. The manuscript is entirely my own work.

THIS THESIS IS DEDICATED TO ALL PREGNANT MOTHERS
IN LABOUR WHO CONSENTED AND PARTICIPATED
IN THE STUDIES DESCRIBED IN THE THESIS

Hypothesis tested

Routine use of internal tocography and quantification of uterine activity by active contraction area measurements results in better obstetric outcome in labour compared with external tocography.

1. shortens duration of induced and augmented labour.
2. lowers dose of oxytocin infusion needed.
3. reduces caesarean sections and operative vaginal deliveries.
4. provides a rational basis to allow trial of labour in women with previous caesarean scar.
5. reduces neonates in poor condition at birth due to difficult labour.

TABLE OF CONTENTS

TABLE OF CONTENTS PAGE NO

TABLE OF CONTENTS

PAGE NO

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LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

Summary

Internal tocography and quantification of uterine activity by active contraction area measurements is of no value in spontaneous normal labour. In augmented labour, internal tocography was associated with no improvement in duration of labour, dose of oxytocin, incidence of operative deliveries or neonates in poor condition at birth compared with external tocography. Whether internal tocography offers any advantage over external tocography in difficult cases of augmentation, ie. those who do not show satisfactory progress of labour in the first few hours of augmentation needs further study. Obstetric outcome was not improved with the use of internal tocography and quantification of uterine activity in induced labour. The knowledge of total uterine activity (TUA) computed with internal tocography may be of value in selected cases where fetal heart rate changes are observed with high uterine activity or in those who fail to progress despite having achieved the total uterine activity according to parity and cervical score. However the cases that are likely to benefit from such an exercise may be too few in number to justify routine internal tocography in induced labour. In those with previous caesarean section scar the uterine activity in augmented labour is higher than that observed in spontaneous normal labour. Those who are likely to deliver vaginally show satisfactory progress within the first few hours of augmentation. A limited period of

LIST OF FIGURES

augmentation should limit TUA and may reduce the chance of scar rupture. Internal tocography may be of value in detecting excessive uterine activity which may not be obvious with external tocography. Sudden decline in uterine activity may be the earliest sign to indicate loss of integrity of previous caesarean scar. Where difficulty arises in recording uterine contractions by external tocography as in an obese or restless patient internal tocography is of value. This thesis concludes that "routine" use of internal tocography and quantification of uterine activity compared with external tocography does not lead to better obstetric outcome in spontaneous, augmented or induced labour. There may be a limited role for selective use of internal tocography where recordings on external tocography are unsatisfactory, in cases of difficult augmentation or induction and in those with previous caesarean scar.

1 INTRODUCTION

1.1 STUDIES ON THE PREGNANT UTERUS AND ITS ACTIVITY

1.2 QUANTIFICATION OF UTERINE ACTIVITY

1.3 OBJECTIVES AND PLANNING OF THE STUDY

1.4 A CHOICE OF EQUIPMENT AND CALIBRATION

B RELIABILITY OF GAELTEC CATHETERS FOR INTRAUTERINE PRESSURE MEASUREMENTS - COMPARISON WITH A FIBREOPTIC CATHETER

C REPRODUCABILITY OF INTRAUTERINE PRESSURE MEASUREMENTS WITH GAELTEC CATHETERS

1. UTERINE ACTIVITY MEASUREMENTS IN OBSTETRICS

1.1 Studies on the pregnant uterus and its activity

The uterus is one of the essential organ in the primates for procreation. Naturally it's structure and function has intrigued many researchers in the past. It was not until the time of Hippocrates (late 5'th century BC) that some understanding of the uterus emerged from the morass of superstition and myth. However, even at this stage, since observations in animals were extrtapolated to the human, many anatomical errors were inevitable. This was especially true for the uterus which was thought to contain several cavities. The ideas of Aristotle (384 - 322 BC), the tutor of Alexander the great, formed a lasting contribution to the course of biological and medical sciences. After dissecting many animals (not man), he described some of the internal organs. These descriptions were sometimes illustrated by drawings which are said to be the first anatomical drawings, and records of these are available (Singer and Underwood 1962). The nomenclature of Aristotle's account of the uterus has remained in a modified form upto the present time. Aristotle's knowledge of physiology was much less profound than his understanding of anatomy.

In the second century, Soranus, who worked in Alexandria in Egypt, the outstanding intellectual centre of the period, wrote a treatsie in gynaecology. However, his anatomical studies too were probably made on animals (Norris

1973). Galan, whose medical ideas held sway for about 1000 years, was another whose descriptions of the human body were based on observations in animals. His views on the uterus were very similar to those of Aristotle, reiterating that the endometrium of the uterine cavity was cotyledonary.

It was not until the 13'th and early 14'th centuries that the dissection of the human body by Mondino dei Luzzi, who occupied the chair of medicine at the university of Bologna, enabled him to refute the prevalent belief that the uterus was an independent entity that would wander about in the body. Surprisingly he too adhered to the notion that the uterus contained many chambers. According to Norris (1973), Berengario de Carpi was probably the first to assert that the uterus was a single cavity thus sweeping away the multichamber concept.

Leonardo de Vinci(1452-1519), who "took all the knowledge for his province", has been called, arguably, the first comparative anatomist since Aristotle. Like Aristotle and Galan, Leonardo dissected many animals, and like many of his predecessors assumed that anatomical structures in man generally resembled those of animals. However, there were instances, as evidenced by his comparative anatomical drawings of animals, birds and man, where Leonardo realised that anatomical differences existed between animals and man. Unlike Aristotle, Leonardo, because of his artistic interests, was concerned with the structure of the body in it's relationship to it's functions (O'Malley and Saunders

1952). Despite this the knowledge of physiology was yet to develop, evidenced by the explanatory note to Leonardo's drawing of the fetus in utero which denies the presence of the fetal heart beat.

The dissection of human cadavers in Padua by Vesalius(1514-1564) confirmed Berengario's assertion of the unilocular nature of the human uterus. Vesalius gave the first detailed description of the human uterus. The term 'uterus' and 'pelvis' appeared in his great anatomical treatsie "De humani corporis fabrica septum"(1542). Vesalius was also famous for his distinguished pupils one of whom, Colombo de Cremona, introduced the terms "labia" and "vagina".

The 18'th century saw the emergence of John and William Hunter who pioneered studies on the gravid uterus, the placenta and it's circulation. By injecting coloured wax the Hunter's demonstrated for the first time that the maternal circulation and fetal vessels were not anastamosed end to end. In the 19'th and 20'th centuries further research has been carried out to elucidate the detail structure and function of the uterus.

The uterine function has been investigated in the nonpregnant state to understand the basis and to formulate therapy for birth control, to enhance fertility, to treat dysmenorrhoea and repeated pregnancy wastage. But the first uterine physiology to be investigated was the contraction

force of the pregnant uterus. Since this thesis is devoted to the uterine activity in labour, only studies related to functions of the pregnant uterus is discussed in this chapter. In 1861, Kristeller used an obstetrical forceps with a dynamometer in the handle to determine the degree of uterine expulsive force. This method had little success. Poppel(1863) and Duncan(1868) tried to judge the strength of contractions by testing the force needed to break the amniotic sac, but this was of little value for continuous assessment of uterine contractions in labour and had considerable patient to patient variability. Schatz(1872 a & b) was the pioneer to introduce a rubber bag filled with water, connected to a mercury manometer to observe intrauterine pressure and volume changes. The rubber bags were sterilised in formalin. Because of it's size it had to be inserted under nitrous oxide and chlorofom anaesthesia and hence was not practical for daily use.

Henricius(1889) worked with nonpregnant uterus, but improved Schatz's method by connecting a thin condom to the manometer by an electroplated catheter and produced the first recording of uterine contractions which was essential for continuous assessment. To avoid anaesthesia Polaillon(1880) used a small rubber air baloon inserted just inside the anterior lip of the cervix but was less successful. But he suggested a "Marey tambour" as a transducer to increase the recording speed which was later adopted by Henricius(1889). Westermark(1893) developed an electroplated catheter attached

to a 2cc baloon with an outer dimension of 3 mm which made placement easier and gave more accurate information but he did not produce continuous recordings. Because of difficulties encountered in producing reliable recordings and problems with insertion further research was in progress. Hensen(1898) increased the baloon size from 15 to 20 cc whilst Wasenius(1907) reduced the size to that used by Westermark. Bourne and Burn(1927) worked on reducing the size of the baloon and made use of a 2.5cc baloon with a diameter of 3.5 mm. The pressure differences were transmitted by water via a gum elastic catheter and rubber tubing and an ink recording obtained on a revolving drum driven by a clock work. The baloon was placed in an extraovular position 8 inches above the cervical os under sterile conditions but with the patient under anaesthesia. Allen and Reynolds (1935) and Reynolds et al. (1947) demonstrated that changes in elasticity of large baloons varied the contact between the baloon and the uterine wall, and the uterine irritability was proportional to the size of the baloon thus invalidating the assessment.

Open catheter techniques were being developed over the same time period and was tried by Wieloch in 1927. It was not popular till Alvarez and Caldeyro(1950) did extensive work with such a technique. This minimised the problem of unreliability with the baloon technique due to it's varied size and the possibility of stretch with age and temperature. Saline filled needles were introduced transabdominally to

measure the uterine pressure changes (Caldeyro Barcia et al. 1950). Though recordings were reliable the technique was thought to be cumbersome. Later micro-baloons were used instead of needles by Caldeyro Barcia and Alvarez (1954 & 1962). Williams and Stallworthy (1952) and Carey (1954) used a less invasive transvaginal approach. Introduction of a polythene catheter with a number of terminal perforations via Drew-Smythe catheter passed through the vagina and cervix into the amniotic cavity became an accepted standard method with some modifications. Sponge tipped catheter (Bengtsson 1968) and extraovular baloon technique (Csapo and Sauvage 1968) were introduced but did not get acceptance into regular use. Smaller and more flexible catheters were produced enabling easy insertion with a small plastic introducer (Turnbull 1957).

With the advent of fetal cardiotocographic monitors, arrangements were possible for the pressure to be transmitted through the fluid filled catheter to a transducer placed at a level on the maternal abdomen consistent with the uppermost point of the uterus. The patient changing posture necessitates the adjustment of the level of the transducer and permits basal pressure measurement. The open ended polythene or plastic catheters need an introducer and are relatively awkward to set up and maintain due to blockage by vernix, blood clot or meconium (Csapo 1970, Odendaal et al. 1976). Partial blockage or air bubbles in the system may attenuate the pressure readings misleading the obstetrician.

Though rare, complications of uterine perforation (Tutera and Neuman 1975, Chan et al.1973), fetal, umbilical cord and placental damage (Nuttal 1978, Trudinger & Pryse Davies 1978) have been reported. This may be due to the relatively rigid nature of the catheter. Though much work has been done with the fluid filled catheter (Cowan et al.1982, Miller et al.1976, Rossavik 1978, Seitchik et al.1977) a better catheter system was needed. Efforts by Karlson (1944) and Csapo (1970) to overcome the problem using a solid state catheter tip pressure transducer were fraught with technical problems, high cost, breakage and lack of stability of the measurements.

Steer et al.(1978) introduced the transducer tipped catheter (Gaeltec, Sonicaid Ltd., Quarry Road, Chichester) which obviated the technical problems of a fluid filled device. These catheters are simple to use, unlikely to cause trauma and are ideal for use in the ambulant patient when the transducer must move about with the patient. The pressure transducer is a bridge strain gauge deposited on a thin metal pressure sensing area which is recessed, thus minimising the accidental damage and enabling lateral pressure measurements and not impact of head or end-on pressure (Fig.1.1-1). The catheter and transducer are sealed in silicone rubber sleeve (diameter of 2.7 mm) functioning sensitively from 0' C to 40' C with a specified full scale pressure range of 0 to 20 kPa (0 to 150 mm Hg). The transducer tip lies in the amniotic cavity and all transmission is then electronic through the

catheter via a 2 M flexible extension cable connected to the contraction module of a standard fetal monitor (Fig.1.1-2). The easy use of this catheter and lt's reliable recording has been well documented (Steer 1979, Gibb & Arulkumaran 1985a). However, it will not produce accurate measurements of absolute basal pressure because the position of the catheter tip is unknown. Upto date no case of fetal, cord or placental damage has been reported with this catheter. Though fragile and expensive, since they can be reused after adequate sterilisation it is cost effective. Each catheter can be used for more than 100 insertions without any need for repairs. Most catheters can be reused like new catheters after replacement of the membrane or after minor repairs. Currently disposable transducer tipped catheters (Arulkumaran et al 1991) are available at low cost, which can be used in patients where it is preferrable to discard the catheter after one use (eg. in a patient with AIDS).

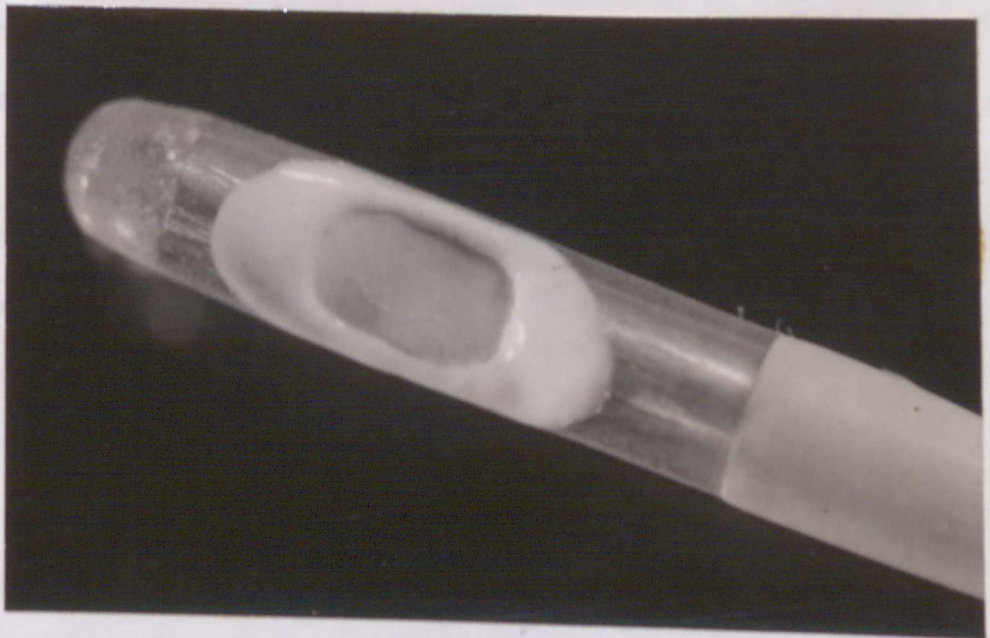


Fig 1.1-1. Transducer just behind the catheter tip in a recessed area

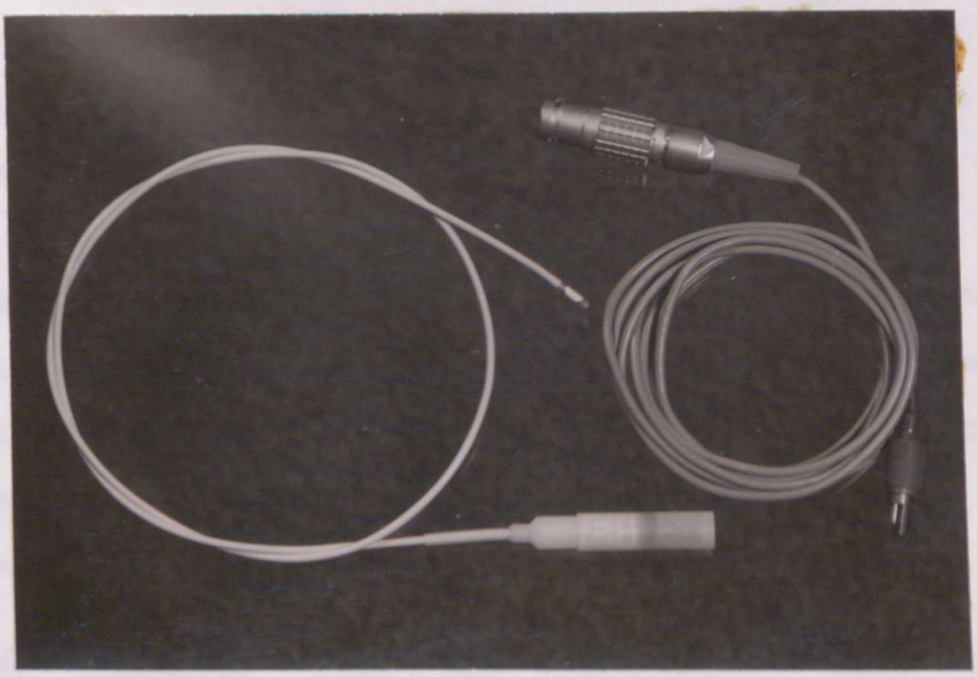


Fig 1.1-2 ."Gaeltec" intrauterine catheter and cable attachment.

A new intrauterine catheter based on the fibre optic principle has been used for uterine activity measurements (Svenningsen et al 1985). It has been found to give comparable and reliable recordings like the fluid filled catheter. A light impulse is passed down one channel in a solid state catheter to a pressure sensitive reflecting metalic disc within a fenestration at the tip of a catheter. The reflected light returns by a different channel and this reading is converted to pressure in mm Hg. Higher the intrauterine pressure greater the angle between the two metallic disc arrangement to give a higher value. The catheter can be used with a Hewlett Packard 8040 or Corometrics 116 fetal monitor with an appropriate interphase.

Though intrauterine pressure recordings are similar to that obtained by a Gaeltec transducer tipped catheter, the Hewlett Packard or Corometrics fetal monitors have no inbuilt programme for integration of the active contraction area i.e. the area under each contraction above the baseline. The fibre optic catheter works in the presence of meconium or blood stained liquor but occassionally the fenestration holding the sensing area gets blocked with blood clot or vernix. Because of this problem and because of the difficulty in computing the active contraction area profiles we have not used this catheter in our studies.

In parallel with the development of internal tocography, external methods of evaluating uterine contractions in labour were in progress. Schaeffer in 1896 made use of a metal hood, the base of which was covered by a rubber membrane. With uterine contractions in labour the membrane on the maternal abdomen was displaced and these changes were recorded by transmission via a tubing connected to a spirometer. Bukoeinsky (1896) used a pneumograph to differentiate the strength of contractions. Fabre (1913) used a similar apparatus but replaced the membrane with a plunger to change the pressure in an air filled tube. Rubsamen (1920) suspended a device of known weight from a pulley and cord system so as to rest it on the maternal abdomen and he obtained recordings on a mechanical drum. But it had the disadvantage that movement by the patient produced artefacts.

Crodel (1930) introduced a tocergometer which was a box with a rod protruding from a basal plate. The box was placed on the maternal abdomen and the movement of the rod due to change in shape of the abdomen was noted and then the values of the extent of elevation, duration and frequency was manually calculated. Frey (1933) added an automatic recording system to the above arrangement. Vignes (1934) employed a similar system for his studies. Dodek (1932) made use of a movable plunger to displace the rubber membrane of a pneumatic chamber. He studied the effect of 12 drugs on pregnant uterus and through a tambour made continuous recordings. Rech (1934) and Moir (1944) used similar equipments. Moir modified the method of recording by hydraulic means. Lorand (1933) achieved direct recording with a miniaturised (8 x 6 x 2.8 cm), calibrated, revolving cylinder and plunger system.

Murphy (1940) used similar systems with a mechanical clockwork and a plunger projected at a fixed distance from the base. This was kept in place on the maternal abdomen by a belt. The introduction of electromechanical devices made the equipment lighter, less bulky and easy to use. Reynolds et al.(1948) introduced a multichannel strain-gauge tocodynamometer. They placed the transducers in a descending order on the midline and investigated the hypothesis of fundal dominance of uterine contractions. They found a quiescent lower segment and diminishing physiological activity from the fundus to the lower segment.

Caldeyro Barcia et al.(1950) studied uterine contractility by a seven channel external method along with intrauterine pressure recordings. Embrey(1940) used a multichannel external tocograph which depended on a hydraulic system to transmit the impulses. This was built to be simple and robust with a view of using it in clinical practice compared with the previous equipment all of which were used for research. A guard ring tocodynamometer: a flat disc constituting an outer ring and an inner circular pressure sensing area was introduced by Smyth (1957). The deflection of a spring mounted on the guard ring reflected the force on the central area. The disc should preferably lie near the fluid filled area of the fundus and when applied carefully was claimed to give a fair approximation of the actual intrauterine pressure.

La Croix (1968) used a hollow gas filled plastic domed transducer applied to the maternal abdomen by adjustable straps. Recordings were obtained via a gas filled system between the plastic dome and the recording device. These recordings were of the same configuration as that obtained by an intrauterine catheter. Though the frequency was identical, only 60 to 90 % of the intrauterine pressure was recorded by this method. In an experimental model, Bell(1981) was able to show that the external recordings consistently measured between 70 and 100 % of the pressure change recorded by the internal system over a range of 5 to 60 mm Hg. It is doubtful whether this occurs in practice.

Much research has gone into developing external and internal tocography and new devices are being developed to improve the recordings still further. But there is no consensus opinion as to whether internal tocography which reflects the intrauterine pressure more accurately would give rise to better obstetric outcome in labour. This thesis addresses that particular issue.

1.2 Quantification of uterine activity

The previous chapter dealt with devices used for measurement of uterine contractions by external and internal means. This chapter deals with quantification of uterine activity which may be useful in clinical practice.

Using clinical methods

Traditionally uterine contractions have been assessed by a hand placed midway between the umbilicus and the uterine fundus. The uterus becomes firmer with contractions increasing in antero-posterior diameter. Approximate duration and frequency of contractions can be recorded by palpating for a period of 10 mins. Though this gives some information about duration and frequency of contractions it gives little information about strength or intensity of contractions. This is the only method practised in most developing countries and is still practised in the developed world. There is no continuous recording of uterine activity but the frequency and duration may be indicated along a time scale by a shaded box method (Fig.1.2-1), or in written form (eg., as 3 contractions in 10 min, each lasting 30 secs in the partograms).

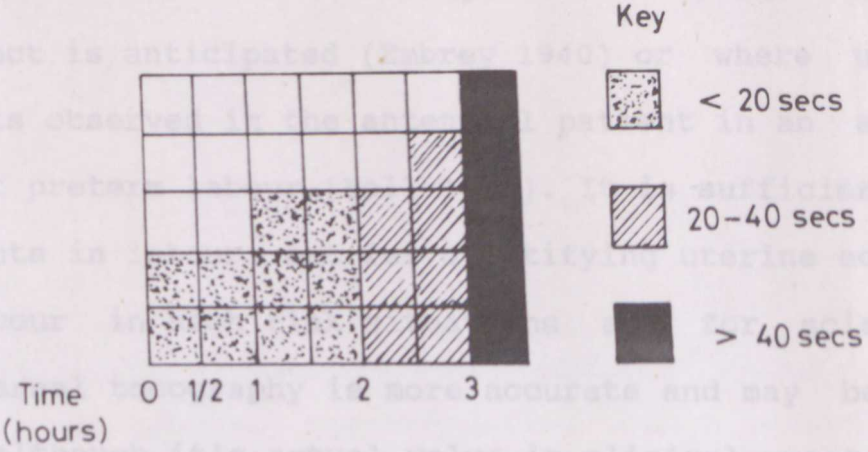


Fig. 1.2-1 Quantification of uterine contractions by clinical palpation

Each square represents one contraction so that if 2 contractions are felt in 10 minutes, two squares would be shaded. The key to the shading indicates the duration of contraction.

Using external tocography

Equipment are available that can make online graphical records of the duration, frequency and strength of contractions. External tocograph recorders use a transducer placed near the uterine fundus to detect changes in the antero-posterior diameter of the abdomen resulting from uterine contractions. The transducer is a plastic plunger or a membrane which although sometimes uncomfortable is

noninvasive and unlikely to harm the mother or fetus (Figs.1.2-2 & 1.2-3). External tocographic recordings only provide a good measure of contraction frequency, fair estimate of contraction duration and an approximation of contraction intensity. External tocography may be suitable for studies of the action of drugs on the uterus where a major effect is anticipated (Embrey 1940) or where uterine activity is observed in the antenatal patient in an attempt to predict preterm labour (Bell 1983). It is sufficient for most patients in labour, but for quantifying uterine activity during labour in high risk situations and for scientific work, internal tocography is more accurate and may be more suitable although it's actual value in clinical practice is yet to be proven.

	Tocography	
Parameter	External	Internal
Contraction		
Frequency	Accurate	Accurate
Duration	Fair estimate	Accurate
Intensity	Approximation	Accurate
Basal tone	Inaccurate	Approximation (due to the location of the tip of the catheter)

Fig 1.2-2. An external tocotransducer with a sensitive membrane to perceive pressure changes

Fig 1.2-3. An external tocotransducer with a plastic plunger device to perceive pressure changes

Using internal tocography

With the development of technology to refine and perfect recording of intrauterine pressure changes, methods of measurement became important. The elements of uterine contractions which have some bearing on their efficiency are frequency, active pressure, duration and coordination (Fig.1.2-4). Amplitude or active pressure is easy to measure and is the difference between the pressure at the peak of a contraction and basal pressure; frequency is calculated over 10 min intervals and duration is the time between an onset and offset of a contraction which depends on precise definitions and may be difficult especially when the decreasing pressure drops slowly to the basal level. Basal tone is the pressure existing at the lowest point of the tracing inbetween contractions which may also be difficult to establish if contractions have a tendency to merge or couple. The several elements described vary independently over a period of time and are difficult to quantify.

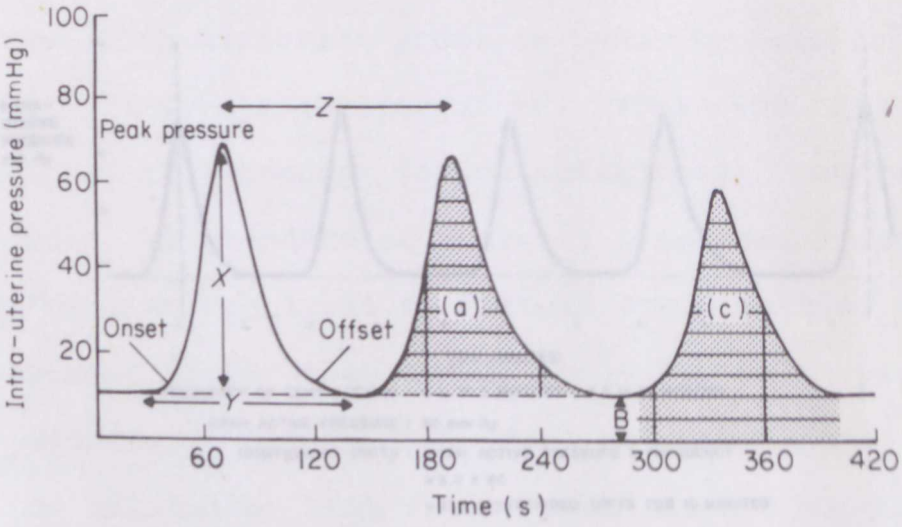


Fig. 1.2-4. Elements and terminology of uterine contractions
x - active pressure or amplitude
y - duration
z - contraction interval related to frequency

a - active contraction area
b - basal tone
c - total contraction area

Caldeyro Barcia et al.(1957) introduced the Montevideo unit (MU) naming the units of uterine activity after the city where they worked. It is the mean amplitude multiplied by the mean frequency over a 10 min period (Fig.1.2-5). Following this example El-Sahwi et al.(1967) from Alexandria introduced the Alexandria units by considering the time factor, i.e. Montevideo units multiplied by the mean duration.

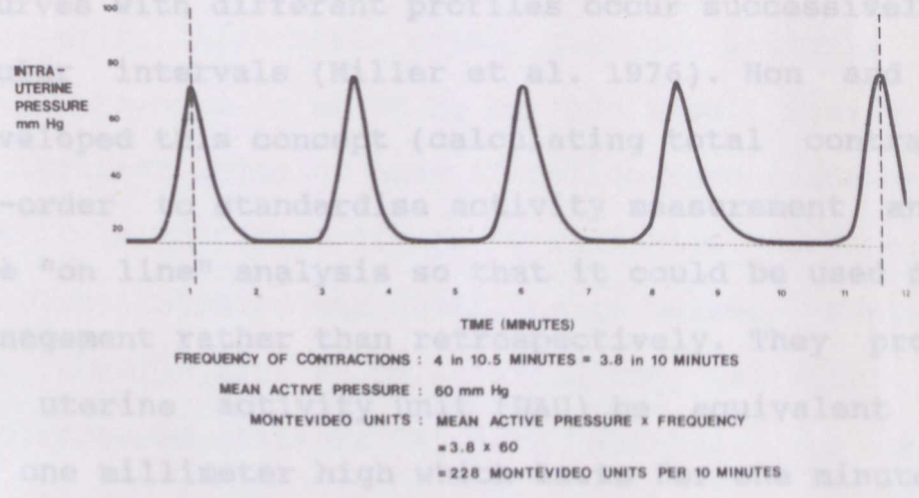


Fig 1.2-5. Calculation of Montevideo units

Bourne and Burn (1927) were the first to suggest that the work done by the uterus was reflected by the area under the pressure curve. Difficulties were encountered in computing the area under the pressure curve on-line whilst labour is in progress. It has been debated whether total contraction area (area under the curve including the area under the baseline) or active contraction area (area of the curve above the baseline), represents useful uterine work. It is known that useful work of the uterus depends on the absolute intensity of the contractions (Caldeyro Barcia et al. 1950). Area under the baseline may account for a large proportion of total area making total area a less sensitive

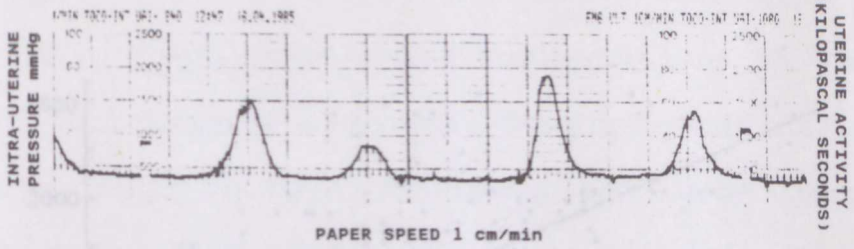
measurement. The quantitation of uterine activity by integration (Jilek et al. 1972) affords a quick and convenient method of measuring the area under a curve. It is more accurate and less time consuming than planimetric measurement being especially useful with asymmetric curves, or when curves with different profiles occur successively or at irregular intervals (Miller et al. 1976). Hon and Paul (1973) developed this concept (calculating total contraction area) in-order to standardise activity measurement and to facilitate "on line" analysis so that it could be used during labour management rather than retrospectively. They proposed that one uterine activity unit (UAU) be equivalent to a rectangle one millimeter high which lasts for one minute and called it 1 torr minute.

In the trend towards systeme international (SI) units, Steer (1977) used the SI unit of pressure the Pascal instead of millimeters of mercury (mm Hg) (1 kilopascal = 7.52 mm Hg). One kilopascal of pressure existing over a duration of one second is 1 kilopascal second (1k Pas). The active contraction area is quantified over a period of time and this is usually 15 minutes hence the uterine activity is expressed in kilo Pascal seconds / 15 minutes (k Pas/ 15 mins)(Fig 1.2-6). Fifteen minutes was selected because of the time taken by the uterus to respond to changes in the rate of oxytocin infusion and because of short term variations in the frequency of contractions. The active contraction area quantified is termed Uterine Activity Integral (UAI). The

traditional uterine activity units (UAU) using mm Hg bears a direct relationship to UAI using 1 kilopascal equivalent to 7.52 mm Hg. One traditional measure of UAU = 7.98 kPas (Fig.1.2-7).

Harbert (1982) reported a comparison of measurements in Montevideo units, Alexandria units, uterine activity units and average pressure in mm of Hg per 10 mins. Similarities between different units of quantification were evidenced by statistically significant linear correlation coeficcients. Gibb et al(1984) studied the relationship between Montevideo units and kPas/15 mins by calculating the activity of 40 normal nulliparous labours by both methods. The uterine activity values in UAI units (k Pas/15 min) when plotted against the corresponding measurements in Montevideo units (Fig 1.2-8) gave a correlation coefficient of 0.71 ($n=337$, $p<0.001$) indicating the close relation between the two units. When the measurements in Montevideo units were treated as the independent variable in the regression analysis, the best fitting straight line, as given by the method of least squares, was found to be $y=3.56\ x + 458.26$. On the average, for every increase of 1 unit on the Montevideo scale, there was an increase of nearly 4 units on the k Pas scale within the range of measurements obtained in our sample.

UTERINE ACTIVITY INTEGRAL : UAI (STEER 1977)



Active Contraction Area
15 minute summation of area
SI unit of pressure KILOPASCAL
(13.3 kPa = 100 mm Hg)
1kPa for 1 sec = 1 KILOPASCAL SECOND
UAI = Active contraction area/15 minutes

Fig. 1.2-6. Recording of UAI as a short dark line against a vertical axis from 0 to 2500 k Pas and the numerical printout of the UAI in addition to mode of recording, paper speed, and time

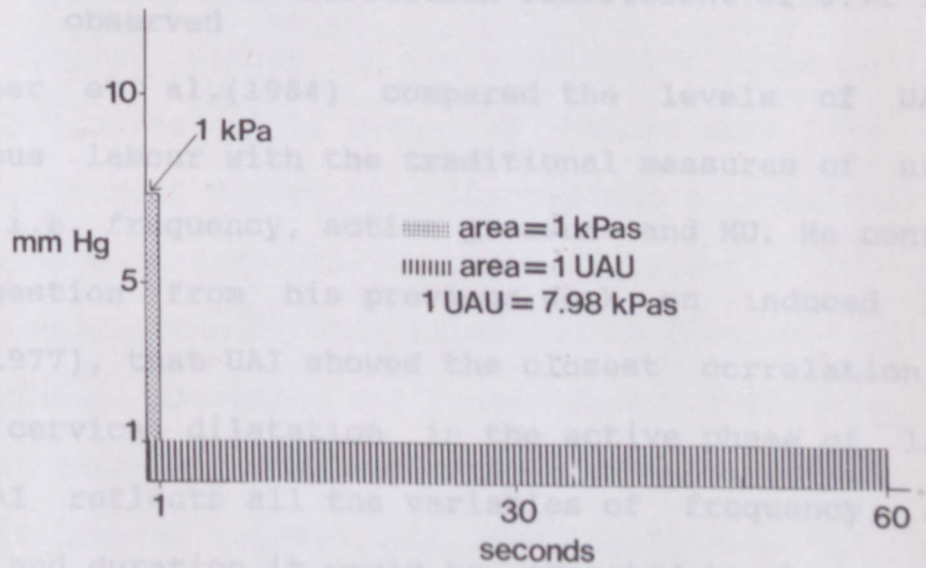


Fig 1.2-7. Relationship of UAU to K Pas

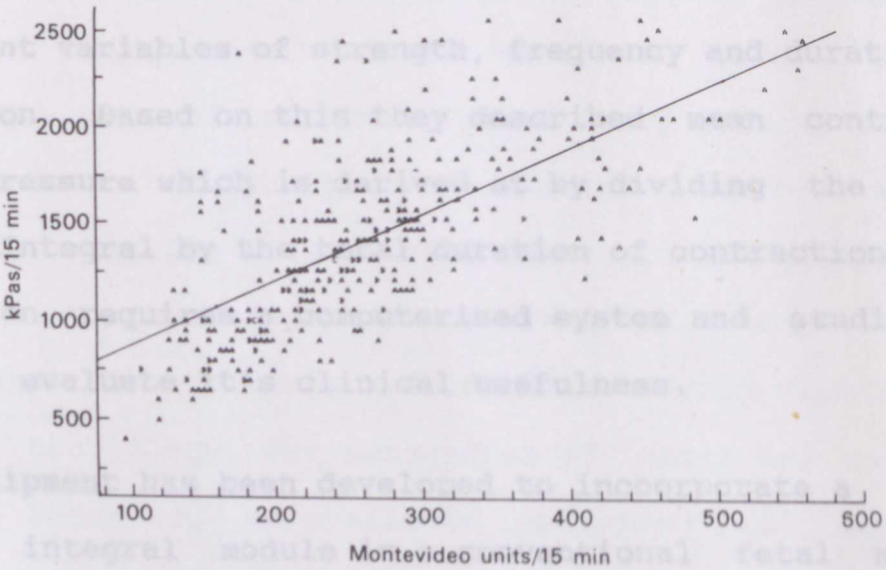


Fig 1.2-8. Relationship of Montevideo units and k Pas/15 min based on uterine activity in 40 nulliparous labour - A correlation coefficient of 0.71 is observed

Steer et al.(1984) compared the levels of UAI in spontaneous labour with the traditional measures of uterine activity i.e. frequency, active pressure and MU. He confirmed the suggestion from his previous work on induced labour (Steer 1977), that UAI showed the closest correlation with rates of cervical dilatation in the active phase of labour. Since UAI reflects all the variables of frequency, active pressure and duration it would be expected to show a better correlation with cervical dilatation than any other variable. But whether managing labour using UAI measurements than frequency of contractions will signficantly alter the

obstetric outcome is not known and is evaluated in this thesis.

Philips and Calder (1987) described mean active pressure (MAP) which represented contributions of the three independent variables of strength, frequency and duration of contraction. Based on this they described mean contraction active pressure which is derived at by dividing the Active Pressure Integral by the total duration of contractions. Such calculation requires a computerised system and studies are needed to evaluate it's clinical usefulness.

Equipment has been developed to incoorporate a uterine activity integral module in a conventional fetal monitor. This module, using the information obtained from the transducer tipped or fluid filled catheter computes the active contraction area every 15 minutes and exhibits it in a digital display window on the module. The same value is printed in figures and is marked by a short dark line on the two channel chart recording paper against a vertical scale marked from 0 to 2500 kPas/15 mins (Fig.1.2-6). The uterine activity values can be correlated to the clinical status of labour. These equipment are commercially available at no extra cost from that of a conventional fetal monitor and has evoked interests to evaluate the usefulness of uterine activity measurements in labour.

1.3 Objectives and planning of the study

Objectives of the study

Uterine activity can be assessed clinically by palpation or by external tocotransducers or intrauterine catheters using modern fetal monitors. Using internal tocography, several methods of quantifying uterine activity has been described (Chapter 1.2). Progress has been made in developing reliable intrauterine catheters and equipment to measure uterine activity as accurately as possible and to quantify it. The appropriate usefulness of such expensive and invasive technology for management of labour has not been defined. Depending on available personnel and equipment, clinical palpation, external or internal tocography is practised rather than based on actual needs. In a centre where facilities are available for internal tocography, it is often used without an indication because the attendant feels that he/she is providing the best to the patient.

This belief is strengthened by the observation that active contraction area profiles correlate better with rate of cervical dilatation compared with individual parameters of frequency, active pressure or it's product in the form of Monte Video units (Steer 1977). It may be, that online quantification of active contraction area profiles and management of labour may lead to better obstetric outcome. However there are no studies to suggest that such advanced invasive and expensive technology in routine use is of

benefit. Its appropriate usefulness has not been defined. Failure to do so would escalate the cost of health care and lead the medical profession into disrepute. The attitude of "Technological Imperative" i.e. use of technology just because it is available even though the situation does not warrant it's use has to change.

The inappropriate use of advanced invasive technology creates antagonism to it's use both amongst the patients and the medical staff. This feeling is justifiable and to avoid this, the situations where the use of technology may be of benefit to the patient should be spelt out and the clinician should be aware of it.

The objective of this study is to test the hypothesis that use of internal tocography and quantification of uterine activity would result in better obstetric outcome. The application of such advanced technology in induced and augmented labour should (1) reduce the length of labour, (2) lower the maximum dose of oxytocin infusion, (3) reduce the caesarean deliveries, (4) result in fewer neonates with birth asphyxia and (5) should help rational management of those undergoing a trial of labour with a previous caesarean scar.

Planning of the study

Scanning the literature it was apparent that although several studies have been done on uterine activity measurements, only a few have made clear distinction between the different factors which might influence the uterine

activity in labour. Many failed to differentiate spontaneous normal labour from induced or augmented labour. Other equally important factors that might influence uterine activity are :parity, presentation, ethnicity, presence of a previous scar, cervical score in induced labour, physical characteristics of the patient and the size of the fetus.

In order to evaluate the usefulness of uterine activity measurements in augmented and induced labour or in those with a previous caesarean scar, the uterine activity in spontaneous normal labour should be known. It was planned to study this first by quantifying active contraction area profiles in a cervical dilatation specific manner. It was to be defined in Chinese nulliparae followed by Chinese multiparae to establish the norms for our population and to evaluate the influence of parity on the uterine activity when controlled for factors of rate of progress of labour, period of gestation, height of mother, unassisted vaginal delivery and birthweight of neonates.

This was to be followed by quantifying the uterine activity in nulliparae and multiparae in spontaneous normal labour in a Malay population controlling for the factors mentioned. The profiles obtained were to be compared with that of a control Chinese population to evaluate the ethnic influence on uterine activity. If it was found to be the same, uterine activity profile so observed were to be used for our total population controlled for parity.

To evaluate the influence of different presentation, uterine activity in breech presentation was studied according to parity and the values compared with that observed for vertex presentation controlling for the period of gestation, age and height of mothers and rate of progress of labour.

Once the uterine activity in spontaneous normal labour controlling for certain factors was defined, the uterine activity in induced labour was studied in relation to parity and cervical score with the present mode of management i.e. when oxytocin is titrated to achieve optimal frequency of uterine contractions. The uterine activity in induced labour was compared with that of spontaneous normal labour according to parity. Two prospective randomised studies followed. In each uterine activty was quantified using an intrauterine catheter. Half the population in each study was managed by titrating oxytocin to achieve predetermined UAI values. In the first study, oxytocin was titrated to achieve 75'th and in the second study to achieve 50'th centile uterine activity profile according to parity in half of the patients whilst in the other half oxytocin was titrated to achieve optimal frequency of uterine contractions. In each study the obstetric outcome of the two groups were compared to evaluate advantages if any of using an intrauterine catheter to quantify uterine activity. Further analysis was carried out to calculate the total uterine activity in induced labour according to parity and cervical score to identify its significance.

Dysfunctional labour which needs augmentation contribute to a third of all caesarean section. A pilot study was carried out to identify the magnitude of the problem in our population with our current method of management using external tocography. Once this was defined the uterine activity in slow labour prior to and after augmentation was studied to identify the contribution of poor uterine activity to dysfunctional labour and to identify the target uterine activity to be achieved with oxytocin titration. A randomised study was carried out to evaluate benefits if any of using an intrauterine catheter. One group was managed by external tocography whilst the other was managed by internal tocography using intrauterine catheters where additional information of active contraction area measurements were available. The obstetric outcome was compared in the two groups to evaluate the advantages if any of using an intrauterine catheter in augmented labour.

Management of patients with a previous casarean scar is a special problem and careful monitoring of uterine contractions in these women is important in current obstetric practice, where women with previous caesarean scar are allowed a trial of labour.

Uterine activity in patients with previous caesarean scar who were admitted in spontaneous labour and who were allowed a trial of labour and found to have a normal progress was studied. The observations were defined in three groups.

Group 1: Those who had the previous operation electively or in the latent phase of labour but no previous vaginal delivery. Group 2: Caesarean section was done in the active phase of labour but had no previous vaginal delivery. Group 3: Those who had a previous caesarean section but also had a vaginal delivery either prior to or after the caesarean delivery. After establishing these norms uterine activity and obstetric outcome in augmented labour in those with a previous caesarean scar was studied.

Based on this study and the one on augmented labour who had no caesarean scar, a reasonable policy is defined for conducting a trial of scar that may reduce repeat caesarean deliveries with little compromise to the scar. To evaluate the impact of this policy the outcome of those patients who had a trial of labour based on this policy was studied over a period of 24 months. Despite these precautions uterine dehisence may occur and uterine activity and features known to be associated with dehisence in such cases are described. Based on these studies conclusions are drawn regarding the appropriate usefulness of an intrauterine catheter and quantification of uterine activity in management of labour.

1.4a Choice of equipment and calibration

All studies were conducted in the labour wards of Kandang Kerbau Hospital and the National University Hospital, Singapore. The studies were approved by the Departmental ethical committee. No new drugs were used and so the Ministry of Health ethical committee approval was not obtained. The purpose and nature of the study was explained to the patients and informed consent obtained prior to recruitment.

It was standard practice to monitor nearly all patients continuously with cardiotocography in the National University Hospital. High risk patients and those who were selected for the studies were monitored in Kandang Kerbau Hospital due to the limited number of fetal monitors available.

Recording of intrauterine pressure changes and online systems for quantification of uterine activity based on such recordings (as active contraction area profiles) were pre-requisites for our study to test the hypothesis proposed. For such online computation of active contraction area profiles a uterine activity integrator module incorporated in the conventional fetal monitor was necessary and this facility was available only with Sonicaid FM 3 R or FM 6 fetal monitors and hence these were used (Sonicaid Ltd., Quarry Road, Chichester). In the studies described, whenever external tocography was required, either the Sonicaid machines or Hewlett Packard 8040 (Hewlett Packard Ltd., Borbringen, Germany) fetal monitors were used.

Three types of intrauterine catheters were available. The fluid filled system, the fibre optic system (AMES Ltd., Norway) and the transducer tipped Gaeltec (Sonicaid Ltd.) catheters. The fluid filled system has problems of blockage by vernix, blood clot and meconium and is awkward to set up compared with the solid state catheters and hence we used the Gaeltec catheters for our studies.

Prior to the clinical studies, reliability of Gaeltec catheters for intrauterine pressure measurement was tested in vitro and in vivo. An adaptor box to convey the recordings to the Sonicaid FM 3 R or FM 6 or Hewlett Packard fetal monitor was necessary if we were to use the fibre optic catheter. Continuous tocography and online quantification of active contraction area profiles was possible with either of the catheters. Because of expenses involved with the adaptor box the fibre optic catheter system was not used for our studies. To make sure that the Gaeltec catheters would give similar recordings like other solid state catheters, the recordings of fibre optic catheters were compared with that of the Gaeltec catheters (Chapter 1.4b). Both catheters were inserted into the same uterine cavity to find the reliability of the systems. Only if found to be reliable were the 'Gaeltec' catheters to be used for our studies. It was also varified that two Gaeltec catheters gave comparable recordings in vitro and in vivo, ie, reproducability of results with the same catheter system (Chapter 1.4c).

Calibration of catheters prior to use

The 'Gaeltec' catheters were calibrated by making use of the 2% activated glutaraldehyde solution in transparent plastic storage tubes which were used to house the catheters. To calibrate with the Sonicaid FM 3 R fetal monitor the catheter was placed in the solution till the yellow marker on the catheter was at the level of the fluid meniscus and the tocho control button on the machine was turned in the clockwise or anticlockwise direction till the toco digital display showed 33 to 35 mm Hg. This was double checked by raising the transducer tip till it was just below the fluid meniscus when the reading was 0 mm Hg.

To calibrate the catheter with the Sonicaid FM 6 fetal monitor the 'TEST' button on the top left hand corner of the machine was touched momentarily when the lower display window in the toco module read "set zero". The catheter was raised above the level of the fluid and the "TEST" button touched when the upper panel displayed 0 mm and the lower window displayed the word "calibrate". Then the catheter was lowered till the yellow marker on it was at the level of the fluid meniscus. The "TEST" button was touched again when electronic calibration took place and gave a reading of 33 mm Hg followed by a display of "int-mm Hg" in the lower window indicating that it was ready for use.

With the FM 3R fetal monitor if the machine was switched off after calibration and restarted again the calibration was not disturbed and from the time it was

switched on the second time the active contraction area was quantified every 15 mins. If it was not switched off and on after calibration the machine starts computing the uterine activity but the first reading was given in less than 15 minutes time and may include the activity recorded off the previous patient kept in memory. This reading had to be ignored for uterine activity integral or active contraction area calculations. With the FM 6 fetal monitor, once the calibration process is completed if the machine is switched off and on again it would not compute the active contraction area profile although the internal pressure recordings would be given. Because of this the first reading is usually for a period of less than 15 minutes and cannot be made use of for construction of active contraction area profiles. Therefore, once the calibration is performed with a Sonicaid FM 6 fetal monitor it cannot be switched off and if it occurs accidentally the catheter has to be recalibrated in the storage tube and reinserted for measurement of active contraction area profiles.

The uterine activity integrator module incorporated with the FM 3 R fetal monitor computed the active contraction area profiles every 15 minutes and displayed it digitally on a window and for purposes of permanent record made a short dark line against a vertical scale from 0 to 2500 k Pas/15 min on the contraction channel. The FM 6 fetal monitor did not have a digital display of the UAI but it printed it numerically every 15 mins in the space between the toco and

fetal heart rate channel in addition to its annotation by a short dark line (Fig 1.2-6).

Gaeltec catheters are reusable and after each use it has to be cleansed and stored in the tubes provided. The 2% activated Glutaraldehyde solution had to be replaced every two weeks to maintain it's antiseptic property. A card attached to the storage tube warns of the day the solution had to be changed. In our practice a soaking time of 3 hours was allowed prior to reuse of the catheter on another patient and use of the catheter on patients who are hepatitis careers was avoided.

The fibre optic catheter was calibrated (as instructed in the 'AMES' operating hand book) with a Hewlett Packard 8040 fetal monitor via the "AMES" interphase using the same storage tube having the 2% glutaraldehyde solution. The calibration procedure was similar to that of Gaeltec catheters with the Sonicaid FM 3R fetal monitor. Instead of the yellow marker line found on the Gaeltec catheter the fibre optic catheter had a black line and calibration involved manipulation of switches in the interphase box in addition to the toco button on the fetal monitor.

1.4b Reliability of Gaeltec catheter for intrauterine pressure measurements. Comparison with a fibre optic catheter

To check whether Gaeltec catheter gave comparable readings like other solid state catheters it was compared with a fibre optic catheter. The two catheters were compared by inserting both catheters in the same patient and by comparing the contraction pressure recordings obtained.

Materials and Methods

Fibreoptic (Transducer) Catheter

The Camtec Fibre Tip catheter used, had an AE 8500 fibre optic pressure sensor and an AE 85 sensor interface electronic measuring unit. Variations in pressure acting on the membrane of the sensor tip is detected by the light emitted through the fibre optical bundle of the sensor, from the light-emiting diode of the sensor interface. The light received is converted into an electrical signal and displayed in units of mmHg. The pressure sensitive diaphragm is housed in a smooth dome at the tip of the catheter, which acts as a form of protection against mechanical damage (Fig. 1.4-1).

Gaeltec Catheter

The Gaeltec pressure transducer is a bridge strain gauge deposited on a thin metal pressure sensing surface. The transducer is so mounted that it measures lateral pressure, and the sensing area is recessed to minimise the risk of accidental damage (Fig 1.4-1). The transducer mounted on the catheter, is connected by a flexible extension cable

to a fetal monitor.

Patients

Simultaneous pressure readings with the fibreoptic and Gaeltec catheters were obtained from 8 patients admitted in spontaneous labour. The catheters were inserted after a diagnosis of established labour has been made, and the forewaters ruptured.

Results

The pressure change from the baseline of each contraction to its peak was measured, for both the fibreoptc and Gaeltec catheters. These peak pressures were identical (Fig. 1.4-2) in most occassions. The pressure changes were then calculated as a ratio, and the mean ratio with its standard deviation was derived for each patient. The coefficient of variation, defined as the standard deviation/mean x 100, was then arrived at, as described by Neuman et al (1972). The use of the coefficient of variation of the ratio of contraction amplitudes eliminates effects due to calibration errors between the transducers (Svenningsen et al, 1985).

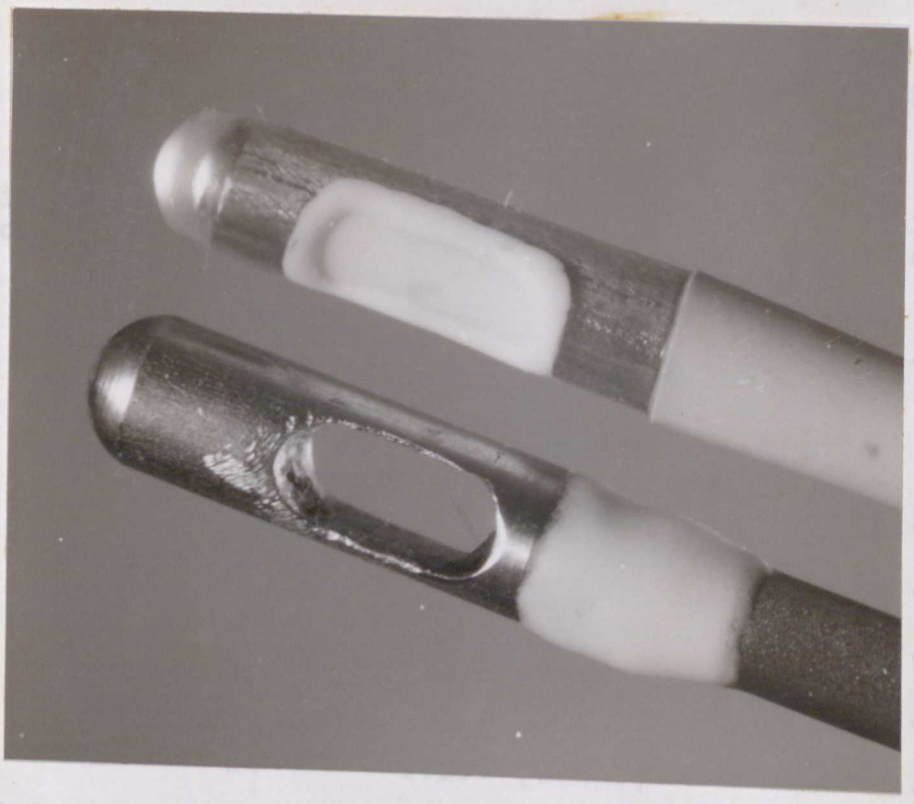


Fig 1.4-1 The tip of the fibreoptic catheter with a smooth dome and distal fenestration housing the mirror arrangement shown alongside the tip of the "Gaeltec" catheter with recessed sensing area behind the rounded tip.

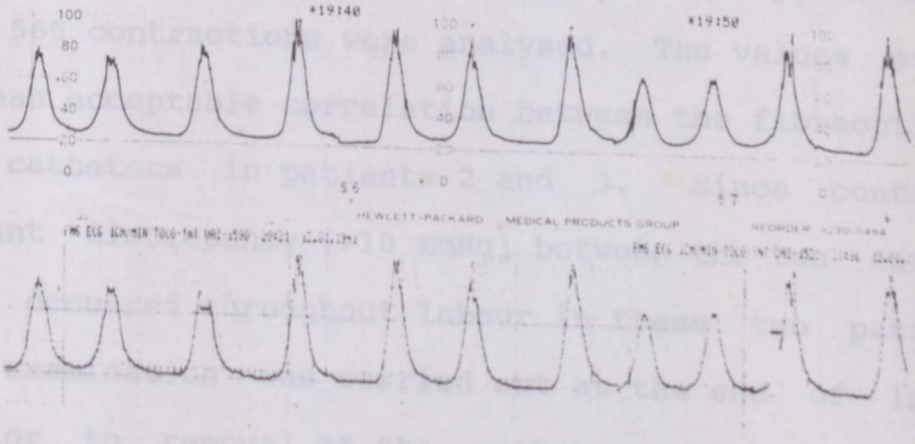


Fig 1.4-2 Comparison of uterine contractions which are identical from the same patient by fibreoptic catheter (upper chart and Gaeltec catheter (lower chart).

Table 1.4-1: Comparison of pressure recorded by Fibreoptic and Gaeltec Catheters

Patient No.	No. of Readings	P1/P2 Ratio (mean s.d.)	Coefficient of Variation
1	119	0.949 (0.201)	21.18
2	71	1.826 (0.424)	32.97
3	28	0.840 (0.359)	42.74
4	72	0.974 (0.145)	14.89
5	68	1.112 (0.125)	11.24
6	60	1.041 (0.216)	20.75
7	123	0.893 (0.102)	11.42
8	24	1.197 (0.146)	12.20

P1 : Pressure recorded by Fibreoptic catheter
P2 : Pressure recorded by Gaeltec catheter
s.d. : Standard deviation

Table 1.4-1 shows the results when all contractions were taken into account, the ratios and coefficients of variation being derived from the inclusion of all contractions regardless of their shapes and patterns. A total of 565 contractions were analysed. The values suggest a less than acceptable correlation between the fibreoptic and Gaeltec catheters in patients 2 and 3. Since continuous significant discrepancy (>10 mmHg) between the two catheter readings occurred throughout labour in these two patients, vaginal examination was carried out at the end of labour, just prior to removal of the catheters, to check their relative positions. It was found that in both patients, due to maternal movement, one of the two catheters had slipped

and was lying low in the lower segment close to the cervical os. The catheter well inside the uterine cavity showed bell-shaped curves while the lower one showed contractions with low amplitude. In other patients even when the catheters were showing nearly equal readings there were occasions when 3 to 5 consecutive contraction curves showed a more than 10 mmHg difference in amplitude. This probably was due to transient malfunction of the sensing surface from blockage by vernix, blood clot or meconium. There was a marked improvement in the coefficient of variation when all patients were considered(9.30 to 16.05) after excluding the readings from the two patients where one of the catheters had slipped down and after excluding those few contractions with transient differences of >10mmHg in the amplitude (Table 1.4-2).

Table 1.4-2: Comparison between Fibreoptic and Gaeltec Catheters after excluding contractions when pressure difference between amplitudes was >10 mmHg

Patient No.	Total No. of Readings	No. of Readings Excluded	P1/P2 Ratio (mean s.d.)	Coefficient of Variation
1	104	15	0.966 (0.155)	16.05
4	68	4	0.985 (0.123)	12.49
5	58	10	1.1080 (0.103)	9.30
6	51	9	1.068 (0.171)	16.01
7	121	2	0.895 (0.101)	11.28
8	19	5	1.172 (0.154)	13.14

P1 : Pressure recorded by Fibreoptic catheter
P2 : Pressure recorded by Gaeltec catheter
s.d. : Standard deviation

Discussion

A good correlation between the Gaeltec catheter and the fluid filled catheter in the measurement of intrauterine pressure was shown by Steer et al (1978). Svenningsen et al (1985) showed fair correlation between the fibreoptic and fluid filled catheters. After excluding the readings from 2 patients where one of the catheters was found to be displaced, the correlation coefficient between the fibreoptic and Gaeltec catheter was found to be 11.24 to 21.18, compared with 2.12 to 43.2 observed by Svenningsen et al (1985) between the fibreoptic and fluid filled catheter in a similar group of patients. The better correlation coefficient observed in our study was expected because of comparison between two solid state catheters, as opposed to comparison with a fluid filled catheter with its inherent problems of greater chance of blockage or leakage in the system.

The results indicate that the pressure transducer incorporating fibreoptics technology and the "Gaeltec" catheter with a bridge strain gauge pressure transducer are reliable for intrauterine pressure measurements and for quantification of uterine activity. As the readings may, in a few cases, be distorted by malposition of the catheter or blocking of the sensor, careful analysis of the contraction curve is necessary. Such problems are usually disclosed from the shape of the contraction curve showing a non-physiological appearance or sudden decline in active pressure.

1.4c Reproducability of intrauterine pressure measurements with Gaeltec catheters

The measurement of intrauterine pressure first became practical in routine clinical practice when Williams and Stallworthy developed an intrauterine pressure catheter which could be passed into the uterus transcervically (Williams and Stallworthy, 1952). Since then, intrauterine pressure catheters have generally been accepted as a reliable means of providing accurate information on intrauterine activity. However, Knoke et al (1976) described a series of experiments in which three intrauterine catheters were passed simultaneously into the same uterus during labour. They showed large differences between the three readings obtained on a contraction by contraction basis. Their findings and other anecdotal reports have given rise to doubts as to whether intrauterine pressure measurement is a valid way of assessing uterine activity in labour (Goodlin, 1989; 1990).

The objective of this study was to assess whether the pressure differences recorded within the same uterine cavity was due to different pressures existing in different parts of the uterus due to amniotic fluid pockets caused by the fetus or whether it was due to inherent problems in the catheter system used. The variation of intrauterine pressure when catheter-tip intrauterine pressure transducers (Gaeltec) were inserted in the same pocket of amniotic fluid in the uterine cavity was compared with the variation when they were

inserted in random locations within the uterine cavity. This would also provide the answer regarding the reproducability of results if the same catheter system is used.

Patients and Methods

Twenty patients admitted to the National University Hospital in early active phase of labour, with ruptured membranes were recruited to the study.

The catheters were calibrated before use as described in chapter 1.4a and inserted transcervically. The accuracy of each pair of catheters was checked in vitro before insertion by simultaneous insertion of the catheters to equal depths in sterile fluid; the reading from the "second" catheter was recorded when the "first" catheter read 0,10,20,30,40 and 50 mmHg. The calibration checks showed that the discrepancies between the catheters were: <1 mmHg 30%, 1 mmHg 23%, 2 mmHg 17%, 3 mmHg 17%, 4 mmHg 10% and 6 mmHg 3% (ie. the difference was <4 mmHg on 97% of occasions).

Informed consent was obtained, and the patients were randomly assigned to 2 groups. In group 1, two sterile Gaeltec catheter-tip pressure transducers were inserted independently into the same uterus. One catheter was inserted posterior to the fetal head and the other anterior or lateral to the fetal head. In group 2, the two catheters were tied together with sterile catgut before insertion, so that the tips of both catheters were at the same level with the sensing surface side by side and would be in the same

fluid compartment in the uterus after insertion.

In each case, one catheter was connected to a Sonicaid FM 3R fetal monitor and the other catheter connected to a Sonicaid FM6 fetal monitor. The baseline pressure in both catheters was set to an identical level by the manual facility to adjust the pressure reading, available in the FM3R fetal monitor. The peak pressures were recorded from the two catheters for each successive contractions in the 10 cases in each group. The catheters were removed only when the patient started bearing down in the late first or early second stage of labour. The catheters which were tied together were checked on removal and none showed displacement from each other.

Results

The results in each of the 20 patients are summarized in Tables 1.4-3 and 1.4-4. Although the recordings showed large contraction by contraction differences, with maximum differences of up to 30 mmHg in group 1 and up to 40 mmHg in group 2, the average mean difference in the active contraction pressure recorded between the 2 catheters was only 3.9 mmHg and 4.0 mmHg respectively. Set against mean active pressure of 40 mmHg and 42 mmHg in groups 1 and 2 respectively, the average differences were not significant. The configuration of the contraction profiles recorded in both catheters were very similar, even when peak contraction pressure varied between them (Fig. 1.4-3). Figures 1.4-4 and

1.4-5 show that when the sum of active pressure recorded in each catheters were compared in each of the 20 cases, there was little systematic difference in the recordings of intrauterine pressure.

Table 1.4-3: Differences in intrauterine pressure measurements when 2 Gaeltec catheters were inserted independently within the same uterus

Case	Mean difference (mm Hg)	Maximum difference (mm Hg)
1	-0.07 (5.49)	12
2	1.78 (5.75)	30
3	7.36 (9.06)	40
4	2.62 (3.83)	20
5	0.87 (8.03)	30
6	-2.73 (4.90)	17
7	1.42 (5.35)	15
8	2.75 (4.37)	15
9	6.96 (8.07)	26
10	13.44 (5.85)	25

Figures in parentheses are standard deviation

Table 1.4-4: Differences in intrauterine pressure measurements when 2 Gaeltec catheters tied together were inserted into the same uterus

Case	Mean difference (mm Hg)	Maximum difference (mm Hg)
1	-2.00 (9.11)	28
2	3.04 (2.33)	13
3	1.87 (3.20)	8
4	1.64 (5.08)	14
5	-3.17 (4.07)	15
6	5.61 (6.86)	30
7	8.20 (3.70)	13
8	4.75 (3.91)	15
9	3.96 (4.52)	13
10	4.91 (3.36)	23

Figures in parentheses are standard deviation

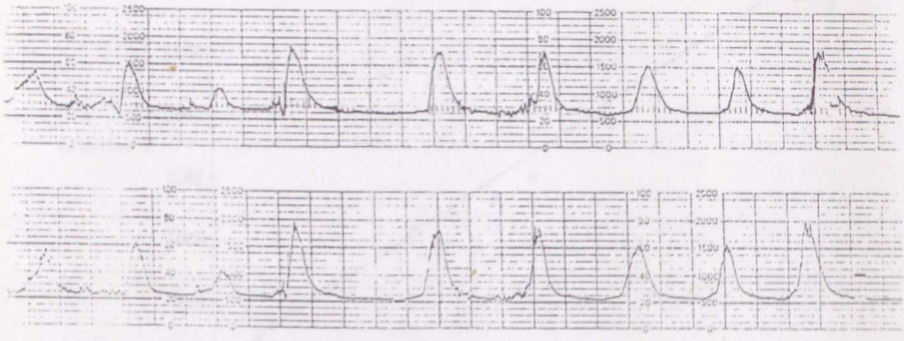


Fig 1.4-3 Similar configuration of the contraction profiles even when peak contraction pressures recorded by the two catheters were different

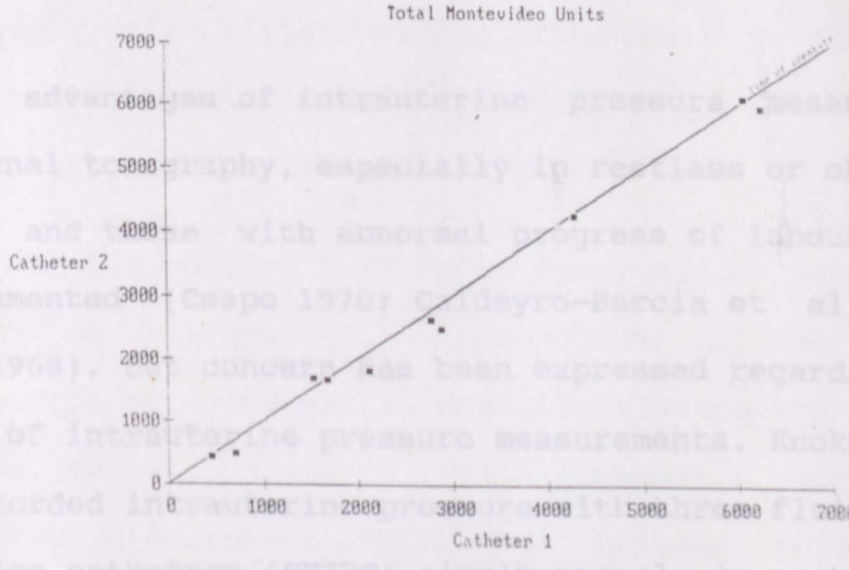


Fig 1.4-4 Comparison of the sum of active pressures recorded in each catheter when two catheters were inserted independently within the same uterus

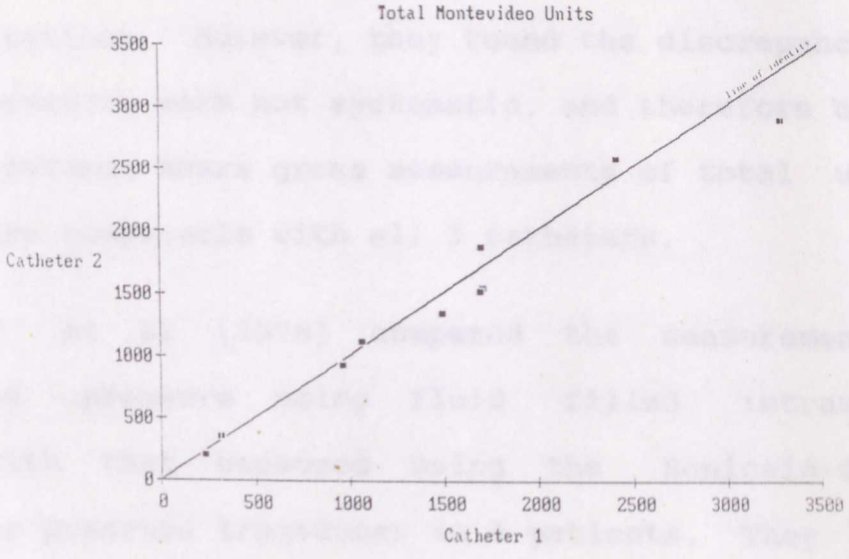


Fig 1.4-5 Comparison of the sum of active pressures recorded in each catheter when the two catheters were tied together and inserted into the same uterus

Discussion

The advantages of intrauterine pressure measurements over external tocography, especially in restless or obese patients, and those with abnormal progress of labour, have been documented (Csapo 1970; Caldeyro-Barcia et al, 1950; Lacroix 1968). But concern has been expressed regarding the validity of intrauterine pressure measurements. Knoke et al (1976) recorded intrauterine pressure with three fluid-filled intrauterine catheters (FFIUC) simultaneously in each of nine women in labour. Their conclusions were essentially that the variation in recorded pressure likely to occur by chance due

to the random nature of catheter placement and loculations of amniotic fluid was approximately 5-10 mmHg. They found a 25% measurement uncertainty and concluded that the pressure of one contraction measured with one catheter should not merit too much attention. However, they found the discrepancies in measured pressure were not systematic, and therefore over a period of several hours gross measurements of total uterine activity were comparable with all 3 catheters.

Steer et al (1978) compared the measurement of intrauterine pressure using fluid filled intrauterine catheter with that measured using the Sonicaid-Gaeltec catheter-tip pressure transducer in 4 patients. They showed only slight differences between the 2 methods. The small systematic underreading of uterine pressure by the fluid filled intrauterine catheter was attributed to blockage in the fluid filled catheters. Neuman et al (1972) comparing pressures derived from fluid-filled catheters with that from an intrauterine sensor found a coefficient of variation similar to that of Steer et al (1978).

Our results confirm that while there may be contraction by contraction differences in recordings of intrauterine pressures from 2 catheter-tip pressure transducers in the same uterus, overall, there is little systematic difference. The observed measurement differences between intrauterine pressure transducers and the fluid filled intrauterine catheters obtained by Neuman et al(1972) and Steer et al

(1978) were explained by the inherent inaccuracy of fluid filled intrauterine catheters due to blockage and compression. However, this reasoning has to be revised in the light of the persistent differences in pressure recordings obtained when two catheter-tip pressure transducers were insertd independently into the same uterus (Table 1.4-3).

It is tempting to suppose that persistent differences in measured active pressure in two catheters placed in the same uterus is due to loculation of fluid within the uterus, so that different compartments develop different active pressures during the same contraction. However, the persistent difference in peak active pressures obtained when 2 catheters are tied together (and hence in the same pocket of amniotic fluid) demonstrates that this is not likely to be the explanation (Table 1.4-4). The reasons for the individual variations from contraction to contraction remain obscure, but may be due to mechanical (direct force) rather than fluid pressure acting on the transducer. Our findings show that although there are variations in the measurement of intrauterine pressure from contraction to contraction, systematically, these variations may be of little clinical significance. It can be concluded that Gaeltec catheters can be used reliably to perform clinical studies as they are likely to show reproducable results.

2 UTERINE ACTIVITY IN SPONTANEOUS NORMAL LABOUR

2.1 IN NULLIPARAE

2.2 IN MULTIPARAE

2.3 IN DIFFERENT ETHNIC GROUPS

2.4 IN BREECH PRESENTATION

2 UTERINE ACTIVITY IN SPONTANEOUS NORMAL LABOUR

2.1 In nulliparae

Nulliparous patients who have had no previous pregnancy that had resulted in the delivery of a viable fetus would be expected to have different uterine activity compared with a parous patient whose uterus had functioned to effect vaginal delivery. Miller et al. (1976) described the uterine activity of 100 primiparous patients in spontaneous labour but included in this group were a proportion of patients who had abnormal progress of labour; a group who could contribute to a reduction in the median uterine activity. Steer et.al reported uterine activity in induced labour in 1975 and later reported uterine activity in an unspecified population and did not make a differentiation between induced and spontaneous labour (Steer 1977). Uterine activity in a group of African nulliparae in spontaneous labour was reported by Cowan et al (1982) but he included 38% of patients who had forceps deliveries. Since there were no publications on uterine activity in spontaneous normal labour in nulliparae at the time of this study and because we wanted to establish the norms for our population we conducted this study. In addition it served to quantify uterine activity as active contraction area in a cervical dilatation specific manner.

Patients and methods

For this study nulliparae were defined as those who had no vaginal delivery of a viable fetus. Those who had spontaneous or induced abortion in the first trimester were

not excluded. Since the possible ethnic influence on uterine activity was not known it was decided to consider patients of Singaporean Chinese origin. Multiple pregnancies were excluded and only singleton with vertex presentaton were recruited. Since the age and height of mothers as well as birth weight of babies may have some influence on the progress of labour as well as uterine activity, 40 patients between 20 and 32 (mean 24.9) years of age, >152 cm in height (mean 157.4 and range 152 to 167), and those at term (mean 39.7 weeks) were studied. These patients were recruited in the active phase of spontaneous labour i.e. after spontaneous onset of regular painful uterine contractions brought about full effacement and 3 cm or more dilatation of the cervix. Subjects so identified had their membranes ruptured if it was still present after informed consent for the proposed study.

The Gaeltec catheter was calibrated and inserted via the vagina and cervix into the uterine cavity as explained in Chapter 1.4. The opportunity was always taken to apply a fetal scalp electrode for continuous electronic fetal heart rate (FHR) monitoring. After these procedures the patient was encouraged to lie on the left or right lateral position till she had an urge to bear down and the cervix was found to be fully dilated and the leading part of the head in the lower pelvic strait.

The progress of labour in the study population was monitored by performing hourly vaginal examinations, and

normal progress was defined as that progressing within 2 hrs to the right of a line drawn at 1 cm/hr from admission dilatation on the partogram. None of the study patients had oxytocin, and those who developed abnormal labour or had assisted instrumental vaginal delivery were excluded from the study.

The intrauterine pressure and fetal heart rate was continuously recorded on a two channel chart recording paper using the Sonicaid FM 3R fetal monitor (Sonicaid Ltd.,Quarry Rd,Chichester). Any patient with an abnormal fetal heart rate tracing was excluded. Analgesia was administered as required in the form of pethidine 50 to 100 mg intramuscularly every 4 to 6 hours. Since epidural analgesia may influence the uterine activity and the study was to define the uterine activity in spontaneous normal labour, patients requiring, or requesting such form of pain relief were excluded from the study. Neonatal outcome was assessed by 1 and 5 min Apgar scores, umbilical cord venous blood pH and the need for assisted ventilation.

Since the rates of cervical dilatation differ in individual patients and 4 readings of uterine activity were recorded in an hour, it was decided that if a patient progressed from 4 to 8 cm in 1 hour, then the activity values were allocated correspondingly to 4 cm, 5 cm, 6 cm and 7 cm respectively. The uterine activity profiles so allocated were analysed individually and collectively. All activity values

were analysed on a TRS - 80 model II micro-computer using a program that could selectively analyse all or some of the values to derive centiles for each cervical dilatation. Individual median levels were obtained for each labour unrelated to cervical dilatation. Cervical dilatation specific uterine activity profile was constructed using the Uterine Activity Integral units (UAI) (using the active contraction area profiles computed by the uterine activity integrator) and Montevideo units (calculated manually) and the results were correlated.

Results

None of the new born was depressed based on Apgar scores and umbilical venous blood acid base values (Table.2.1-1). The cervical dilatation at the time of recruitment to study is shown in table.2.1-2. The majority (75%) were admitted to the study at or prior to 5 cm dilatation.

Table 2.1-1: Neonatal characteristics (n = 40)

	Mean	Range
Birth weight (grams)	3169.0	2656.0 - 4000.0
Apgar score at 1 min	8.9	8.0 - 9.0
Apgar score at 5 min	10.0	10.0 - 10.0
Umbilical venous blood pH	7.37	7.28- 7.49

Table 2.1-2: Dilatation of cervix at entry in 40 patients

Dilatation (cm)	Patients (n)	Cumulative (%)
3	13	33
4	9	55
5	8	75
6	3	83
7	4	93
8	3	100

When the uterine activity of individual patients, recorded in UAI units were examined, it was noted that the second reading was much higher than the first or third readings in 37 of 40 patients. Since this value was nearly twice that of the first and third reading it was not considered for construction of the uterine activity profile. However when Montevideo units were calculated there was no increase in the second 15 minute value. So these values were included for construction of the uterine activity profile in Montevideo units.

The median uterine activity value for each individual patient was calculated and is represented in Fig.2.1-1. The lowest median uterine activity associated with spontaneous labour was 855 k Pas/15 min. There was a wide distribution of median levels upto 2500 k Pas/15 min with the majority of patients being in the range of 1000 to 1900 k Pas/15 min.

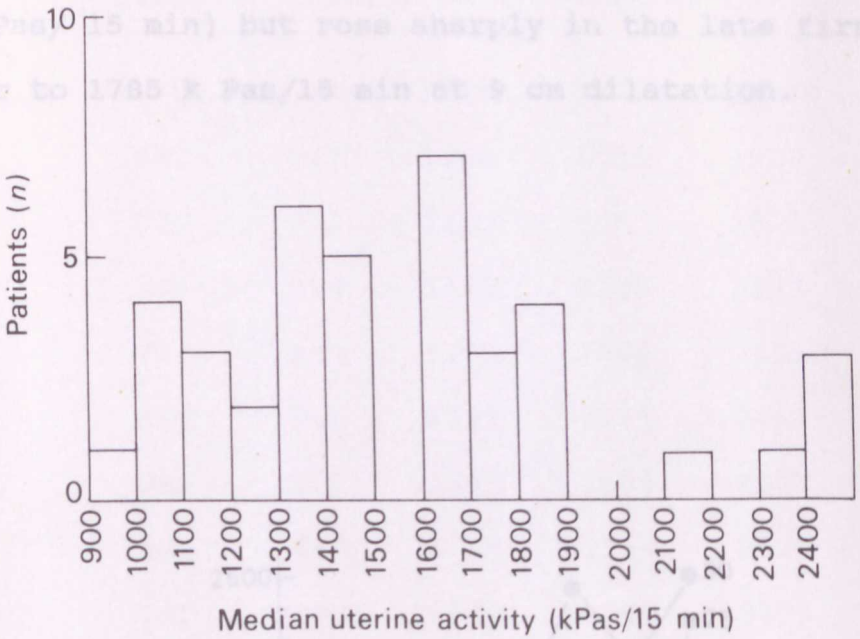


Fig 2.1-1 Median uterine activity of individual patients for the whole labour.

There were 427, 15 min readings available for overall pooled analysis to construct cervical dilatation specific uterine activity profile. As mentioned earlier 40 second 15 min readings were excluded when the profile was constructed in k Pas/15 min. Exploratory analyses of the data showed that some of the distributions of uterine activity values were asymmetrical when examined for various dilatation sizes. Distributions for dilatations of 5, 7 and 8 cm were found to be significantly skewed to the right while that for a dilatation of 9 cm was shown to be significantly platykuritic. Since it was inappropriate to use the arithmetic mean to summarize these values, the median (50 th centile) and other selected centile values were derived for

each set (Table.2.1-3) and is shown in Fig.2.1-2. The median value showed gradual increase from 3 cm cervical dilatation (1196 k Pas/ 15 min) but rose sharply in the late first stage of labour to 1785 k Pas/15 min at 9 cm dilatation.

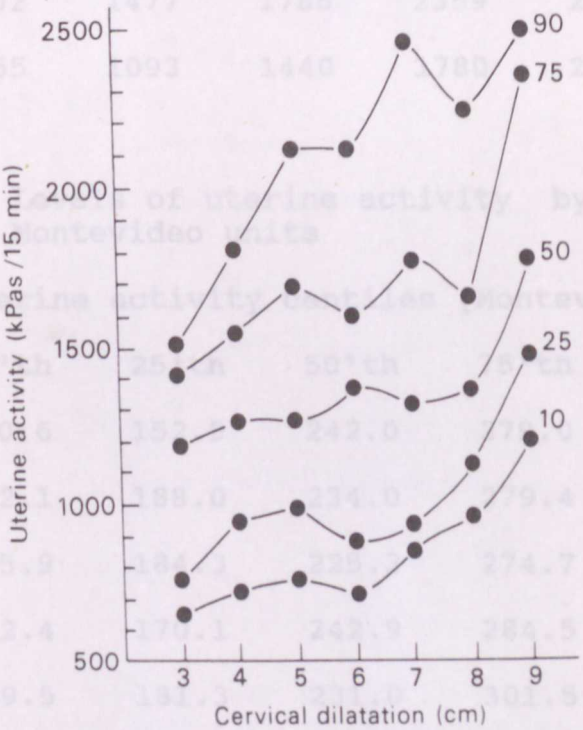


Fig 2.1-2. Cervical dilatation specific uterine activity in kPas/15 min in nulliparous spontaneous normal labour.

Table 2.1-3: Levels of uterine activity by centiles (excluding second reading) in k Pas/15 min

Cervical dilatation (cm)	Uterine activity centiles (k Pas/15 min) 10'th	25'th	50'th	75'th	90'th	No. of readings
3	650	767	1196	1419	1516	22
4	726	952	1270	1557	1813	37
5	764	995	1269	1700	2135	47
6	714	883	1375	1606	2125	50
7	853	940	1320	1775	2469	59
8	963	1127	1367	1658	2247	72
9	1202	1477	1785	2359	2500	100
3-10	855	1093	1440	1780	2375	387

Table 2.1-4: Levels of uterine activity by centiles in Montevideo units

Cervical dilatation (cm)	Uterine activity centiles (Montevideo units) 10'th	25'th	50'th	75'th	90'th	No. of readings
3	110.6	152.9	242.0	279.0	341.0	25
4	152.1	188.0	234.0	279.4	331.0	43
5	155.9	184.3	225.2	274.7	324.3	52
6	142.4	170.1	242.9	284.5	368.1	51
7	149.5	181.3	231.0	301.5	369.8	61
8	170.4	212.6	246.5	290.1	425.5	73
9	230.2	279.0	325.5	436.4	545.6	94
3-10	155.8	198.0	254.0	314.0	422.0	399

The uterine activity profile constructed in Montevideo units showed a similar profile with little increase from 242

MU/ 15 min at 3 cm to 246.5 MU/15 min at 8 cm and then a steep rise to 325.5 MU/ 15 min at 9 cm dilatation (Table 2.1-4 & Fig.2.1-3).

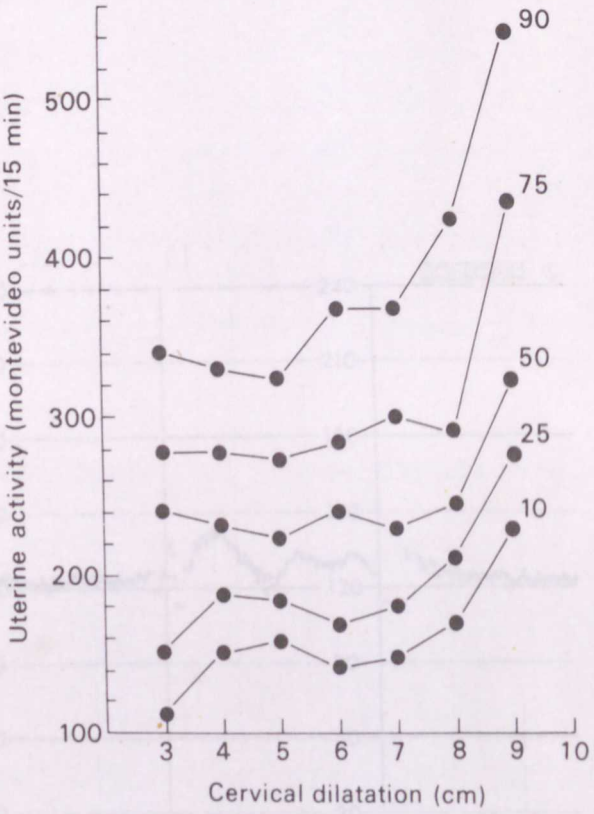


Fig 2.1-3. Cervical dilatation specific uterine activity in Montevideo units in nulliparous spontaneous normal labour.

Although in the majority of patients in normal labour the contraction pattern was regular in terms of frequency, starting with a lower frequency in early labour and increasing with advance of time, there were a few who had an irregular pattern.

Those who had the irregular pattern exhibited the same irregularity in most part of their labour. The degree of irregularity or inco-ordination varied from some coupling of contractions causing a hammock effect on the baseline between contractions to merging of contractions (Figs.2.1-4,5 & 6).

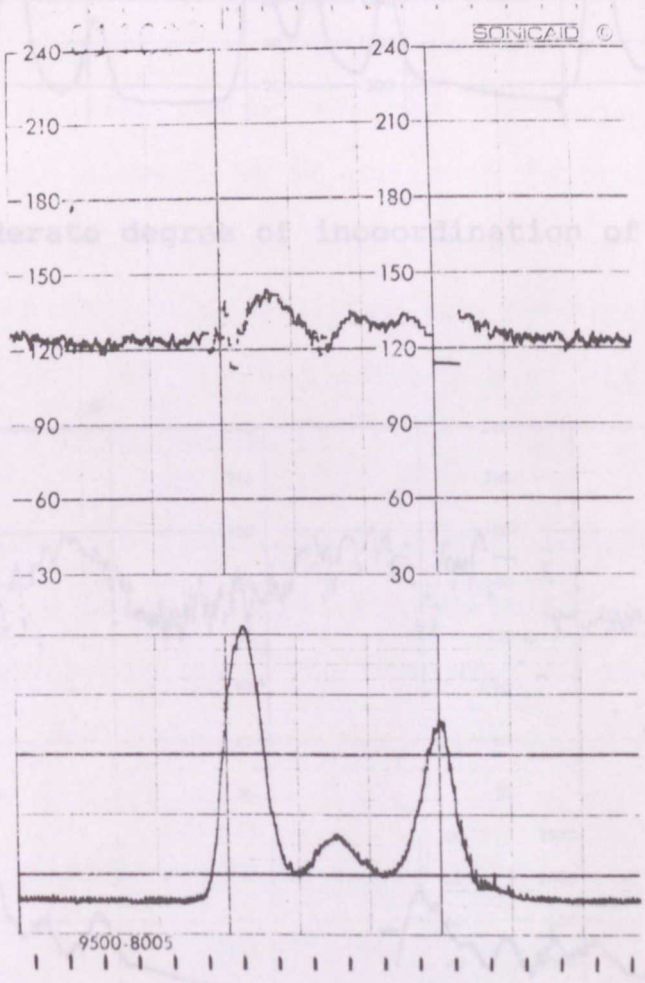


Fig 2.1-4 Minor degree of incoordination of contractions.

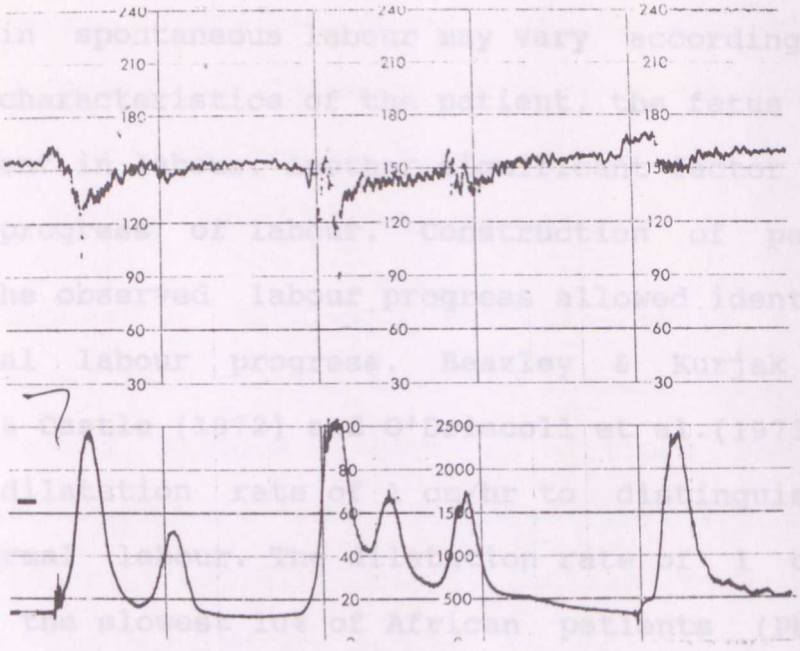


Fig 2.1-5. Moderate degree of incoordination of contractions.

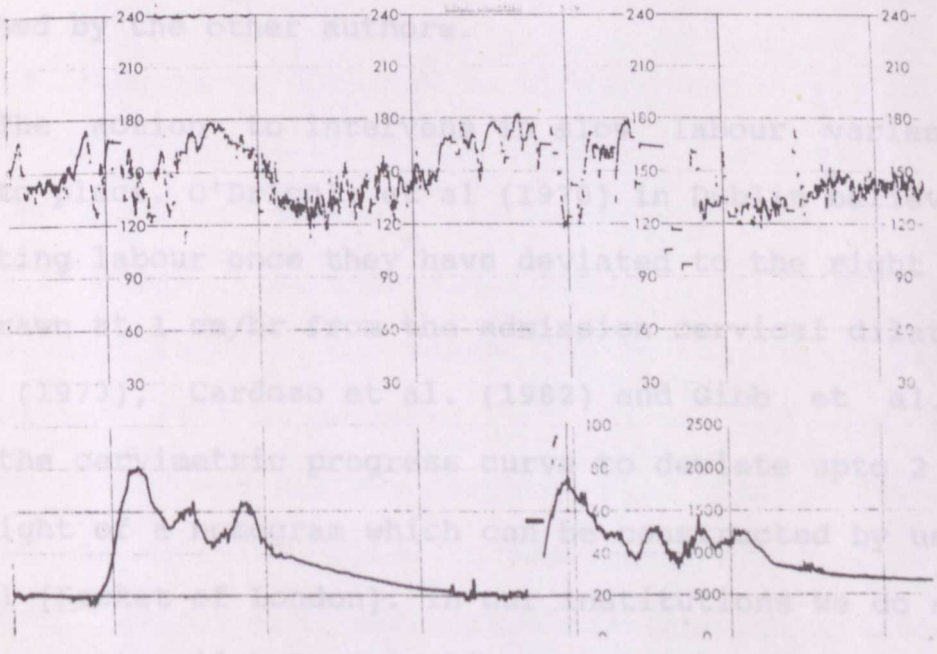


Fig 2.1-6. Severe degree of incoordination of contractions.

Discussion

The population studied was selected as the uterine activity in spontaneous labour may vary according to the physical characteristics of the patient, the fetus and how they present in labour. Another significant factor is the rate of progress of labour. Construction of partographs plotting the observed labour progress allowed identification of abnormal labour progress. Beazley & Kurjak (1972), Philpott & Castle (1972) and O'Driscoll et al.(1973) used a cervical dilatation rate of 1 cm/hr to distinguish normal from abnormal labour. The dilatation rate of 1 cm/hr was shown by the slowest 10% of African patients (Philpott & Castle 1972) and slowest 5% of patients in Friedmans (1955) study from the USA. Since our study was confined to Singaporean population we followed the nomogram constructed by Ilancheran et al. (1977) which was similar to that published by the other authors.

The action to intervene in slow labour varies from place to place. O'Dricoll et al (1970) in Dublin believes in augmenting labour once they have deviated to the right of the line drawn at 1 cm/hr from the admission cervical dilatation. Studd (1973), Cardozo et al. (1982) and Gibb et al.(1982) allow the cervimetric progress curve to deviate upto 2 hrs to the right of a nomogram which can be constructed by using a stencil (Rocket of London). In our institutions we do not use a labour stencil but use a line of 1cm/hr from admission cervical dilatation once the patient is in the active phase

of labour (alert line) and augment labour if they deviate to the right of a line drawn 2 hrs parallel (action line) to the expected progress line (Arulkumaran & Ingemarsson 1985a). In our study we considered all those who were to the left of the action line to have had normal labour as they had no oxytocic augmentation and delivered without assistance.

The pioneering studies by Caldeyro-Barcia & Poseiro (1960) suggested that uterine activity increased markedly as labour progressed. Studies by Cowan et al.(1982) and Steer et al.(1984) do not support these findings. They found a steep increase of uterine activity only in the late first stage of labour and our results are similar to the latter studies. Huey et al.(1976) and Miller (1983) made similar observations but their results are not comparable in view of the different study population, the use of a fluid filled catheter system and a different method of computation of uterine activity.

The results we obtained is closely comparable to that reported by Cowan et al.(1982) although our median value (1440 kPas/15 min) for the whole labour was lower than that reported by Cowan et al 1982 (1842 kPas/ 15 min). This may be due to several reasons. One reason may be that their patients were shorter (154 cm compared with 157 cm) and had a 38% incidence of forceps delivey compared with none in ours. They allocated all activity values to previously observed cervical dilatation rather than assuming a constant progression of labour described by Friedman (1955) whilst we allocated the

values in a progressive manner to the observed progress in cervical dilatation. We excluded the second activity value (whilst they did not) after insertion of the catheter for profile construction because it was much higher than the first or third values. This rise appeared to be related to rupture of membranes just prior to insertion of the catheter or due to stimulation of the cervix and lower uterine segment whilst inserting the catheter rather than related to the process of labour. This transient phenomenon was not observed when the activity was calculated in the Montevideo units (MU) and may be that changes occured in the elements that kPas units measure which MU do not measure. Mitchell et al.(1977) reported a rapid increase in peripheral plasma concentration of 13,14-dihydro-15-keto prostaglandin F soon after vaginal examination with or without amniotomy. Our observations may be a functional result of this phenomenon.

Despite these differences our results are more similar to that of Cowan etal.(1982) than Steer (1977). Steer (1977) considered an unspecified population and included induced labour and yet their values with a range of 700 to 1500 kPas/15 min were much lower than our values. The Sonicaid FM 3R fetal monitor calculates upto maximal values of 2500 kPas/15 min and we recorded such values on 35 occasions out of 417 observations.

With suitable modifications it is possible to record higher uterine activity values as Cowan et al.(1982) recorded

values of 3270 k Pas/15 min. We found no evidence of fetal distress with high uterine activity levels although Steer (1977) speculated that this is a possibility at levels above 1500 k Pas/15 min. In induced labour there could be some degree of placental compromise which may have been the indication for induction and high uterine activity may unmask this. Fetal distress is more of a relation of the fetoplacental reserve and the uterine activity rather than one related to fixed levels of uterine activity.

The results of this study on uterine activity in nulliparae was reported in 1984 (Gibb et al.1984). At the same time and following that there were some reports on the same subject (Steer et al.1984, Al-Shawaf et al.1987, Fairlie et al.1988). The values reported by Steer et al.1984 was lower while one from Scotland and the other from Saudi Arabia had values similar to that reported by us. Quantification in Montevideo units (MU) was done to permit comparison with results of Caldeyro-Barcia and Poseiro (1960) and to compare profiles of MU with those of k Pas/15 min. Our median activity level of 180 MU/10 min in late labour and 217 MU/10 min at 9 cm dilatation was similar to the level reported by Caldeyro-Barcia and Poseiro (1960). We did not find their observation of a steady rise of activity from 120 MU/10 min to 180 MU/ 10 min during the first stage of labour. Cowan et al.(1982) reported the mean overall level of 197 MU/10 min and not the detail profile to allow for comparison. Our profiles with MU and k Pas units were similar with a

correlation coefficient of 0.71 ($p < 0.001$) for relevant values (Chapter 1.4a).

The relative place of one or the other method of quantification of uterine activity has to be assessed in relation to it's clinical usefulness. Obviously an online system is preferable although similar profiles are obtained with different methods. MU do not consider the duration of contraction but both units depend on the recognition of baseline pressure which tends to vary throughout labour. The "hammock" effect and the prolonged descent of pressure during relaxation of a contraction increases the area under the curve but one is not sure whether they constitute useful work. A system that quantifies the area under the upswing and perhaps part of the downswing of the contraction curve may represent useful work. Tromans et al.(1982) considered this problem and suggested that quantification should cease when a threshold value of 5 mm Hg above the baseline was recognised. Caldeyro-Barcia and Alvarez (1962) found that pressures < 25 mm Hg did not lead to progress of labour and such pressures can be observed to persist after some contractions. Even if such finer calculation is not possible, it is important that the machine recognises a new baseline.

We observed marked variation in amplitude, duration, frequency and substantial degrees of inco-ordination of contractions with normal progress of labour as reported by Schulman and Romney (1970) and Effer et al.(1969). This is

not to deny that there is a significant relation between co-ordination and efficiency (Caldeyro-Barcia & Alvarez 1962) but to distinguish incoordinate uterine action from inefficent uterine action either of which may occur without the other. The efficiency of uterine contractions has to be assessed retrospectively based on the progress in cervical dilatation. Uterine activity measurements are unlikely to give additional useful information if partographic labour progress is normal. This is more so because of the wide range of uterine activity observed in normal labour.

In summary we found that in Chinese nulliparae, normal labour progress was associated with a minimal uterine activity of 855 k Pas/ 15 min and with an overall median level of 1440 k Pas/ 15 min. The wide range of activity and the different degrees of inco-ordination suggest that quantification of uterine activity in spontaneous normal labour may be of little value. Whether the knowledge of such values will be of use in managing induced labour or those in spontaneous labour with slow progress who need augmentation of uterine contractions have to be studied.

2.2 The influence of parity on uterine activity in spontaneous normal labour

Clinicians acknowledge that the multiparous woman with a previous vaginal delivery seems more likely to have an easy labour than her nulliparous counterpart. This may be due to a more advanced cervical dilatation on admission, more efficient uterine action, reduced cervical and pelvic tissue resistance or a combination of these factors. The functional difference between nulliparous and multiparous labour has been a subject of study for many years. Turnbull (1957) observed lower pressures associated with faster progress in the multiparous patient compared with the nulliparous. He proposed that this was due to the lower cervical and pelvic tissue resistance.

But the findings of Hendricks et al. (1970) and Duignan et al. (1975) indirectly support the theory that labour in multiparae may appear easier and shorter because of admission at advanced cervical dilatation. In cervimetric studies without intrauterine pressure measurements they found the multiparous labour to be shorter because the cervical dilatation on admission to hospital was greater compared with nulliparae and constant acceleration of the rate of progress led to apparently faster rates in those admitted in labour at more advanced cervical dilatation. But when corrected for admission cervical dilatation there was great similarity between the progress curves of nulliparae and multiparae. Steer et al.(1984) in a study on uterine activity in

spontaneous normal labour using modern technology reported similar cervical dilatation specific uterine activity profiles for nulliparae and multiparae. To clarify some of the conflicting evidence present and to establish the norms for our population we embarked on a study on uterine activity in multiparous labour. Since patients in different types of labour would be expected to exhibit different uterine activity profiles we confined our study to those in spontaneous labour with normal progress. Other than parity and type of labour; race, age, height of mother and birthweight of baby may have some influence. Our study was designed controlling for these factors.

Patients and methods

Multiparous women of Chinese origin who were atleast 152 cm tall and admitted at term in spontaneous labour to the University unit labour ward were considered for the study. If they had a singleton pregnancy in a vertex presentation informed consent was obtained after explaining the purpose and the conduct of the study. Those patients who were recruited but had oxytocin augmentation or had an operative delivery or had a neonate in poor condition were excluded from the study. These selection criteria were strictly adhered to inorder to, have a group of patients whose uterine activity profile can be compared to the uterine activity profile of nulliparae described in chapter 2.1.

Once they were in established labour with regular painful uterine contractions and an effaced, 3 cm (or more)

dilated cervix, the membranes were ruptured if they were still intact. The calibration of the catheter and insertion was performed as described in chapter 1.4. Data collection and analysis was similar to that described in the methodology section of chapter 2.1.

Results

The maternal and neonatal characteristics are given in table 2.2-1. Of the 40 patients, 30 had one previous vaginal delivery, 8 had 2 and 2 had 3 or more. The age group (mean age 27.9 years) and parity distribution of patients were representative of the multiparous population delivered in Singapore. The mean height was 157.3 cm, mean gestation 39 weeks and 5 days and mean birth weight of babies 3222 gms. All deliveries were unassisted and the babies were born in good condition. These parameters were compared with the nulliparous group who were studied previously (Chapter 2.1). The mean maternal age was 3 years older in the multiparous group and the mean birth weight was 50 g heavier. Maternal height, gestation, Apgar scores and umbilical vein pH values showed no significant differences. Table 2.2-2 shows the cervical dilatation on admission to the study; 78 % were admitted at or < 5 cm dilatation.

Table 2.2-1: Maternal and neonatal characteristics of the 40 study patients

	Mean	SD	Range
Age (years)	27.9	3.88	20 -36
Height (cm)	157.3	6.38	152 -170
Gestation (weeks)	39.6	1.07	37 -42
Birthweight (g)	3222.0	407.66	2500 -4200
Apgar score (1 min)	8.9	0.35	8.0 -10.0
Apgar score (5 min)	10.0	-	-
Cord venous blood pH	7.37	0.049	7.28 -7.46

Table 2.2-2: Distribution of the 40 patients by cervical dilatation size at admission

Dilatation size at admission (cm)	No. of patients n = 40	Cumulative %
3	13	33
4	8	53
5	10	78
6	6	93
7	3	100

Analysis of uterine activity

There were 334, 15 minute values of uterine activity of which 40 were excluded from profile construction because of excessively high values for the second 15 minute period. Exploratory analysis of the data showed that some of the distribution of uterine activity values was asymmetrical when examined for various dilatation sizes. Hence, the median (50th centile) and other selected centiles were derived for each set. Table 2.2-3 shows the uterine activity values tabulated in a dilatation specific manner and these values

are illustrated graphically in Fig.2.2-1.

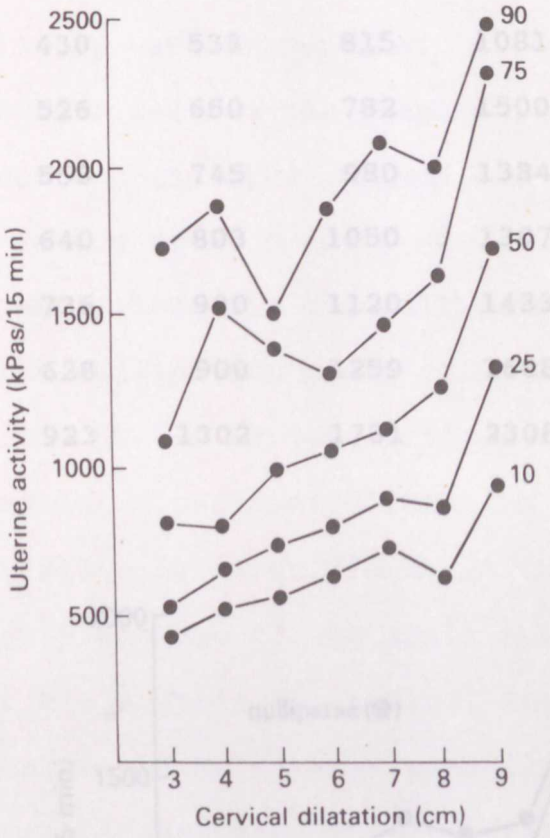


Fig 2.2-1. Cervical dilatation specific uterine activity in k Pas/15 min in multiparous spontaneous normal labour.

The median values increased slowly from 815 k Pas/ 15 min at 3 cm dilatation to 1259 k Pas/ 15 min at 8 cm dilatation but then rose sharply to 1731 k Pas/ 15 min at 9 cm dilatation. Values of 2500 k Pas/ 15 min occured on 23 occasions.

Table 2.2-3: Levels of uterine activity by centiles (excluding second reading)

Cervical dilatation (cm)	Uterine activity centiles (k Pas/15 min) 10th	25th	50th	75th	90th	No. of readings
3 - 9	623	800	1130	1560	2146	294
3	430	538	815	1081	1727	24
4	526	650	782	1500	1876	33
5	553	745	980	1384	1492	44
6	640	803	1050	1307	1859	41
7	736	900	1120	1433	2170	49
8	628	900	1259	1668	2020	49
9	923	1302	1731	2308	2500	54

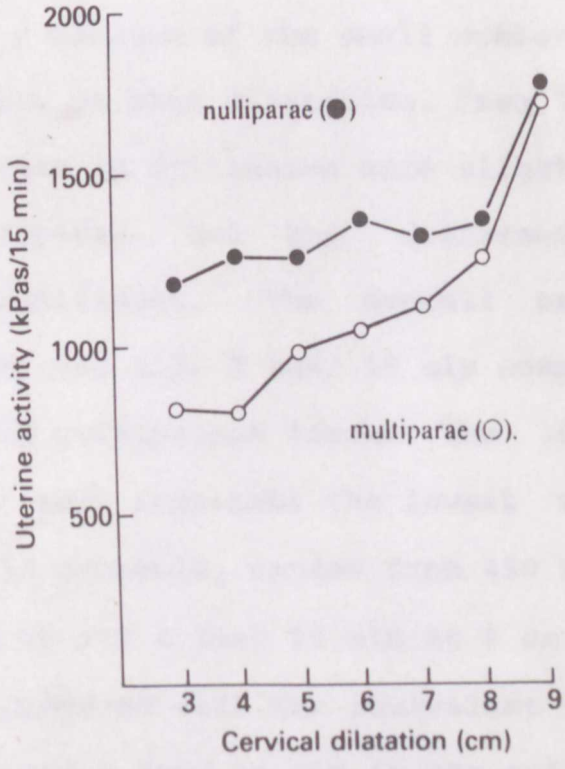


Fig 2.2-2. Comparison of uterine activity in nulliparous and multiparous labour (median values, 50th centiles).

Since there was no major differences between the population group studied and the nulliparous group in our earlier study; both groups having had spontaneous normal labour, the cervical dilatation specific uterine activity profiles were compared. The differences in median uterine activity levels by various cervical dilatation sizes are recorded in table 2.2-4 and the graphical representation of the median values for the study groups are shown in Fig 2.2-2. The median values at 3, 5 and 6 cm dilatation were shown to be significantly lower in the multiparous group compared with those in the nulliparous group using the non-parametric median test. Although the largest difference of 488 k Pas/ 15 min was recorded for a cervical dilatation of 4 cm, this was just not statistically significant at the 5 % level (p =0.0688) probably because of the small number of readings (n= 69) available at this dilatation. From 7 cm dilatation onwards, the values in multiparae were slightly lower than those in nulliparae but the differences were not statistically significant. The overall median value in multiparous labour was 1130 k Pas/ 15 min compared with 1440 k Pas/ 15 min in nulliparous labour. The 10th centile of activity, which may represent the lowest value at which normal progress is probable, ranged from 430 k Pas/ 15 min at 3 cm dilatation to 923 k Pas/ 15 min at 9 cm dilatation in the multiparae compared with the equivalent values of 855 k Pas/ 15 min and 1202 k Pas/ 15 min in the nulliparae.

Table 2.2-4: Differences in median uterine activity levels at various cervical dilatation

Cervical dilatation (cm)	Uterine activity (k Pas/ 15 min) Nulliparae	Multiparae	Difference	p
3	1196	815	381	0.0366L
4	1270	782	488	0.0688
5	1269	980	289	0.0402
6	1375	1050	325	0.0143
7	1320	1120	200	0.1629
8	1367	1259	108	0.5090
9	1785	1731	54	0.8603

Discussion

Turnbull (1957) reported that multiparae progressed in labour faster than nulliparae with lower pressures. But at that stage the graphical construction of the cervimetric progress of labour introduced by Friedman (1955) had not been delineated although it was about to gain universal acceptance, so cervical dilatation specific uterine activity was not available. Further, the results obtained in the past were with the fluid filled catheter which was recognised to have problems for reliable continuous recording because of possible blockage by vernix, mucus, meconium or blood clot. It was also our intention to quantify this online so that these values may not only be used for a study comparing it with nulliparous activity but could also be used in clinical practice. Excluding these details our findings on overall uterine activity in labour was in agreement with the findings

reported by Turnbull (1957).

Caldeyro-Barcia and Poseiro (1960) referred only indirectly to the effect of parity on uterine activity. Huey et al.(1976) found that multiparae expended 36% less uterine activity than the nulliparae from 3 cm cervical dilatation until delivery. We found the uterine activity to be significantly lower in multiparae compared with nulliparae till 6 cm cervical dilatation after which there was a steep rise in uterine activity values in both groups losing the significant difference; although the values in multiparae was always lower than that of nulliparae. The difference in observation between our study and that of Huey et al. (1976) may be due to our strict selection criteria based on maternal height, rate of progress of labour, normal vaginal delivery and the use of median (because of the wide scatter of uterine activity values for each cm cervical dilatation) rather than mean uterine activity value to construct the profile.

Steer et al.(1984) reported that uterine activity in nulliparae and multiparae were similar in spontaneous normal labour. This may be due to the fewer number of patients, low parity structure or other charecteristics attributable to the population they studied. After we reported our observations described in this chapter (Arulkumaran etal.1984a), Al-Shawaf et al (1987) reported similar findings, and they showed the uterine activity values to be significantly different in each cervical dilatation from 3 to 9 cm when the parity structure

was over 5. A recent report by Fairlie et al.(1988) adds confirmation to our finding that less uterine activity is required to effect vaginal delivery in multiparous patients than nulliparous patients. In our Singaporean Chinese multiparae, the lowest value likely to be associated with acceptable progress in labour was 430 k Pas/ 15 min at 3 cm dilatation. The overall median level of activity in the active phase was 1130 k Pas/ 15 min.

Until the late first stage of labour most of the uterine activity is expended to bring about effacement and dilatation of the cervix. In the late first stage and second stage of labour in addition to cervical dilatation, descent of the head takes place and the uterine activity needed may be higher than the rest of the labour as reflected by the steep rise in activity. Although uterine activity in multiparae was lower throughout labour it was significantly so until only the late first stage, suggesting that parity may have greater influence on the resistance offered by the cervix rather than the pelvic tissue.

With the descent of the head characteristic of the late first stage of labour (Friedman 1955) many multiparous patients commenced expulsive efforts which was clearly seen in tocographic traces. This urge to bear down is more likely to be a function secondary to descent of the head than to the cervix being 10 cm dilated. Examination of the tocographic recordings of patients who are 'pushing' shows that the area under the pressure curve contributed by

episodes of 'pushing' is negligible. In our previous study on nulliparae we have noted that even when uterine activity was quantified in Montevideo units, ignoring pressure due to 'pushing', a steep rise of activity occurs at 9 cm dilatation. Whilst pressure registered as a result of 'pushing' cannot strictly be described as uterine activity it is inseperable from it. This steep increase in activity in the late first and second stage of labour is due to stretching and dilatation of the upper vagina and cervix the " Ferguson reflex" (Ferguson 1941). Vascika et al.(1978) have shown that this is mediated by oxytocin release more of which is detected in the late first stage of labour.

2.3 Ethnic influence on uterine activity in spontaneous normal Labour

Physiological functions in man appear to be uninfluenced by ethnic differences when controlled for physical characteristics of the individual and environmental factors. Various physiological parameters like the blood pressure, heart rate, renal function etc. are found to be similar barring minor differences that can be accounted by differences in the individual physical characteristics. In the same ethnic group these parameters vary with varying physical characteristics. In contrast disease processes and degree of response to disease processes tend to be different in the different ethnic groups and this may be due to environmental factors and the genetic make up.

The rate of progress of labour has been shown to be similar in different ethnic groups living in the same environment (Duignan et al.1975). Although uterine activity in spontaneous normal labour for different ethnic groups living in different environment has been described (Cowan et al.1982, Gibb et al.1984, Steer et al.1984) there are no comparative studies. Such a study would be of interest especially if controlled for physical characteristics and the environmental influence. It is also of clinical relevance especially in Singapore because of the multiracial composition if we were to use the uterine activity profile derived from one ethnic group for management of another. So we studied uterine activity in a group of Malay patients

the second stage of labour and pain relief was by intramuscular pethidine 50 to 75 mg 4 to 6 hourly or by inhalation of a mixture of 50% oxygen and 50% nitrous oxide when required. Progress of labour was assesed by 2 to 3 hourly vaginal examination. Those dilating to the left of a line drawn 2 hours parallel to the right of the expected progress line of 1 cm/hr constituted the study population. Those dilating at a slower speed and had oxytocic augmentation, those who had epidural analgesia for pain relief, those who developed abnormal fetal heart rate pattern and those who needed operative delivery were excluded from the study. The active contraction area profile was quantified online every 15 min by the uterine activity integrator module incorporated into the fetal monitors. These values were allocated in a progressive manner to the observed progress in cervical dilatation.

Similar to the earlier studies, information of age, height, parity, period of gestation, Apgar scores at 1 and 5 min, cord arterial blood pH value and birthweight of the neonate were recorded in a computerised coding sheet soon after delivery, prior to transfer to the postnatal ward.

Uterine activity values were analysed individually and collectively using a computer program that could selectively analyse all or some of the values to derive centiles for each cervical dilatation. In an appreciable proportion of patients, the second 15 min reading after insertion of the

catheter was high compared with the first or the third reading and was not included for the profile construction. Cervical dilatation specific uterine activity values were analysed collectively and profiles constructed for nulliparae and multiparae.

The median uterine activity values in the Malays (35 nulliparae and 35 multiparae) were compared with those in 35 nulliparous and 35 multiparous Chinese women matched for maternal age, height and birthweight of infants reported in chapters 2.1 and 2.2 using the Mann-Whitney U test. The median uterine activity of Malay nulliparae was compared with that of Malay multiparae using the Mann-Whitney U test.

Results

The maternal and neonatal characteristics of the Malay population studied and those of the control Chinese women selected from the previous studies (Chapters 2.1 and 2.2) are shown according to parity in table 2.3-1.

Table 2.3-1: Maternal and neonatal characteristics of the population studied

	Nulliparae		Multiparae	
	Chinese n = 35	Malay n = 35	Chinese n = 35	Malay n = 35
Age in years	24.9(2.8)	24.1(3.2)	28.2(3.9)	27.2(4.1)
Height in cm	157.4(3.5)	156.4(3.9)	157.5(4.1)	156.9(2.6)
Gestational age in weeks	39.3(1.1)	39.0(1.5)	39.4(1.1)	39.6(1.4)
Birth weight in gms	3153(354)	3150(386)	3282(396)	3239(353)

Results are mean (SD) values.

There were no statistically significant differences between the Chinese and Malays in mean age , height, period of gestation or birthweight when controlled for parity. Of the 35 Chinese multiparae, 25 had one previous vaginal delivery, 8 had two, and 2 had three or more. Of the 35 Malay multiparae 27 had one, 6 had two,and 2 had 3 or more vaginal deliveries. In the parous women there was no difference in the parity between the Malays and the Chinese when compared by odds ratios. All the babies in the study had Apgar scores > 6 at 1 and 5 min. All the Malay babies had cord arterial blood pH values > 7.15 and in the Chinese cohorts all had umbilical vein blood pH values > 7.25.

The cervical dilatation specific uterine activity profiles of the Malay nulliparae and multiparae are shown in tables 2.3-2 and 2.3-3 respectively. A wide range of activity was associated with normal progress of labour. The median uterine activity values in the Malay nulliparae and multiparae were compared (Fig 2.3-1). The nulliparae had significantly higher uterine activity values than the multiparae except at 5 and 6 cm.

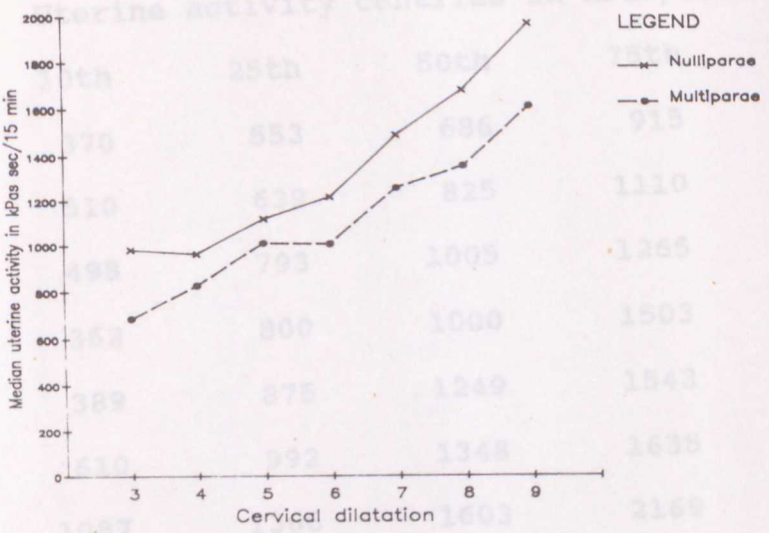


Fig 2.3-1. Cervical dilatation specific median uterine activity in Malay nulliparae and multiparae in spontaneous normal labour.

Table 2.3-2: Cervical dilatation specific uterine activity by centiles in Malay nulliparae

Cervical dilatation (cm)	Uterine activity centiles in kPas/15min					No of readings
	10th	25th	50th	75th	90th	
3	547	644	980	1492	2350	12
4	613	780	960	1430	1663	31
5	542	773	1113	1480	1745	44
6	640	890	1210	1530	2011	47
7	764	1112	1479	1871	2359	50
8	1101	1369	1670	2170	2407	50
9	1375	1550	1960	2500	2500	61
3-9	746	1000	1450	1940	2404	295

Table 2.3-3: Cervical dilatation specific uterine activity by centiles in Malay multiparae

Cervical dilatation (cm)	Uterine activity centiles in kPas/15 min					No of readings
	10th	25th	50th	75th	90th	
3	370	553	686	915	1070	16
4	510	639	825	1110	1265	24
5	498	793	1005	1265	1621	38
6	362	800	1000	1503	2066	41
7	389	875	1249	1543	1973	42
8	610	992	1348	1635	1820	44
9	1087	1366	1603	2169	2500	46
3-9	524	820	1165	1540	1983	251

Table 2.3-4: Cervical dilatation specific median uterine activity (k Pas/15 min) in Malay and Chinese population controlled for parity

Cervical dilatation (cm)	Nulliparae		Multiparae	
	Chinese n=35	Malay n=35	Chinese n=35	Malay n=35
3	1235(19)	980(12)	720(12)	686(16)
4	1256(34)	960(31)	781(31)	825(24)
5	1269(42)	1113(44)*	979(38)	1005(38)
6	1370(41)	1210(47)	1058(34)	1000(41)
7	1365(52)	1479(50)	1148(42)	1249(42)
8	1367(61)	1670(50)**	1375(43)	1348(44)
9	1870(87)	1960(61)	1681(44)	1603(46)
3-9	1440(336)	1450(295)	1140(252)	1165(251)

Number of readings for each cm dilatation excluding the second value is given in parenthesis.

* $p < 0.05$; ** $p < 0.01$.

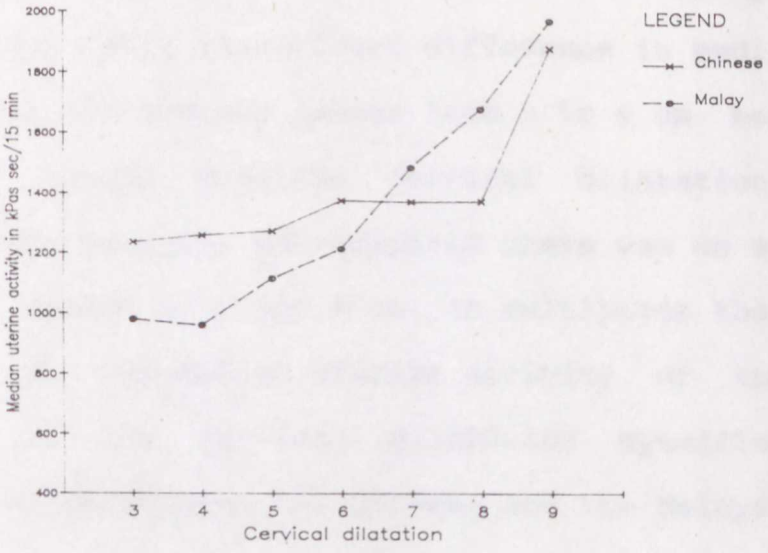


Fig 2.3-2. Cervical dilatation specific median uterine activity in Malay and Chinese nulliparae in spontaneous normal labour.

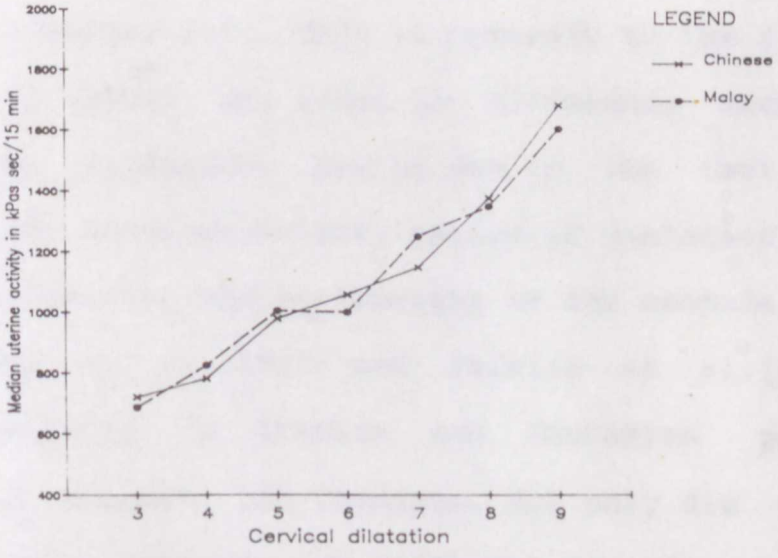


Fig 2.3-3. Cervical dilatation specific median uterine activity in Malay and Chinese multiparae in spontaneous normal labour.

The cervical dilatation specific median uterine activity in the Malay and Chinese population controlled for

parity is shown in table 2.3-4 and is illustrated graphically in Figs 2.3-2 and 2.3-3. In the nulliparae there was no statistically significant difference in median uterine activity for the overall labour from 3 to 9 cm between the two ethnic groups. When the cervical dilatation specific median uterine activity was compared there was no significant difference except at 5 and 8 cm. In multiparae there was no difference in the median uterine activity of the overall labour or of the cervical dilatation specific uterine activity profile between the Chinese and the Malays.

Discussion

Our findings of the difference in uterine activity profile between nulliparae and multiparae in the Malay population is similar to what we found in our Chinese population (Chapter 2.2). This is contrary to the finding of Steer et al.(1984) who found no difference according to parity. This difference may be due to the fact that we controlled for maternal height, period of gestation, rate of cervical dilatation and birthweight of the neonate. Studies by Al-Shawaf et al.(1987) and Fairlie et al.(1988) on uterine activity in Arabian and Caucasian populations respectively support our findings. Not only did they find that the uterine activity was different according to parity, but their reported absolute values according to parity were similar to the findings in the Malay population (Chapter 2.3/ Arulkumaran et al.1989a) and that described in our Chinese population (Chapter 2.1/Gibb et al.1984, Chapter

2.2/Arulkumaran et al.1984a).

Our findings that the uterine activity profile in spontaneous normal labour in our Malay population was similar to that of our Chinese when controlled for parity, certain maternal characteristics and the rate of progress of labour lends support to the hypothesis that the human uterus acts in a similar way in different races. Short maternal stature, abnormal pelvic shape, fetal macrosomia and other 'pathological variables' such as uterine fibroids may lead to ethnic differences more apparent than real. It is therefore reasonable to believe that normal profiles may be applied to many racial groups when controlled for certain characteristics and it may contribute to management when intrauterine pressure monitoring is used.

2.4 Uterine activity with breech presentation

Due to fear of causing perinatal death or morbidity due to birth injury or asphyxia at the time of assisted vaginal delivery the incidence of caesarean delivery for breech presentation has increased to nearly 80 % (Quilligan & Zuspan 1982). But centres with a liberal attitude to caesarean section with rates of 30 to 40 % has reported little increase in perinatal morbidity or mortality (Svenningsen et al. 1985). Such centres opt for vaginal delivery when met with certain safety criteria; good pelvic measurements, optimal size of the fetus, satisfactory progress of labour and appropriate facilities for fetal monitoring (Hill et al. 1976, Goldenberg & Nelson 1984, Eilen et al. 1984, Svenningsen et al. 1985, Gimovsky et al. 1985).

Normal progress in spontaneous labour with breech presentation has been found to be similar to control vertex presentation in nulliparae and slightly longer in multiparae (Duignan 1982, Borten 1983). But little information is available about uterine activity in spontaneous labour progressing normally with breech presentation. This may be important because if labour progress is abnormal with levels of uterine activity similar to that found in patients with normal progress, it may indicate the possibility of fetopelvic disproportion. On the other hand if suboptimal uterine activity is found with abnormal progress of labour and if one is satisfied with the fetopelvic relationship and the condition of the baby, it may be reasonable to augment

the uterine activity to normal levels and to give a short trial of labour.

In order to do this the uterine activity observed cannot be compared with uterine activity profile derived from patients with vertex presentation, as the presentation may influence the uterine activty even when controlled for parity and rate of progress of labour. We conducted a study to establish the uterine activity in spontaneous labour with breech presentation who had normal progress resulting in vaginal delivery of neonates in good condition. These values could form the basis to decide whether uterine activity was normal or abnormal prior to deciding on augmentation. These values were also compared with uterine activity observed in patients with vertex presentation (Chapters 2.1 and 2.2) controlled for parity, progress of labour and certain patient characteristics to find the influence if any of breech presentation on uterine activity in labour.

Patients and methods

Women with singleton breech presentation at term admitted in spontaneous labour to the University unit labour ward were considered for the study. If clinical assessment and X - ray pelvimetry showed an adequate pelvis (an anteroposterior pelvic inlet > 11.5 cm) and the size of the fetus was considered to be not more than 3500 g, informed consent was obtained and the patient recruited for the study. When the patient entered the active phase of labour (cervix

effaced and 3 or more cm dilated), the membranes were ruptured if they were intact after excluding cord presenation and high presenting part. A sterile transducer tipped Gaeltec catheter was calibrated and introduced into the uterine cavity as described in chapter 1.4. Whenever possible a fetal electrode was applied to the heel or buttock avoiding the genitalia or toes for continuous monitoring of the fetal heart rate. An external ultrasound transducer was used when this was not possible.

Progress of labour was assessed by 2 to 3 hourly vaginal examination inorder to proportionatley allocate the recorded uterine activity values to the observed cervical dilatation. Patients were considered to be progressing satisfactorily if the rate of cervical dilatation was to the left of a line drawn 2 hrs parallel to a rate of cervical dilatation of 1 cm/hr from the admission cervical dilatation. Those whose progress was slow and was to the right of this line had their labour augmented or were delivered by caesarean section and were excluded from the study.

Patients were nursed in the lateral position. Pain relief was by pethidine 50 to 75mg IM 4 to 6 hourly or by entonox (50% nitrous oxide and 50% oxygen) inhalation. Those who had epidural analgesia were not included in the analysis. When the patient complained of bearing down sensation, the dilatation of the cervix was checked and if it was fully dilated the catheter was removed and patient allowed to bear down in the dorsal position. Assisted breech delivery was

carried out by the specialist or senior resident on duty. The information of patient's age, parity, height, period of gestation and cervical dilatation specific uterine activity were recorded in a computerised coding sheet. Prior to transfer from the labour ward, the neonatal chracteristics of Apgar scores at 1 and 5 min, cord arterial blood pH values and birth weight of the baby were added to the record. The uterine activity values were analysed according to parity in a cervical dilatation specific manner, pooling the values for a specific dilatation. A TRS-80 model II microcomputer with a programme that could selectively analyse all, or some of the values, was used to derive percentiles for each cervical dilatation. Individual median values were obtained for each labour unrelated to cervical dilatation.

The values so obtained for a specific dilatation and for the entire labour in nulliparae and multiparae were compared using the Mann Whitney U test for nonparametric statistical evaluation. From the previously reported series of uterine activity in nulliparae and multiparae with a vertex presentation (Chapter 2.1 and 2.2), cervical dilatation specific median uterine activity values were derived from a control group of patients. They were controlled to have similar maternal age, height, duration of gestation, rate of progress of labour and neonates with good Apgar scores like the patients studied with a breech presentation. These values were compared with the median values obtained for breech presentation according to parity

using the Mann Whitney U test to evaluate any possible effect of breech presentation on uterine activity.

Results

The set criteria were met by 20 nulliparae and 12 multiparae with breech presentation during the period of study. The patient and neonatal characteristics of these patients and their controls are shown in table 2.4-1. By design there was no significant difference in height or parity. Within each parity group the mean birth weight, as expected was lower in the cases with breech presentation. All Apgar scores at 1 min was over 4 and at 5 minutes was over 6 and most cord arterial blood pH values were above 7.15. But the mean cord arterial blood pH values were significantly lower in breech deliveries ($p < 0.001$)(Table 2.4-1).

Table 2.4-1: Patient and neonatal characteristics

	Nulliparae		Multiparae	
Presentation	Breech n=20	Vertex n=20	Breech n=12	Vertex n=12
Patient & neonatal characteristics				
Mean height in cm	154.3(6.0)	156.2(3.2)	156.8(4.7)	157.2(3.9)
Mean parity	0	0	1.8(0.9)	1.3(0.5)
Mean 1 min Apgar score	7.7(1.6)	8.9(0.3)	6.7(2.5)	9.9(0.3)
Mean 5 min Apgar score	9.7(0.8)	10.0	8.9(1.7)	10.0
Mean cord arterial blood pH	7.23(0.09)*	7.32(0.05)	7.24(0.08)*	7.33(0.04)
Mean birth weight in gm	2974(403)	3168(320)	3184(294)	3268(430)

* $p < 0.001$. Values are means (SD).

The cervical dilatation specific 50th percentile uterine activity values in breech presentation, according to parity are given in table 2.4-2 and shown in Fig 2.4-1. At all cervical dilatations the uterine activity was lower in multiparas but reached significance only at 7 cm dilatation ($p < 0.05$). But when the uterine activity for the whole labour was considered (3 to 9 cm dilatation) it was significantly lower in multiparas ($p < 0.05$).

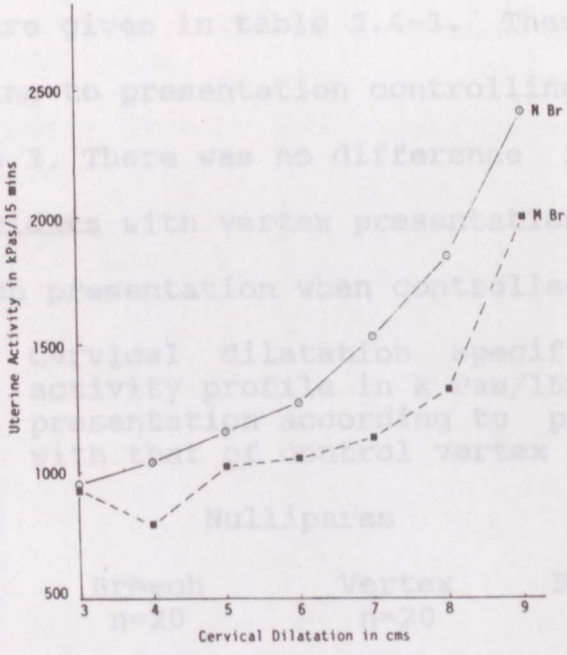


Fig. 2.4-1. Cervical dilatation specific median uterine activity in nulliparae and multiparae with breech presentation.

N Br. Nulliparae breech M Br - Multiparae breech.

Table 2.4-2. Cervical dilatation specific median uterine activity values in k Pas/15min in breech presentation according to parity

Cervical dilatation	3cm	4cm	5cm	6cm	7cm	8cm	9cm	3-9cm
Nulliparas n=20 (318 readings)	945	1039	1158	1270	1530	1843	2415	1290*
Multiparas n=12 (200 readings)	930	790	1020	1050	1125	1317	2000	1128*

* $p < 0.05$

The cervical dilatation specific median uterine activity values of the controls along with that of their respective counterparts with breech presentation according to their parity are given in table 2.4-3. These values were compared according to presentation controlling for parity in Figs. 2.4- 2 & 3. There was no difference in the uterine activity in patients with vertex presentation compared with those with breech presentation when controlled for parity.

Table 2.4-3: Cervical dilatation specific uterine activity profile in k Pas/15min in breech presentation according to parity compared with that of control vertex presentation

Parity	Nulliparas		Multiparas	
Presentation	Breech n=20	Vertex n=20	Breech n=12	Vertex n=12
Cervical dilatation				
3cm	945	1179	930	759
4cm	1039	1213	790	825
5cm	1158	1155	1020	1008
6cm	1270	1185	1050	1040
7cm	1530	1310	1125	1040
8cm	1843	1334	1317	1160
9cm	2415	1826	2000	1712
3-9cm	1290	1381	1128	1036

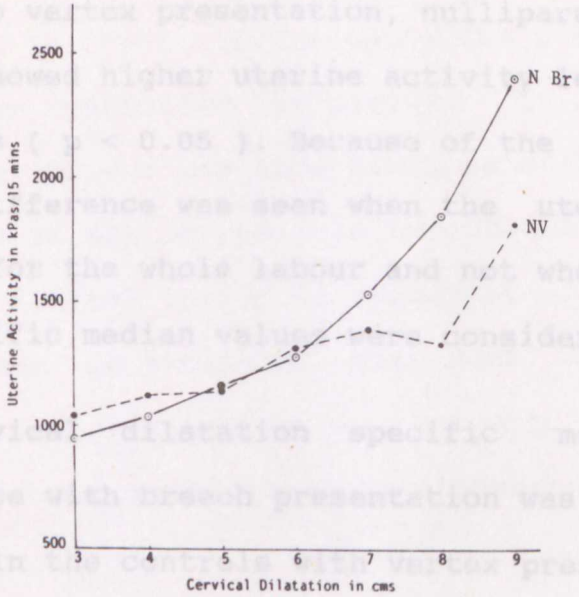


Fig 2.4-2. Cervical dilatation specific median uterine activity in nulliparous breech and vertex presentation.

N Br - Nulliparae Breech N V - Nulliparae Vertex

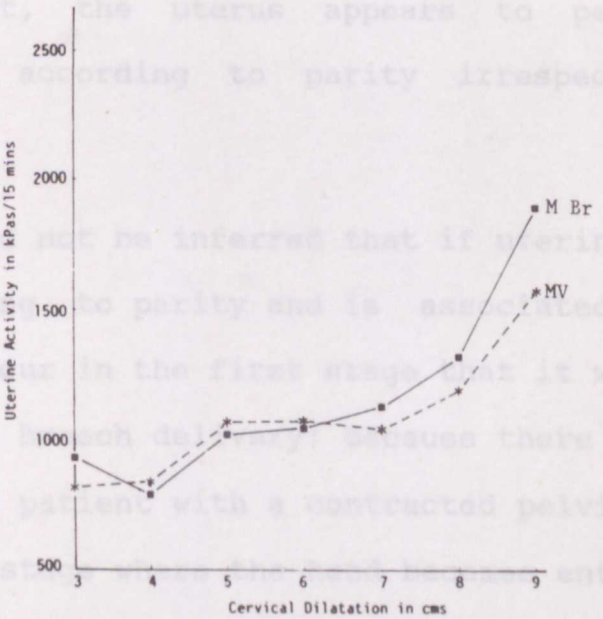


Fig 2.4-3. Cervical dilatation specific median uterine activity in multiparae with breech and vertex presentation.

M Br - Multiparae Breech M V - Multiparae Vertex

Discussion

Similar to vertex presentation, nulliparas with breech presentation showed higher uterine activity levels compared with multiparas ($p < 0.05$). Because of the small numbers studied this difference was seen when the uterine activity was calculated for the whole labour and not when the cervical dilatation specific median values were considered.

The cervical dilatation specific median uterine activity in those with breech presentation was not different to that found in the controls with vertex presentation when controlled for parity. Although the numbers were too small to subdivide them into subgroups with various forms of breech presentation, it appears that, for a similar speed of cervical dilatation and satisfactory descent of the presenting part, the uterus appears to perform similar uterine work according to parity irrespective of the presentation.

It should not be inferred that if uterine activity is normal according to parity and is associated with normal progress of labour in the first stage that it will result in a safe assisted breech delivery; because there is literature showing that a patient with a contracted pelvis can deliver quickly to the stage where the head becomes entrapped in the small pelvis (Beischer 1966). We used strict inclusion criteria regarding pelvic measurements and fetal size resulting in good outcome. It is known that the cervimetric

progress in breeches is almost similar to vertex presentation (Duigan 1982, Borten, 1983) and this study presents evidence to suggest that in these circumstances the uterine activity is similar when controlled for parity. In patients with breech presentation who has slow progress of labour and low uterine activity it may be possible to achieve a safe vaginal delivery with a limited period of augmentation if fetopelvic disproportion can be excluded. With such management good results have been reported in patients with breech presentation from our institution (Arulkumaran et al, 1989b).

3 UTERINE ACTIVITY IN AUGMENTED NORMAL LABOUR

3.1 AUGMENTATION OF LABOUR - MAGNITUDE OF THE PROBLEM AND OBSTETRIC OUTCOME IN CURRENT PRACTICE WHEN LABOUR IS MANAGED BY EXTERNAL TOCOGRAPHY

3.2 UTERINE ACTIVITY IN DYSFUNCTIONAL LABOUR AND TARGET UTERINE ACTIVITY TO BE ACHIEVED WITH OXYTOCIN TITRATION

3.3 OXYTOCIN TITRATION TO ACHIEVE PRESET ACTIVE CONTRACTION AREA VALUES COMPARED WITH PRESET FREQUENCY OF CONTRACTIONS TO ACHIEVE BETTER OBSTETRIC OUTCOME

3.4 DOES INTERNAL TOCOGRAPHY RESULT IN BETTER OBSTETRIC OUTCOME COMPARED WITH EXTERNAL TOCOGRAPHY

3.1 Augmentation of labour - Magnitude of the problem and obstetric outcome in current practice when labour is managed by external tocography

Progressive cervical dilatation and descent of the fetal head are prerequisites for a normal vaginal delivery. The cervix dilates in 2 phases. The first phase, latent phase, is associated with shortening in length (effacement) of the cervix from about 3 cm to less than 0.5 cm concomitant with dilatation from 0 to 3 cm. In the second phase (active phase) the cervix dilates from 3 to 10 cm and is fairly rapid at an approximate rate of 1 cm per hour. These cervical dilatation patterns in normal labour have been studied in different population groups (Studd et al. 1975, Illancheran et al.1977) and the active phase of cervical dilatation has been found to be almost similar in different ethnic groups in nulliparae and multiparae (Duignan et al 1975). Based on median values of different studies abnormal progress of labour has been described and is identified with the use of partograms (Arulkumaran & Ingemarsson 1985a).

Though the deviation from the norm may be due to relative or absolute disproportion between the presenting part of the fetus and the maternal pelvis, more often than not it is due to inefficient uterine contractions (Steer et al 1985b, Arulkumaran et al 1991b). Early recognition of abnormal progress of labour and active management with the use of oxytocin infusion to augment uterine contractions has led to reduction in the incidence of prolonged labour, fetal

and maternal infection, operative deliveries and poor fetal outcome (O'Driscoll et al.1970).

Use of partogram and augmentation with oxytocin is accepted practice when labour progress is deviating from the norm based on an expected progress line constructed by a stencil or by an arbitrary line drawn at 1 cm per hour from the admission cervical dilatation (Cardozo et al, 1982, Arulkumaran & Gibb 1987b). However, opinion differs as to how long after the deviation occurs should one start oxytocin and for how long one should augment labour.

Some allow a 2-hour grace period to the right of the expected progress line before augmenting (i.e. a speed less than 1 cm in 3 hours) (Arulkumaran and Ingemarsson 1985a) while others augment as soon as the progress deviates from the normal (O'Driscoll et al 1970). Practice also varies as to the duration of augmentation. The value of prolonging the period of augmentation in patients with unsatisfactory progress of labour in the first 4 hours of augmentation is not established. One aim of this prospective study was to identify the magnitude of the problem as to what percentage of our population needs augmentation. Secondly it was to evaluate the benefits, measured in terms of mode of delivery and neonatal condition, in prolonging the augmentation period for another 4 hours in patients with unsatisfactory progress of labour during the initial 4 hrs, the whole labour being managed by external tocography.

Patients and methods

Patients admitted in spontaneous labour to the labour ward at Kandang Kerbau Hospital, Singapore, under the care of the University Depatment of Obstetrics and Gynaecology were considered for the study. Those with malpresentation and multiple pregnancy were excluded. Once the patient reached the active phase of labour (cervix effaced and 3 cm dilated) she was recruited for the study. An artificial rupture of the membranes was performed (if membranes were intact) and the admission dilatation marked on the partogram. An expected progress line at a speed of 1 cm per hour was drawn (alert line) followed by an action line drawn 2 hours parallel and to the right of the alert line. The progress of labour was reviewed at 4 hourly intervals by an abdominal examination for the descent of the head and by a vaginal examination for cervical dilatation. Uterine contractions by external tocography and fetal heart rate by an ultrasound transducer was observed by continuous electronic fetal monitoring.

If the progress of labour was to the left of the action line labour was allowed to progress spontaneously. If the progress of labour was to the right of the action line, the patient was diagnosed to have dysfunctional labour and an oxytocin infusion of 2 mu per min was started using an 'IVAC' peristaltic infusion pump. The dose rate was escalated by 2 mu per min every 30 min until uterine contractions were 1 in 2 to 2 1/2 min. The oxytocin dose was reduced when fetal heart rate abnormalities or uterine hyperstimulation was

observed.

Four hours after the commencement of oxytocin, a vaginal examination was performed to assess the progress of labour. The dysfunctional labour was considered to be corrected and the labour progress satisfactory in patients with a cervical dilatation of 1 cm or more per hour. Patients with slower rate of cervical dilatation were considered to have unsatisfactory progress of labour. Both these groups were reviewed at 4 hourly intervals and the obstetric outcome in terms of mode of delivery, indication for operative delivery and the neonatal outcome assessed by Apgar scores and the need for admission to neonatal intensive care unit for reasons of birth asphyxia or birth injury were recorded before the patient was discharged from the hospital.

The data was analysed in relation to the parity and the type of dysfunctional labour in the active phase. If the progress was slow from the time of admission and was to the right of the action line it was termed primary dysfunctional labour (PDL). If the labour progressed normally in the early active phase but subsequently failed to progress or progressed slowly prior to full dilatation of the cervix, it was termed secondary arrest of labour (SAL).

Results

Over a 5 month period 2,803 patients were admitted in spontaneous labour. Patients with multiple pregnancy,

malpresentation, preterm labour, or antepartum haemorrhage were excluded leaving 2,518 patients satisfying the study criteria. Progress of labour judged by progressive cervical dilatation was within the action line in 2,199 (87.3%) patients. Labour was augmented with oxytocin in 319 (12.7%) patients crossing the action line. These patients formed the study group and consisted of 220 nulliparas (19.0% of all nulliparae admitted in labour) and 99 multiparas (7.3% of all multiparae admitted in labour) (Table 3.1-1). Of those with abnormal labour progress 94.5% of nulliparas and 90.9% of multiparas had PDL whilst 5.5% of nulliparas and 9.1% of multiparas had SAL. Epidural analgesia was used in 2% of patients in this series and there was no case of uterine rupture.

Table 3.1-1: Type of abnormal labour according to parity

Progress of labour	Nulliparas n=1158	Multiparas n=1360	Total n=2518
Normal progress	938(81.0)	1261(92.7)	2199(87.3)
Abnormal progress	220(19.0)	99(7.3)	319(12.7)
Type of abnormal labour	n = 220	n=99	n=319
Primary dysfunctional labour (PDL)	208(94.5)	90 (90.9)	298(93.7)
Secondary arrest of labour (SAL)	12(5.5)	9 (9.1)	21 (6.3)

% is given in parenthesis

The progress of labour at the end of the first 4 hours of augmentation in the 220 nulliparas with abnormal labour is shown in Table 3.1-2. Of the 208 with PDL, 135(64.9%)

responded well with satisfactory progress (1cm or more per hour) after oxytocin augmentation; the corresponding figure for patients with SAL was 75.0%. Patients with PDL needed significantly higher doses (mean values) of oxytocin than those with SAL.

The mode of delivery and neonatal outcome is given in table 3.1-2. Those mothers with PDL and unsatisfactory labour progress after 4 hours of augmentation (35.1%), had shorter maternal height, needed a higher dose of oxytocin and had a longer labour compared with those whose labour progress in response to oxytocin was satisfactory. Only half in the former group (51.7%) had vaginal delivery after prolonging the period of augmentation, compared to 98.5% in the group with satisfactory labour progress noted in the first 4 hours of augmentation. In nulliparas, with SAL no diffrences in height of mothers, birth weight of babies, dose of oxytocin, or duration of labour were observed between those who had satisfactory or unsatisfactory progress of labour following augmentation. All with satisfactory progress to augmentation delivered vaginally, whilst only one third of those with unsatisfactory labour progress delivered vaginally when additional time was given. However, the results in this group (SAL) has to be interpreted with caution due to the small numbers involved.

Table 3.1-2: Obstetric characteristics, mode of delivery, and neonatal outcome in 220 nulliparas with abnormal labour augmented with oxytocin

Type of labour before augmentation	Primary dysfunctional labour n=208		Secondary arrest of labour n=12	
Labour progress after augmentation	Satis. n=135(64.9)	Unsatis. n=73(35.1)	Satis. n=9(75.0)	Unsatis n=3(25.0)
Mean height of mother in cm (SD)	156.1(5.3)	154.1(4.8)**	156.1(3.7)	152.5(6.4)
Mean birthweight of baby in gms(SD)	3203(391)	3251(402)	3444(281)	3360(115)
Mean duration of labour in hrs(SD)	9.4(3.4)	14.9(4.2)***	10.8(2.8)	13.7(1.8)
Mean maximum dose of oxytocin in mu/min(SD)	9.3(3.5)	14.0(7.6)***	6.7(2.5)	9.3(3.1)
Normal vaginal delivery (%)	89(65.9)	16(21.9)	4(44.4)	0
Instrumental vaginal delivery (%)	44(32.6)	21(28.7)	5(45.6)	1(33.3)
Lower segment Caesarean section(%)	2(1.5)	36(49.3)	0	2(66.6)
Apgar score < 7 at 5 min	1	1	0	0

Satis. - Satisfactory

Unsatis. - Unsatisfactory

** p < 0.01 : *** p < 0.001 (paired t-test)

Total n =220;

Normal vaginal delivery n=109(49.5%),

Instrumental vaginal delivery n=71(32.3 %) and

Caesarean section n=40(18.2%).

Multiparas responded better to oxytocin augmentation; 86.7% of the patients with PDL and 55.6% of the patients with SAL had satisfactory labour progress after augmentation (Table 3.1-3). Patients with SAL had significantly heavier babies. The 12 multiparas with PDL and an unsatisfactory labour progress after 4 hours of augmentation had a longer duration of labour and higher dose of oxytocin compared to those with satisfactory labour progress. Such differences were not observed in those with SAL. All 83 patients (PDL=78, SAL=5) but one with satisfactory progress of labour to oxytocin augmentation were delivered vaginally. When the response to oxytocin augmentation was unsatisfactory, despite additional time, 58.3% of those with PDL and 75.0% with SAL needed a Caesarean section.

When the results were analysed based on parity without categorising into different types of abnormal labour, 144 (65.5%) of the nulliparas showed good progress of labour to oxytocin augmentation and in this group the caesarean section rate was only 1.4%. In comparison, in the group who did not progress satisfactorily after augmentation (76 patients) half of the cases (50.0%) needed abdominal delivery. In multiparas the trends were similar with a low caesarean section rate (1.2%) in the group with satisfactory progress of labour and a high rate (62.5%) in those with poor progress with augmentation. The majority of nulliparas (81.8%) and multiparas (88.9%) with dysfunctional labour were delivered

vaginally after oxytocin augmentation. There were only 2 cases of birth asphyxia, both in nulliparas with PDL, one in the group who progressed satisfactorily, the other in the group with poor progress despite augmentation.

Table 3.1-3: Obstetric characteristics, mode of delivery and Neonatal outcome in Multiparas with abnormal labour augmented with oxytocin

Type of labour before augmentation	Primary dysfunctional labour n=90		Secondary arrest of labour n=9	
Labour progress after augmentation n = (%)	Satisfact. 78(86.7)	Unsatisfact. 12(13.3)	Satisfact. 5(55.6)	Unsatisfact 4(44.4)
Mean height of mother in cm (SD)	155.1(5.1)	154.3(5.8)	155.0(3.7)	155.3(7.0)
Mean birth weight of baby in gms (SD)	3174(408)	3211(414)	3490(533)	3818(149)
Mean duration of labour in hrs(SD)	7.8(3.6)	13.7(7.3)***	7.6(3.9)	9.6(3.8)
Mean maximum dose of oxytocin in mu/min(SD)	7.4(2.6)	10.7(4.9)***	7.6(3.0)	5.5(1.0)
Normal vaginal delivery(%)	66(84.6)	3(25.0)	3(60.0)	0
Instrumental vaginal delivery (%)	11(14.1)	2(16.6)	2(40.0)	1(25.0)
Caesarean section(%)	1(1.3)	7(58.3)	0	3(75.0)
Apgar score < 7 at 5 min	0	0	0	0

*** $p < 0.0001$ (paired t-test).
Satisfact. - Satisfactory. Unsatisfact. - Unsatisfactory.

Total n=99
Normal vaginal delivery 72 (72.7%);
Instrumental vaginal delivery 16 (16.2%);
Caesarean section 11 (11.1%).

Discussion

Recent reports have highlighted dystocia and previous Caesarean section as major contributory factors for rising caesarean section rate (Yudkin & Redman 1986, Arulkumaran et al.1985b). Dystocia is predominantly due to inadequate uterine contractions and to a lesser extent due to cephalopelvic disproportion, malposition or a combination of these. Steer et al.(1985b) quantifying uterine activity reported that 75% of patients with slow progress (< 1 cm in 3 hours) in the active phase of labour had lower than 10'th percentile uterine activity observed in spontaneous normal labour. In our study 81.8% of nulliparas and 88.9% of multiparas with dysfunctional labour delivered vaginally with oxytocic augmentation suggesting that poor uterine contractions was the major cause of abnormal labour progress.

When labour fails to progress normally, rarely does one find obvious problems in the passenger such as malpresentation or a recognisable abnormality in the passage. Unsatisfactory pelvic shape and suboptimal dimensions of vertex presentation due to various degree of extension of the head are difficult to recognise. Based on the results observed it is likely that dystocia in the majority of patients is due to weak contractions or minimal disproportion, which is corrected by further flexion, moulding and 'pelvic give' which is achieved by oxytocic augmentation.

The types of dysfunctional labour are often thought to signify the underlying problem for the slow labour. Primary dysfunctional labour, where there is a slow progress from the onset of the active phase, is thought to be due to poor contractions. Secondary arrest of labour, where the labour progresses satisfactorily in the early active phase but later slows down or fails to progress, is thought to be due to cephalopelvic disproportion either genuine with a well flexed head or relative because of malposition and deflexed head. In secondary arrest of labour the subsequent weak contractions at the time of slow or arrested progress, is assumed to be due to the inherent behaviour of the uterus when disproportion is encountered. In this study multiparas with SAL had heavier babies than those with PDL but 6 out of 9 patients with SAL responded to oxytocic augmentation and delivered vaginally suggesting that disproportion is unlikely to be the major cause for secondary arrest of labour. In the cases delivered vaginally minor disproportion might have been overcome with further flexion, moulding and rotation associated with augmentation.

Majority of patients responded with satisfactory labour progress after oxytocic augmentation; 65 - 75% of the nulliparas and 56 - 87% of the multiparas depending on the type of dysfunctional labour (tables 3.1- 2 & 3). The caesarean section rates in these groups were very low, 0 - 1.5%, indicating the value of oxytocin augmentation.

The study aimed to identify the magnitude of the

problem of dysfunctional labour and to evaluate the benefits of managing these patients with oxytocin augmentation, external tocography and of prolonging the augmentation period by another 4 hours in patients with unsatisfactory labour progress in the first 4 hours of augmentation. Even if the caesarean section rate was fairly high in the latter group of patients, nearly half of those with PDL delivered vaginally 50.6% of the nulliparas and 41.6% of the multiparas. In patients with SAL and an unsatisfactory response to the initial period of augmentation, the caesarean section rate were slightly higher; 66.6% and 75.0% in nulliparas and multiparas respectively. But it should be noted that the number of patients with secondary arrest of labour were few to derive major conclusions. With the described management protocol, when nulliparas and multiparas were considered together, 252 (84.6%) of 298 patients with PDL delivered vaginally and of the 21 cases of SAL, 16(76.2%) delivered vaginally. Our results suggest that the association between SAL and cephalopelvic disproportion is not strong.

Adapting a policy of allowing a 2 hour grace period to the right of the expected progress line resulted in an overall 12.7% augmentation rate; 19.0% for nulliparas and 7.3% for multiparas.

A period of 8 hours of augmentation resulted in an 18.2% caesarean section rate in nulliparas and 11.1 % in multiparas with dysfunctional labour. If the period of

augmentation have been limited to 4 hours the caesarean section rate would have been almost double; 35.5% for nulliparas and 17.2% for multiparas (tables 3.1-2 & 3). If this 2 hour period of grace had not been used the augmentation rate would have been at least doubled. A 41% augmentation rate has previously been reported for a similar group of patients (O'Driscoll et al.1984). Our results suggest that augmentation of slow labours (<1 cm in 3 hours) would benefit both nulliparas and multiparas regardless of the type of dysfunctional labour. In dysfunctional labour in the absence of gross disproportion or fetal compromise a period of 8 hours of augmentation of labour should result in 80% of nulliparae and 90% of multiparae delivering vaginally with little risk of intrauterine or birth asphyxia or birth injury.

3.2 Uterine activity in dysfunctional labour and target uterine activity to be achieved with oxytocin titration

Active management of labour has become an accepted practice in many labour wards. It is based on recognition of poor progress of labour and augmenting poor uterine activity after excluding malpresentation and obvious cephalopelvic disproportion (O'Driscoll et al 1984, Studd et al, 1982). In the active phase of first stage of labour when the progress of cervical dilatation deviates to the right of a line drawn at 1 cm per hour or to the right of an expected progress line drawn using a stencil, from the admission cervical dilatation, it is termed dysfunctional labour (Gibb & Arulkumaran 1986, Cardozo et al, 1982). We studied the uterine activity in spontaneous labour of nulliparous women to find out the relative contribution of inefficient uterine contractions and cephalopelvic disproportion to primary dysfunctional labour.

It has been suggested that knowledge of pre and post augmentation uterine activity derived by the use of an intrauterine catheter may identify those who are likely to have CS for failure to progress (Reddi et al, 1988). To varify this the obstetric features and pre and post augmentation uterine activity of those who had failure to progress and needed CS despite adequate augmentation were compared with those who delivered vaginally.

There is limited literature regards the target uterine

activity that has to be achieved by oxytocin titration to effect good obstetric outcome. Steer et al (1985b) suggest that a frequency of 1 in 3 min may be optimal and frequencies more than this may lead to fetal distress. To answer this question we subdivided our population to those who had "optimal" frequency of 1 in 3 min or more prior to augmentation and those who had frequencies less than 1 in 3 min. The obstetric features, pre and post augmentation uterine activity and the outcome of these two groups of patients were compared to identify the target uterine activity to be achieved with oxytocin augmentation.

Patients and methods

Nulliparae admitted in spontaneous labour at term with a vertex presentation were considered for the study which was approved by the departmental ethical committee. When the patient was in the active phase of labour (cervix effaced and 3 cm or more dilated) artificial rupture of membranes was performed. From the admission cervical dilatation two lines were drawn, one at a rate of 1 cm per hour (alert line) and the other parallel and 2 hours to the right (action line). Vaginal examination was performed every 3 to 4 hours to assess the progress of labour. Those who showed poor progress and were to the right of the action line on review examination were diagnosed to have dysfunctional labour and had oxytocic augmentation. These women constituted the study population. After informed consent a sterile "Gaeltec" transducer tipped intrauterine catheter was introduced via

the vagina and cervix after calibration as stated in Chapter 1.4. A Sonicaid FM 6 or FM 3R fetal monitor with a built in uterine activity integrator module (Sonicaid Ltd., Chichester) was used to compute the active contraction area profiles every 15 minutes. A scalp electrode was attached to the fetal scalp for continuous electronic fetal heart rate (FHR) monitoring.

The age and height of patient, period of gestation, dilatation of cervix at admission and at commencement of augmentation and duration of labour prior to augmentation were noted. The mean frequency, amplitude and uterine activity quantified by active contraction area for the period of one hour prior to commencement of oxytocin infusion were calculated.

Oxytocin infusion was commenced at a dose of 2.5 mu/min using a peristaltic infusion pump (Dropmat Secura, Braun, Melsungen, Germany) and increased by increments of 2.5 mu every 30 min till the frequency of painful contractions were 6 to 7 in 15 min and were clinically thought to be adequate (duration > 40 sec). Once this was achieved, the dose of oxytocin was maintained unless FHR changes or uterine hyperstimulation (> 7 contractions/15 min or increase in baseline pressure over 15 mmHg for more than 3 mins) necessitated a reduction in the dose. The mean frequency, active pressure and uterine activity quantified by active contraction area for 15 min in kilo Pascal seconds/15 minutes were calculated from the observations made in the first hour

after the optimal dose of oxytocin was reached. Analgesia was according to patient's choice and was by inhalation of a mixture of 50% nitrous oxide and 50% oxygen or intramuscular injections of pethidine 75 to 100 mg four to six hourly. None in the study had epidural analgesia. The duration of post augmentation period, mode of delivery, indication for operative delivery, birthweight, Apgar scores at 1 and 5 min and cord arterial blood pH values were recorded. The number of newborns needing assisted ventilation or admission to neonatal intensive care unit was noted.

The pre and post augmentation uterine activity of the study population were calculated and compared. Students t test was used to evaluate the statistical significance. To evaluate whether pre and post agumentation uterine activity would differentiate those with inefficient uterine activity from those likely to have cephalopelvic disproportion, the study group was divided into those who had failure to progress and needed CS and those who had progressed satisfactorily and had vaginal delivery. The obstetric characteristics and uterine activity (pre and post) in those who had CS for failure to progress due to cephalo pelvic disproportion was compared with those who delivered vaginally.

To identify the target uterine activity needed with oxytocin infusion to achieve good obstetric outcome, the study population was subdivided based on the pre augmentation

uterine activity into those who had "optimal" frequency of uterine contractions of equal or greater than 1 in 3 min (Steer et al, 1985b) and those who had "suboptimal" frequency of contractions of less than 1 in 3 min. The obstetric characteristics of those who had "optimal" preaugmentation frequency of uterine contractions were compared with those, who had "suboptimal" frequency of uterine contractions.

Results

Seventy five nulliparae were studied with a mean maternal age of 26.6 (+ 3.4) years, height of 154 (+ 4.8) cm and period of gestation of 39.1 (+ 1.8) weeks. Mean cervical dilatation on admission was 3.3 (+ 0.8) cm and at time of augmentation was 4.2 (+ 1.0) cm. Mean maximum dose of oxytocin was 8.1 (+ 3.8) mu/min. There were 9 cases who needed temporary reduction of oxytocin dose because of uterine hyperstimulation in 6 and fetal heart rate changes in 3. The preaugmentation period was 5.1 (+ 2.0) hrs and the mean length of the first stage of labour was 8.7 (+ 3.0) -hrs. There were 15 forceps deliveries (20%), of whom 11 were for prolonged second stage of labour. There were 7 caesarean sections (9.3%) of whom 6 (8.0%) were for failure to progress in labour associated with cephalopelvic disproportion. The mean birth weight was 3255 (+ 365) gms -and there were only 2 infants with 1 min Apgar score less than 5 and none with 5 min Apgar score less than 7. The mean cord arterial blood pH was 7.24 + 0.06 and there were no admissions to the neonatal intensive care unit. The pre and post augmentation uterine activity for the population studied

are given in Table 3.2-1. Paired t test showed significantly higher ($p < 0.001$) post augmentation uterine activity in terms of mean frequency, active pressure and active contraction area compared with pre augmentation uterine activity.

Table 3.2-1: Pre and post augmentation uterine activity in 75 nulliparae with primary dysfunctional labour

Uterine activity	Pre	Post
Mean frequency of uterine contractions/15 min	4.3 (1.2)	6.8 (1.2)**
Mean active pressure in mm Hg	31.6 (10.1)	46.3 (11.7)**
Mean active contraction area in k Pas/15 min	1038 (346)	1888 (381)**

Standard deviation is given in parenthesis

** $p < 0.001$

There were 25 cases who had a mean "optimal" frequency of at least 5 contractions/15 min in the pre augmentation period. In these patients the mean frequency, active pressure, active contraction area/15 min were calculated from uterine contractions for a period of 1 hr prior to augmentation and 1 hr after the maximum dose of oxytocin was reached. When compared with the pre augmentation values the post augmentation mean frequency, active pressure and active contraction area values were significantly greater ($p < 0.001$) (Table 3.2-2).

The obstetric features and outcome of those who had "optimal" frequency of contractions were compared with those with "suboptimal" frequency of contractions. There was no significant difference in mean maternal age, height, period

of gestation and cervical dilatation on admission or at the time of augmentation in the two groups. The maximum dose of oxytocin, duration of pre or post augmentation period, caesarean deliveries, birth weight of babies and neonatal condition at birth were not different in the two groups. When the pre and post agumentation uterine activity in those who had "optimal" and "suboptimal" frequency of pre augmentation uterine contractions were compared there were no significant differences in the mean amplitude or active contraction area profiles between the two groups but the mean frequency of pre augmentation uterine contractions/15 min was less in the group who had "suboptimal" frequency of contractions ($p < 0.001$) (Table 3.2-2).

Table 3.2-2. Pre and post augmentation uterine activity in those who had "optimal" and "sub optimal" contraction frequency prior to augmentation

Preaugmentation frequency of uterine contractions	"optimal" n = 25	"sub optimal" n = 50
Pre augmentation uterine activity		
mean frequency/15 min	5.6 (0.5)	* 3.7 (0.8)
mean active pressure in mm Hg	30.7 (8.0)	32.0 (11.0)
mean active contraction area in k Pas/15 min	1167 (323)	979 (340)
Post augmentation uterine activity		
mean frequency/15 min	7.1 (0.9)	6.6 (1.7)
mean active pressure in mm Hg	43.1 (7.4)	48.0 (13.1)
mean active contraction area in k Pas/15 min	1895 (353)	1884 (397)

Standard deviation is given in parenthesis

* $p < 0.001$

Seven patients in the study group had caesarean deliveries, all except one for failure to progress due to cephalopelvic disproportion. One had CS for fetal distress. The obstetric features of mean maternal age, height, period of gestation, cervical dilatation at time of admission and augmentation, time duration prior and after agumentation, maximum dose of oxytocin and the neonatal condition at birth were not significantly different in the group who had CS for failure to progress when compared with those who had vaginal delivery. There was no significant difference in the pre and post augmentation uterine activity between the two groups (Table 3.2-3).

Table 3.2-3: Pre and post augmentation uterine activity according to mode of delivery

Mode of delivery	CS for CPD n = 6	VD n = 68
Pre augmentation uterine activity		
mean frequency of contractions/ 15 min	3.9 (1.6)	4.3 (1.1)
mean active pressure in mm Hg	18.6 (8.1)	32.8 (9.4)
mean active contraction area in k Pas/15 min	678 (249)	1107 (404)
Post augmentation uterine activity		
mean frequency of contractions/ 15 min	7.8 (0.9)	6.7 (1.2)
mean active pressure in mm Hg	35.0 (10.9)	47.2 (11.3)
mean active contraction area in k Pas/15 min	1634 (400)	1912 (373)

Standard deviation is given in parenthesis

CPD: Cephalopelvic disproportion
CS : Cesarean section
VD : Vaginal delivery

Discussion

CS for failure to progress in labour contributes to a third of all caesarean sections and also to a third of the rising incidence of caesarean deliveries (Consensus in Medicine - Caesarean Child Birth 1981). Studies on the diagnosis and management of slow progress of labour may help to formulate better management policies and to reduce the incidence of caesarean deliveries for dystocia. Although many studies have eluded to the benefits of oxytocin augmentation in slow labour (O'Driscoll et al, 1984, Bottoms et al, 1987) there is general concern about the use of oxytocin when encountered with slow progress of labour. This may be partly due to the difficulties encountered in differentiating whether the slow progress is due to inadequate uterine activity or due to compromised cephalo-pelvic relationship or both. The fear of litigation with the misuse of oxytocin may be an additional factor (Fuchs, 1985). Steer et al (1985b) measured uterine activity in slow progress of labour and recorded that the commonest cause of slow labour was inefficient uterine action. Our study confined to nulliparae with vertex presentation supports this finding. We observed the uterine activity of the patients with dysfunctional labour to be below the 50'th centile to that reported in a similar group of patients in our population who had normal progress of labour (Gibb et al,

1984 - Chapter 2.1).

There were six cases who failed to progress despite adequate augmentation and were delivered by CS for cephalopelvic disproportion. These patients had similar pre and post augmentation uterine activity like those who delivered vaginally. Contrary to earlier reports (Reddi et al, 1988) we found uterine activity measurements not helpful in identifying those who were likely to have cephalo-pelvic disproportion.

There were 25 cases (33.3%) who had "optimal" frequency of uterine contractions of 1 in 3 min just prior to augmentation but they exhibited low uterine activity when active contraction area were measured. Steer (1977) has shown that active contraction area correlates better with rate of cervical dilatation than frequency of uterine contractions in spontaneous or induced labour. Studying uterine activity in slow labour Steer et al (1985b) have suggested, that when facilities are not available for computation of uterine activity measurements, the dose of oxytocin should not be increased more than 8 mu/min and the target frequency of contractions should not exceed one in three minutes. He has postulated, that practice contrary to this may lead to more babies with poor Apgar scores. In most centres facilities for quantification of uterine activity in labour is not available. If one were to depend on frequency of contractions, a frequency of 1 in 3 min though considered

"optimal" (Steer et al, 1985b) may be inadequate when there is failure to progress in labour as shown in our study.

In the 25 patients who were in this category there was no clinical evidence of cephalopelvic disproportion and the attending midwife assessed the contractions to be inadequate based on it's frequency (< 4 in 10 mins) and duration (< 40 secs) and decided to augment labour. It is our practice to increase the oxytocin infusion as described till the contractions are clinically judged to be adequate ie. frequency of 4 to 5 in 10 mins and duration > 40 secs. With the implementation of such a policy all 25 patients except one delivered vaginally (20 normal and 4 forceps deliveries). There was no incidence of fetal distress and the infants were born in good condition.

In nulliparae the commonest cause of dysfunctional labour is inefficient uterine contractions. Oxytocic augmentation to achieve a mean frequency of 6 to 7 contractions/15 min which are clinically judged to be adequate based on its duration results in good obstetric outcome. Such augmentation for an adequate period is necessary to identify those with cephalopelvic disproportion (Arulkumaran et al, 1987c). Care should be exercised to observe fetal heart rate changes and uterine hyperstimulation which may necessitate a temporary reduction in the dose of oxytocin.

3.3 Oxytocin titration to achieve preset active contraction area values compared with preset frequency of contractions to achieve better obstetric outcome in augmented labour

Active management of labour is the norm in current obstetric practice. As described in Chapter 3.1, 19.0% of our nulliparae and 7.3% of our multiparae require augmentation of labour. Of these 18.2% of nulliparae and 11.1% of multiparae needed caesarean section and the majority for failure to progress. By evaluating uterine activity in those who had slow progress of labour we found that poor uterine activity was a major cause of slow labour (Chapter 3.2) and a majority of them responded to oxytocics and delivered vaginally. Uterine activity is usually assessed by measuring the frequency and duration of contractions either by palpation or by simple technique of external tocography. Alternatively it can be more accurately quantified by measuring active contraction area profiles using an intrauterine catheter and a uterine activity integrator module incorporated in the standard fetal monitor. Such information has been said to be of value in patients with slow progress of labour (Steer et al.1985b, Reddi et al.1988). Further, active contraction area has been shown to correlate better with the rate of cervical dilatation compared with frequency or amplitude of contractions alone (Steer 1977; Steer et al.1984) but whether such information will be of value in clinical practice has not been tested.

In most centres titration of oxytocin for augmentation of slow labour is based on measuring frequency of uterine contractions, monitored by external methods. Since, it is not known whether oxytocin titration to achieve preset uterine activity computed by active contraction area measurements will result in better obstetric outcome than oxytocin titration to achieve preset frequency of uterine contractions we evaluated this by a randomised study in nulliparae who had slow progress of labour.

Patients and methods

Nulliparous patients at term admitted in spontaneous labour to the National University Hospital labour ward were considered for the study. Those with a vertex presentation and whose progress in the active phase of labour was slow after membrane rupture were recruited. Patients were reviewed every 3 to 4 hours and the labour was diagnosed to be slow if the progress in cervical dilatation was to the right of a line drawn 2 hour parallel to the expected progress line of 1 cm per hour from the admission cervical dilatation.

A Gaeltec intrauterine catheter was introduced after calibration with a Sonicaid FM 3R or FM 6 fetal monitor as described in Chapter 1.4. When the diagnosis of slow labour was made the uterine activity was recorded for an hour prior to oxytocin infusion. Oxytocin infusion was commenced at a rate of 2.5 mu per minute and the dose escalated every 30 min by 2.5 mu/min till the target uterine activity was achieved. The patients were randomly allocated to 2 groups by using

sealed envelopes. One group of patients received oxytocin till they achieved preset frequency of uterine contractions of 6 in 15 minutes, each contraction lasting >40 secs. The other group received oxytocin till they achieved preset uterine activity of 1750 k Pas/15 min or more which corresponds to the 75'th centile of uterine activity in nulliparae in spontaneous normal labour (Chapter 2.1). If there was no increase in active contraction area (stable phase uterine activity - Steer et al.1975) despite further increase in oxytocin infusion to achieve 1 750 k Pas/15 min and if there was a tendency for hyperstimulation before reaching 1 750 k Pas/ 15 min then the dose of oxytocin was not increased.

The patient characteristics of age, height, period of gestation, length of pre- and post- augmentation period, mode of delivery, if operative delivery the indication, birthweight of neonates, 1 and 5 min Apgar scores and cord arterial blood pH values were recorded in a computerised coding sheet before the patient was transferred from the labour ward. The mean frequency, active pressure and uterine activity (measured as active contraction area) were calculated for a period of one hour just prior to augmentation and for one hour after the maximum dose of oxytocin was reached. Number of times the dose of oxytocin had to be reduced for reasons of fetal heart rate changes or uterine hyperstimulation (i.e. more than 7 contractions in 15 min or elevation of basal tone by 15 mm Hg for more than 3

min) in either group was noted. The observations and patient characteristics in the two groups were compared using the chi-square test and t-test.

Results

There was no difference in maternal age, height and period of gestation in the 2 groups. Progress of labour was reviewed every 3 to 4 hours. Most patients were diagnosed to have slow labour in the first and some in the second review. The mean cervical dilatation at the time of admission to the labour ward and when they were diagnosed to have slow labour was not different in the 2 groups (Table 3.3-1). There was no difference in the length of labour from the time of admission to the time of augmentation and from this time to the time of delivery in the 2 groups. Evidence of transient hyperstimulation during the process of escalation of the oxytocin dose was observed in 6 cases in the group who had oxytocin to achieve preset frequency of uterine contractions and in 11 in the other group but the difference was not statistically significant.

Table 3.3-1: Labour characteristics according to mode of oxytocin infusion

Oxytocin infusion to achieve "preset"	Frequency n=34	Uterine activity n=34
Mean cervical dilatation on admission to labour (cm)	3.2 (0.8)	3.2 (0.8)
Mean cervical dilatation at augmentation (cm)	4.3 (1.1)	4.2 (1.0)
Mean maximum dose of oxytocin in mu/min	8.3 (3.7)	8.0 (3.1)
Cases of hyperstimulation in whom oxytocin dose was reduced	6 (17.6%)	11 (32.4%)
Mean length of pre-augmentation period (mins)	298 (90)	293 (80)
Mean length of post-augmentation period (mins)	206 (117)	230 (114)

SD is given in parenthesis. % is shown as (%)

Mode of delivery and neonatal outcome in these patients are shown in Table 3.3-2. There was no difference in the caesarean section rate and rate of instrumental vaginal deliveries in the 2 groups. The instrumental vaginal deliveries in both groups were for prolonged second stage of labour. Poor neonatal outcome judged by 1 and 5 min Apgar scores and cord arterial blood pH values did not show any difference. There were 3 cases with cord arterial blood pH below 7.15 in the group who had oxytocin titrated to achieve preset uterine activity and 1 in the group who had oxytocin to achieve preset frequency of uterine contractions.

Table 3.3-2: Mode of delivery and neonatal outcome

Oxytocin infusion to achieve "preset"	Frequency n=34	Uterine activity n=34
Caesarean section	4 (11.8%)	2 (5.9%)
Instrumental vaginal deliveries	5 (14.7%)	6 (17.5%)
Neonates with 1 min Apgar score <5	1	3
Neonates with 5 min Apgar score <7	0	1
Mean cord arterial blood pH	7.25(0.06)	7.25(0.07)

Number and % shown as (%). SD is given in parenthesis

The uterine activity over a period of one hour prior to the commencement of oxytocin, and for a period of one hour once the maximum dose of oxytocin was achieved did not show any difference in the mean frequency, mean active pressure or mean uterine activity between the 2 groups (Table 3.3-3).

Table 3.3-3: Pre- and Post-augmentation uterine activity according to methods of oxytocin infusion

Oxytocin infusion to achieve"preset"	Frequency n=34	Uterine Activity n=34
Mean frequency of uterine contractions/15 min		
pre-augmentation	4.4 (1.3)	4.3 (1.5)
post-augmentation	6.9 (1.1)	7.1 (1.0)
Mean active pressure of uterine contractions/15 min		
pre-augmentation	32.1(11.4)	30.8 (8.3)
post-augmentation	42.4(10.9)	42.9 (9.4)
Mean uterine activity in k Pas/15 min		
pre-augmentation	964 (348)	966 (291)
post-augmentation	1869 (385)	1854 (254)

SD is given in parenthesis

Discussion

Nulliparae with vertex presentation and poor progress of labour was chosen for this study to exclude the influence of parity and presentation in the progress of labour. Both groups had intrauterine catheters to nullify the influence if any of the presence of catheter on the progress of labour, to avoid missing information regarding frequency of uterine contractions in an obese or restless patient and to identify early any evidence of hyperstimulation which may be difficult with external tocography. The physical characteristics of the patients, the obstetric features of cervical dilatation on admission or on recruitment to study and the pre-augmentation period did not differ in the 2 groups.

The results obtained in terms of post-augmentation period, the number of operative deliveries, the neonatal condition at birth or birth weight of babies were similar in the two groups. The pre- and post-augmentation uterine activity quantified by mean frequency, mean active pressure and mean active contraction area profiles did not differ in the two groups.

Studies published in recent years (Steer et al.1985b, Reddi et al.1988) suggest that measurement of active contraction area profiles may be of value in augmented labour. However, these studies did not explain how measurement of active contraction area profiles would benefit patients with slow labour. Studies in induced labour

(Chapters 4.2 & 4.3) did not show any advantage in obstetric outcome when oxytocin was titrated to achieve preset uterine activity levels compared with a group who had oxytocin to achieve preset optimal frequency of uterine contractions.

It is difficult to define "optimal" uterine activity which has to be achieved in augmented labour. Ideally it should be one that produces satisfactory progress of labour with no uterine hyperstimulation. Hyperstimulation is identified by observing the frequency of uterine contractions and the rise in the basal tone of the uterus. Both these features are not physiological and can cause compromise even to a healthy fetus. Early identification of hyperstimulation may be possible with internal tocography compared with external means. Quantification of active contraction area profile contributes little in terms of prospectively identifying these cases. There are additional problems in defining "optimal" uterine activity based on active contraction area profiles. Both nulliparae and multiparae exhibit a wide range of uterine activity in spontaneous normal labour (Chapters 2.1, 2.2 & 2.3). In order to include as many patients as possible we aimed for the 75'th centile activity found in spontaneous normal labour. The tendency for hyperstimulation in 33% of the study population illustrates the fact that this value may not be "optimal" but this is to be expected because of the wide range of active contraction area profiles seen in augmented labour.

Although, the design of the study was such that once the "stable phase" or 75'th centile uterine activity was identified, the dose of oxytocin was maintained, the clinical outcome was similar to that achieved by titrating oxytocin to achieve "optimal" frequency of uterine contractions. In fact, the active contraction area achieved with oxytocin titration to produce optimal frequency of contractions was similar to that achieved when oxytocin was titrated to achieve 75th centile value of spontaneous labour or stable phase uterine activity. It would be easier and more rational to use the frequency of uterine contractions to guide oxytocin titration as this has some influence on oxygenation of the fetus. In those patients who show little progress despite having optimal frequency of uterine contractions whether measurement of active contraction area to guide oxytocin infusion would improve clinical outcome needs further study. We conclude that the obstetric outcome was similar when augmentation of labour was performed with internal tocography to achieve optimal frequency of contractions or preset active contraction area values. Optimal frequency can be judged by external tocography and may be adequate in augmented labour compared with the use of internal tocography. The next study was undertaken to find the answer and is described in Chapter 3.4.

3.4 Augmentation of labour: Does internal tocography result in better obstetric outcome compared with external tocography

Dystocia or difficult labour constitutes one third of all caesarean sections and has contributed to a third for the increase in caesarean deliveries (Caesarean child birth 1982). Augmentation of slow labour to reduce this rising trend has become an accepted practice and with the belief of achieving better results, many centres use intrauterine catheters without cost benefit analysis. Intrauterine catheters are used with or without facilities for calculation of active contraction area profiles. There is no study to show that use of an intrauterine catheter would result in better clinical outcome compared with managing augmented labour with external tocography. A prospective randomised study was conducted to answer this question.

Patients and methods

Patients at term admitted in spontaneous labour to the National University Hospital, Singapore were considered for the study. Those with vertex presentation and whose progress in the active phase of labour was to the right of a line drawn 2 hours parallel to the expected progress line of 1 cm per hour after membrane rupture were recruited.

Once slow progress of labour was diagnosed, obvious cephalopelvic disproportion and malpresentation were excluded and oxytocin infusion was commenced at a rate of 2.5 mU/min and the dose escalated every 30 min by 2.5 mU/min till the target uterine activity was achieved. For titration of

oxytocin infusion the patients were randomly allocated using a random number table to one of two groups:

1) External tocography group. Oxytocin was titrated to achieve 6-7 painful contractions every 15 mins as recorded by external tocography (using a Hewlett Packard 8040 fetal monitor) and were clinically judged to be adequate (duration > 40 secs) by the attending midwife.

2) Internal tocography group. Oxytocin was titrated to achieve painful contractions of 6-7/15 mins judged to be of adequate strength (Active pressure > 30mmHg and duration > 40 secs as recorded by internal tocography). Despite such contraction frequency if there was failure to progress and if the active contraction area levels did not reach the 75'th centile of uterine activity observed in spontaneous normal labour according to parity i.e. 1750 kilo Pascal seconds/15 min in nulliparae (Chapter 2.1) and 1500 k pas/15 min in multiparae (Chapter 2.2), option was given to further escalate the dose of oxytocin to reach these values unless fetal heart rate changes or evidence of hyperstimulation was noticed. A Gaeltec* intrauterine catheter was used after calibration with a Sonicaid FM 3R or FM 6 fetal monitor as described in Chapter 1.4. There was online computation of active contraction area in k Pas/15 min. A scalp electrode was attached to the fetal scalp for continuous electronic monitoring of the fetal heart rate in both groups.

The patient characteristics of age, parity, period of gestation in weeks, cervical dilatation at time of augmentation, length of pre and post augmentation period, maximum dose of oxytocin, mode of delivery, if operative delivery the indication, birthweight of neonate, 1 and 5 min Apgar scores and whether neonate needed assisted ventilation or admission to the neonatal intensive care unit were recorded in a computerised coding sheet before the patient was transferred from the labour ward. The number of times the dose of oxytocin had to be reduced for reasons of hyperstimulation (i.e. more than 7 contractions in 15 mins) or fetal heart rate changes (or both) in each group was noted. The observations and patient characteristics in the two groups were compared using the chi-square test and t test.

Results

The patient characteristics according to the method of tocography are shown in table 3.4-1. There was no significant difference in mean maternal age, parity structure and period of gestation in weeks between the two groups.

Table 3.4-1: Patient characteristics and obstetric features according to method of tocography

Method of tocography	External n=125	Internal n=125
Mean age (years)	28.9(4.2)	28.4(4.4)
Number of multiparae (%)	30 (33.6)	40 (32.0)
Mean period of gestation (weeks)	39.1(1.6)	39.1(1.3)
Mean cervical dilatation (cm) at time of augmentation	4.2(1.4)	4.1(1.1)

SD is given in parenthesis, ns - not significant

Most patients were diagnosed to have slow progress in the first review 3-4 hours after entering the active phase of labour with absent membranes. There was no difference in mean cervical dilatation at the time of unsatisfactory progress and commencement of augmentation between the 2 groups (Table 3.4-1). The length of labour prior to augmentation was slightly longer in group 2 who had internal tocography (<0.03), whilst the length of augmentation was similar in the 2 groups (Table 3.4-2). There was no case in group 2 where a further escalation of oxytocin dose was required to achieve 75'th centile uterine activity found in spontaneous normal labour according to parity as they showed such activity with a contraction frequency of 6 to 7 in 15 min. It was necessary to temporarily reduce the dose of oxytocin because of uterine hyperstimulation or fetal heart rate changes, or both, in 19.0% of patients in the group monitored by external tocography, and in 20.2% of patients in the group monitored by an intrauterine catheter. The difference was not

statistically significant. The mean maximum dose of oxytocin was similar in the two groups.

Table 3.4-2: Features of labour according to method of tocography

Method of tocography	External n=125	Internal n=125	
Length of labour prior to augmentation (mins)	397.0(159.5)	442.2(160.1)	p<0.03
Length of labour post augmentation (mins)	273.0(227.5)	268.6(158.4)	ns
Maximum dose of oxytocin (mU/min)	11.1(7.8)	11.0(9.7)	ns
Cases in whom temporay reduction in the dose of oxytocin was warranted	24 (19.0 %)	25 (20.2 %)	ns

Values are mean and (SD). ns - not significant.

Mode of delivery and neonatal outcome are shown in table 3.4-3. There was no statistical difference in the caesarean section rates between the 2 groups. In the external tocography group, 1 of 16 caesarean sections were performed for fetal distress and the remaining 15 were for failure to progress. Of the 21 caesarean sections performed in the internal tocography group, 3 were for fetal distress and 17 were for failure to progress. The proportion of patients in each of the two groups who had caesarean section for fetal distress or failure to progress were not statistically different. Neonatal outcome judged by 1 and 5 min Apgar scores and the need for assisted ventilation or admission to the neonatal intensive care were similar in the two groups (Table 3.4-3).

The mean birthweights of babies were similar in the two groups. To identify the effect if any on the neonatal outcome by the episodes of transient hyperstimulation, the number of neonates with Apgar score less than 7 at 1 min in those who had hyperstimulation was compared with those who did not have any such episodes. In the external tocography group, 3 of 24 (12.5 %) who had transient hyperstimulation and 8 of 101 (8 %) who did not have any such episode had Apgar score < 7 at 1 min. In the internal tocography group, 5 of 25 (20 %)in those who had transient hyperstimulation as opposed to 8 of 100 (8 %)in those who did not, had Apgar score of < 7 at 1 min. These differences were not significant. When the data was pooled, 8 of 49 (16 %) who had transient hyperstimulation and 16 of 201 (8 %) who did not have any such episodes had Apgar score of less than 7 at 1 min but these differences were not statistically significant.

Table 3.4-3: Mode of delivery and neonatal outcome according to method of tocography

Method of tocography	External n=125	Internal n=125	
Number of caesarean sections	16(12.6)	21(16.9)	ns
Number of instrumental vaginal deliveries	17(13.4)	21(16.1)	ns
Apgar score < 7 at 1 min	4(3.2)	6(4.8)	ns
Apgar score < 5 at 5 min	2(1.6)	1(0.8)	ns
Admission to neonatal intensive care for birth asphyxia	1	1	
Mean birth weight in grams(SD)	3257(389)	3260(412)	ns

% is shown in parenthesis unless specified. ns - not significant

Discussion

The physical characteristics of the patients and cervical dilatation at time of augmentation were not significantly different in the two groups. The influence of parity calculated by odds ratio was similar in the two groups (table 4.4-1). The length of post augmentation period, mean maximum dose of oxytocin, incidence of vaginal delivery, and neonatal outcome were similar in the two groups.

Titration of oxytocin to achieve preset frequency of uterine contractions can be achieved by either external or internal tocography. It has been suggested that active contraction area profiles measured by use of intrauterine catheters may improve the obstetric outcome in augmented labour (Steer et al.1985b, Reddi et al.1988).

In our study, use of intrauterine catheter to assess frequency of contractions or active contraction area profiles did not confer any advantage over external tocography in managing augmented labour in terms of obstetric and neonatal outcome. In a busy clinical practice it is easier, less invasive and cheaper to assess clinically adequate uterine contractions by external tocography, than using an intrauterine pressure catheter. The role of intrauterine catheter in clinical practice has not been defined. Where difficulty is encountered in recording uterine contractions by external methods as in an obese or restless patient and in those who show little progress despite having optimal

frequency of uterine contractions assessed externally, use of an intrauterine catheter may be beneficial but would have to be evaluated.

4 UTERINE ACTIVITY IN INDUCED LABOUR

4.1 UTERINE ACTIVITY ACCORDING TO PARITY AND CERVICAL SCORE

4.2 OBSTETRIC AND NEONATAL OUTCOME WHEN OXYTOCIN WAS TITRATED TO ACHIEVE STABLE PHASE UTERINE ACTIVITY OR 50TH CENTILE UTERINE ACTIVITY OBSERVED IN SPONTANEOUS NORMAL LABOUR ACCORDING TO PARITY COMPARED WITH 75TH CENTILE UTERINE ACTIVITY OR OPTIMAL FREQUENCY OF CONTRACTIONS

4.3 OBSTETRIC OUTCOME WHEN OXYTOCIN WAS TITRATED TO ACHIEVE 75TH CENTILE UTERINE ACTIVITY OBSERVED IN SPONTANEOUS NORMAL LABOUR ACCORDING TO PARITY COMPARED WITH OPTIMAL FREQUENCY OF UTERINE CONTRACTIONS

4.4 TOTAL UTERINE ACTIVITY AND THE CONCEPT OF CERVICAL AND PELVIC TISSUE RESISTANCE

4. UTERINE ACTIVITY IN INDUCED LABOUR

4.1 Comparison of uterine activity in induced and spontaneous labour

Induction of labour for maternal or fetal indications has become an accepted obstetric practice. The incidence ranges from less than 5% (Pearson & Andrews 1980) to nearly 35% (McNaughton 1980) and at times have reached values of 50% (Tipton & Lewis 1975). In Singapore it varies from 5 to 10% in public institutions and upto 20% in the private sector. Majority of these inductions are performed by artificial rupture of membranes and immediate oxytocin infusion in the lines popularised by Turnbull and Anderson (1968a). Concern has been expressed about it's injudicious application because of the associated increase in caesarean section rate (Arulkumaran et al 1985 b&c).

The main indications to this increased incidence in caesarean section rate are failed induction of labour and fetal distress. The former is usually due to induction of nulliparae with an unfavourable cervical score whilst the latter can be due to the compromised condition of the fetus for which the induction was performed or it may be due to the unphysiological uterine activity associated with the use of oxytocin infusion. Little is known of the uterine activity in such labours according to parity and cervical score and how it compares with the uterine activity of spontaneous normal labour. The knowledge of this activity may permit one to evaluate the different methods of induction and to identify

the method which closely mimics spontaneous normal labour so as to give the maximal benefit to the fetus and to the mother.

In our unit induction of labour in majority of patients is by artificial rupture of membranes followed immediatley by oxytocin titration. The uterine activity was quantified according to parity and cervical score from the time of induction to the second stage of labour and the values compared with those reported in spontaneous normal labour according to parity (Chapter 2.1 & 2.2). The neonatal out come was assessed by Apgar scores and umbilical cord venous blood pH values and were compared with those of the control patients.

Patients and Methods

Women admitted for induction of labour at term to the University unit labour ward at Kandang Kerbau Hospital with singleton pregnancies presenting with the vertex were considered for the study. Those with previous caesarean scar or who had prostaglandin for cervical priming or induction were excluded from the study. At the time of the study the induction rate was 9.8% and the leading indications were hypertensive disease of pregnancy, gestational diabetes, static weight or weight loss at term and prolonged pregnancy (Arulkumaran et al 1984b).

On admission to the labour ward the cervical score was assessed by allocating scores of 0 to 2 for each of four

qualities of the cervix (position, length, dilatation and consistency) in addition to the station of the head. After an initial strip of cardiotocographic tracing forewater amniotomy was performed and the colour and quantity of the amniotic fluid noticed. A transducer tipped catheter (Gaeltec) was introduced as described in Chapter 1.4 and uterine activity was quantified online from the time of insertion. Oxytocin infusion was commenced using an IVAC (503)* peristaltic infusion pump (IVAC Corporation, SanDiego USA) and was operated manually to increase the dosage by 2 mu from a starting dose of 2 mu/min in an arithmetic fashion. The dosage was increased every 15 min until an optimal frequency of 6 to 7 painful contractions per 15 mins which were thought to be clinically adequate (duration > 40 seconds). The dose of oxytocin was transiently stopped or reduced when there were fetal heart rate changes or uterine hyperstimulation. Pain relief in labour was by inhalation of Entonox (50% nitrous oxide and 50% oxygen) or by pethidine 75 to 100 mg intramuscularly. Those who had epidural analgesia were not included in the study.

Information of patients name, age, height, parity and period of gestation were captured in a computerised coding sheet. The cervical score, colour of amniotic fluid, fetal heart rate pattern, length of first stage of labour, mode of delivery, indication if operative delivery and neonatal condition judged by Apgar scores and umbilical cord venous blood pH values were recorded before the patient was

discharged from the labour ward. The active contraction area values were recorded from the initiation of induction till the end of first stage of labour. The results were analysed according to parity and cervical score using the SPSS package on the IBM 3033N computer of the National University of Singapore. Paired student t test was used for statistical analysis.

Results

Of the 57 patients recruited to the study 2 had caesarean delivery, one for cephalopelvic disproportion and the other for failed induction of labour and were excluded from the analysis of uterine activity values. The uterine activity of 25 nulliparae and 30 multiparae who had vaginal delivery were studied in relation to their cervical score (Score of ≤ 5 - poor cervical score and ≥ 6 good cervical score). The patient characteristics were similar (table 4.1-1) except that the multiparae were older. The mean maximum dose of oxytocin to effect successful induction of labour was significantly higher in nulliparae with poor cervical score compared with those with good cervical score. In multiparae the dose was not influenced by the cervical score.

Table 4.1-1: Physical characteristics of patients studied

Parity	Nulliparae		Multiparae	
Cervical score	⩽ 5 n=13	⩾ 6 n=12	⩽ 5 n=10	⩾ 6 n=20
Mean age in years	25.5(5.3)	26.1(8.5)	30.5(8.7)	29.7(8.9)
Mean height in cm	154.2(8.8)	153.7(7.7)	156.4(10)	157.1(11.8)
Mean cervical score	4.5(1.0)	7.6(1.8)	4.5(1.4)	7.3(1.9)
Mean period of gestation in weeks	40.0(2.7)	40.1(2.4)	40.0(3.6)	40.0(3.6)
Mean maximum dose of oxytocin in mu/min	14.3(12.5)**	9.0(7.9)	7.8(5.5)	8.1(7.5)

** $P < 0.001$
2 Standard deviations are given within parenthesis

The obstetric outcome of patients are shown in table 4.1-2 according to parity and cervical score. There was a significant difference in the length of labour according to cervical score when controlled for parity being longer in those with a poor cervical score ($P < 0.01$). Similar differences were observed when controlled for cervical score, the nulliparae having a longer labour ($P < 0.01$). The nulliparae with good cervical score and multiparae with a poor cervical score had similar lengths of labour.

Table 4.1-2: Obstetric outcome of induced labour by parity and cervical score

Parity	Nulliparae		Multiparae	
Cervical score	≤ 5 n=13	≥ 6 n=12	≤ 5 n=10	≥ 6 n=20
Mean length of first stage of labour in hrs	8.4(7.2)**	4.6(2.7)	4.9(4.0)	3.4(3.6)
No. of assisted vaginal deliveries	5	3	0	1
Mean Apgar score at 1 min	9.0	8.8	8.9	9.0
at 5 min	9.8	10.0	9.9	10.0
Mean cord venous pH	7.34(.09)	7.33(.09)	7.35(.08)	7.39(.12)
Mean birth weight in gms	3320(801)	2965(645)	3116(1038)	3297(933)

** $P < 0.01$
2 Standard deviations are given within parenthesis

Assisted delivery was more common in nulliparae with poor cervical scores. The neonatal Apgar scores at 1 and 5 min and the umbilical cord venous blood pH values were satisfactory and were not significantly different in the groups studied. The infant birth weights in the four groups were within the normal range of that observed in our obstetric population.

Since a considerable length of labour is spent in the latent phase of labour prior to effacement of the cervix and because the length of labour varied in the different groups, uterine activity in the first stage of labour was analysed by

dividing the length of labour into five segments. The initial phase of induced labour when oxytocin infusion was titrated to achieve adequate uterine contractions beyond which the oxytocin dose was not increased was termed the incremental phase. The interval between the end of the incremental phase to the end of first stage of labour was divided into four equal portions. This enabled us to observe the sequential values of uterine activity with the observed progress of labour. The distribution of uterine activity values in different time segments were skewed and hence the median value in each time segment was calculated for comparison (Table 4.1-3) and for profile construction (Fig. 4.1-1). There was a significant steep rise in uterine activity in the incremental phase ($p<0.001$) with increments of oxytocin infusion. A plateau in uterine activity was observed in the subsequent three segments and was around 1750 k Pas/15 min in nulliparae and in those multiparae who were induced with a poor cervical score whilst it was around 1500 k Pas/15 min in multiparae with a good cervical score. Despite no further increase in oxytocin dose in the last quarter there was a steep increase in uterine activity associated with the late first stage of labour as that observed in spontaneous labour. However this increase was minimal in those with poor cervical score in both parity groups but was significantly increased in those with a good cervical score at induction (nulliparae $p < 0.002$, multiparae $p < 0.006$).

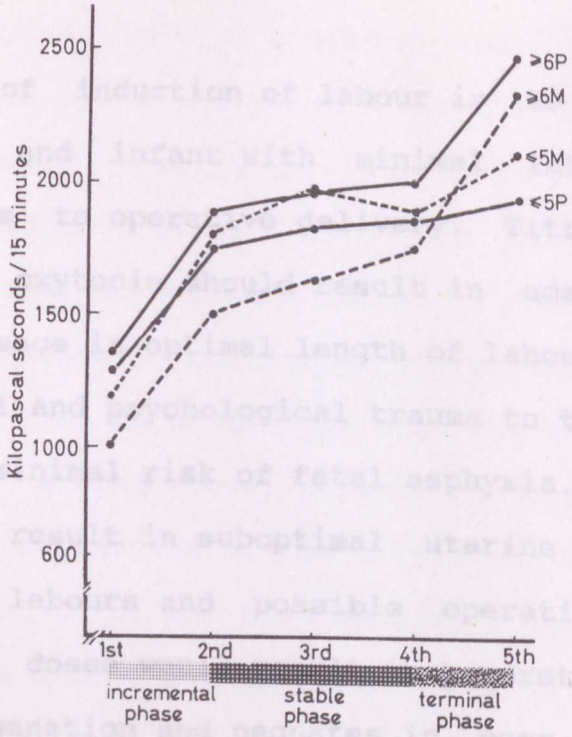


Fig 4.1-1. Median uterine activity in induced labour according to parity and cervical score.

Table 4.1-3: Uterine activity in induced labour by parity and cervical score

Parity	Nulliparae		Multiparae	
Cervical score	⩽ 5	⩾ 6	⩽ 5	⩾ 6
	n = 13	n = 12	n = 10	n = 20
Median uterine activity in k Pas/15 min				
Incremental phase	1290 (111)	1364 (61)	1194 (66)	1013 (82)
Stable phase (1'st 25%)	1745 (82)	1883 (42)	1800 (39)	1500 (36)
Stable phase (2'nd 25%)	1815 (76)	1950 (39)	1970 (36)	1625 (36)
Stable phase (3'rd 25%)	1852 (74)	1990 (36)	1980 (31)	1750 (33)
Terminal phase(4'th 25%)	1930 (71)	2468* (33)	2103 (26)	2333* (31)

* P < 0.002 ** P < 0.006
Number of observations based on which each value was calculated is given within parenthesis

Discussion

The aim of induction of labour is to result in a healthy mother and infant with minimal interference and without recourse to operative delivery. Titration of the correct dose of oxytocin should result in adequate uterine activity and hence in optimal length of labour which will minimise physical and psychological trauma to the mother and also will have minimal risk of fetal asphyxia. Insufficient oxytocin would result in suboptimal uterine activity and hence in long labours and possible operative deliveries whilst excessive doses would result in hyperstimulation and poor fetal oxygenation and neonates in poor condition or operative delivery for iatrogenic fetal distress. Poorly controlled oxytocin infusion is known to result in low umbilical cord arterial blood pH values (Kubli & Ruttgers 1971).

We studied the uterine activity in labour induced by artificial rupture of membranes and oxytocin infusion to bring about 6 to 7 contractions in 15 minutes. The earlier studies by Steer et al.(1975) and Woolfson et al.(1976) did not quantify the observed uterine activity in the SI units of Uterine Activity Integral (UAI). Subsequent study by Steer (1977) gave information in UAI but lacked the information according to parity and cervical score. Our study showed that the uterine activity gradually increased with the increasing dose of oxytocin (Incremental phase). When the rate of oxytocin infusion was maintained once optimal

frequency of contractions were achieved, there was no further increase in uterine activity and a stable phase uterine activity was observed. Towards the late first stage of labour there was a spontaneous steep rise in the uterine activity (despite no increase in oxytocin infusion) similar to that observed in spontaneous normal labour (Cowan et al.1982, Gibb et al.1984). This rise is compatible with the Ferguson reflex (1941) which is a functional effect of the release of oxytocin due to stretching of the cervix and upper vagina (Vascika et al.1978). It may also be partly due to increased sensitivity of the uterus to oxytocin with progress of labour (Sica Blanco & Sala 1961, Krapohl et al.1965). The terminal spurt of activity was not significantly higher in those with poor cervical scores, probably because the cervix and uterus were not ready to labour. This may be one of the factors for the 38.5% forceps rate in nulliparae with poor score compared with a 25% rate in those with a good score although this difference was not significant.

In nulliparae the lowest median uterine activity in the stable phase for those with good cervical score was 1882 k Pas/15 min and was 1745 k Pas/15 min in those with poor cervical score compared with an overall median activity of 1440 k Pas/15 min for those in spontaneous normal labour (Chapter 2.1). In multiparae the median stable phase uterine activity was 1500 k Pas/15 min in those with good cervical score and was 1880 k Pas/15 min in those with a poor cervical score compared with an overall median value of 1130 k Pas/15

min in those in spontaneous normal labour (Chapter 2.2). These values show that higher levels of uterine activity are reached in induced labour and are maintained for longer periods than spontaneous labour. These findings are at variance with the early study by Steer (1977 and 1979) who reported similar uterine activity profiles in spontaneous and induced labour in nulliparae and multiparae. The uterine activity profile in induced labour appears to be similar in nulliparae with any score and multiparae with poor score (Fig.4.1-1), but due consideration has to be given to the different lengths of labour which will denote that nulliparae with poor cervical score would have to perform much more total uterine activity compared with the other groups.

The neonatal outcome in induced labour assessed by Apgar scores at 1 and 5 mins and umbilical cord venous blood pH values compared favourably with that observed in spontaneous normal labour (Chapters 2.1 & 2.2) except in nulliparae with good cervical score who had significantly lower ($P < 0.01$) (but good) umbilical cord venous pH values compared with the values in the other groups. (Table.4.1-4).

These findings clearly indicate that uterine activity in labour induced by oxytocin infusion and artificial rupture of membranes exhibit higher uterine activity than spontaneous normal labour. In most instances there is little compromise to the fetus with careful monitoring. In current practise

oxytocin is titrated to achieve optimal uterine contractions based on external tocography.

Table 4.1-4: Umbilical cord venous pH values in spontaneous and induced labour

Parity	Nulliparae		Multiparae	
Spontaneous labour	(n=40)	7.37(.10)	n=40	7.37(.09)
Induced labour Cervical score $\leq$ 5	(n=12)	7.34(.08)	n=9	7.35(.07)
Induced labour Cervical score $\geq$ 6	(n=12)	7.32(.08)*	n=18	7.39(.12)

* $P < 0.01$
*Only statistical significance was in nulliparae with good cervical score who had a lower pH to that of spontaneous labour.

2 standard deviations for the pH values are given within parenthesis

But doubts are cast about the accuracy of external tocography (La Croix 1968), and it has been shown that active contraction area profiles measured by an intrauterine catheter are more reflective of the rate of cervical dilatation than single parameters of frequency or amplitude of uterine contractions (Steer 1977). Based on this it is believed that titrating oxytocin to achieve a stable phase uterine activity may benefit the outcome in induced labour (Woolfson et al.1976,Steer 1979). But stable phase uterine activity would differ from patient to patient and may be difficult to recognise and may pause problems to the practising midwife. An alternative would be to titrate

oxytocin to achieve preset uterine acitivty levels according to parity based on uterine activity observed in spontaneous normal labour (Chapter 2.1 & 2.2). But studies should first determine the optimal uterine activity with active contraction area measurements that should be achieved when oxytocin is titrated to induce labour. This should result in better obstetric outcome compared with oxytocin titration to achieve optimal frequency of contractions.

4.2 Obstetric and neonatal outcome when oxytocin was titrated to achieve stable phase uterine activity or 50'th centile uterine activity observed in spontaneous normal labour according to parity compared with achieving 75th centile activity or optimal frequency of contractions

Induction of labour has been practised for many years by medical, surgical or combined methods. The discovery of the oxytocic activity of posterior pituitary extract (Dale 1906) and it's subsequent introduction into clinical use (Blair Bell 1925) was a historic landmark in obstetric practice. Oxytocin was given by the buccal route (Maxwell 1964) and the nasal route (Hofbauer & Hoerner 1927) but it was Theobald et al. (1948) who introduced the intravenous pitocin drip. Although Theobald described his dosage regimen as physiological, it's pharmacological nature was later demonstrated by the finding of extremely low levels of endogenous oxytocin in spontaneous labour (Chard et al.1970). Dangers to the fetus by oxytocin infusion (Liston & Campbell 1974) and the possibility of uterine rupture even in primigravidae (Daw 1973) were reported. Intrapartum fetal hypoxia was associated with poorly controlled oxytocin infusion (Kubli & Ruttgers 1971); an increased incidence of neonatal jaundice after oxytocin induced labours (Ghosh & Hudson 1972) and the possibility of electrolyte disturbance in the mother (Burt et al.1969) also came to light. Therefore it is no surprise that research has progressed to identify the best way to titrate oxytocin.

Efficient uterine contractions are necessary for

adequate progress of labour but the fetus may be temporarily deprived of oxygen during a contraction. An ideal system combines acceptable labour progress with maximum protection of the fetus. But it is difficult to define the acceptable or optimal level of uterine activity that would bring about acceptable progress of labour without compromising the condition of the fetus.

A closed loop automatic infusion system (AIS) [Sonicaid Ltd., Chichester] for titrating the dosage of oxytocin according to a preset programme using data derived from an intrauterine catheter became available in the 80s (Carter & Steer 1980). The pump titrates oxytocin to achieve and maintain uterine activity levels of 700-1500 k Pas/15 min. The dose was escalated arithmetically in increments of 2 mu/min every 15 min from a starting dose of 2 mu/min. Whenever a 'stable phase' of uterine activity (700-1500 k Pas/15 min) was achieved the dose rate was maintained. If a level above 1500 k Pas/15 min occured the dosage was halved. These preset levels were around the 50'th centile uterine activity observed in nulliparae in spontaneous normal labour (Chapter 2.1) and was equal to values between 50th and 75th centile uterine activity observed in multiparae in spontaneous normal labour (Chapter 2.2). Since the system was capable of identifying the 'stable phase' uterine activity and would deliver oxytocin to achieve 50th to 75th centile activity seen in spontaneous normal labour we decided to make use of the "AIS" to titrate oxytocin to one group of patients whilst

another group had manual titration using a peristaltic infusion system to achieve 2000 k Pas / 15 min in nulliparae or 1500 k Pas/ 15 min in multiparae ie. greater than 75th centile activity observed in spontaneous normal labour. In case uterine hyperstimulation ensues whilst trying to achieve > 75th centile uterine activity, oxytocin was titrated to achieve optimal frequency of contractions (6 to 7/15 min) each lasting for > 40 seconds. The obstetric and neonatal outcome were compared to identify advantages if any of titrating oxytocin infusion to achieve "stable phase" or 50th to 75th centile uterine activity compared with oxytocin titration to achieve 75'th centile uterine activity profile according to parity or "optimal" frequency of uterine contractions.

Patients and methods

Patients were selected from those having labour induced in the University unit, Kandang Kerbau Hospital, Singapore. The induction rate was 9.8% and the leading indications were hypertensive disease of pregnancy, prolonged pregnancy and abnormal weight gain at term. The study was restricted to singleton pregnancy presenting by the vertex with no history of previous operative delivery.

All patients were examined before induction and the cervical score was assessed as described in Chapter 4.1. Induction was by artificial rupture of the membranes and oxytocin infusion. A transducer tipped (Gaeltec) intrauterine

catheter was inserted and a fetal scalp electrode applied. A Sonicaid FM 3 R fetal monitor was used for continuous monitoring of uterine activity and fetal heart rate.

Patients were allocated to the automatic infusion system (AIS) or peristaltic infusion system depending on the availability of the AIS system. The AIS was used on the automatic infusion mode (AIS group) as recommended by the manufacturer, but if labour progress was unsatisfactory after 9 hrs, the facility for manual override was used to achieve higher uterine activity levels or satisfactory contractions as determined by clinical assessment with contractions occuring ever 2-2.5 min lasting >40 seconds. In the second group, the peristaltic infusion pump (IVAC 503, Sandiego, California) was operated manually to increase the dosage of oxytocin from 2 mu/min in a semi-arithmetic fashion until uterine activity was clinically satisfactory or attained 2000 kPas/ 15 min in a nullipara or 1500 k Pas/ 15 min in a multipara (IVAC group). Whilst titrating to achieve such uterine activity, if hyperstimulation was observed the oxytocin was titrated to achieve 6 to 7 contractions every 15 min, each contraction lasting for > 40 secs.

If fetal distress was encountered, it was managed clinically including temporary reduction of the oxytocin infusion rate, fetal scalp blood sampling or delivery, if necessary. Epidural analgesia was not used; pethidine in a dosage of 50 - 75 mg im 4 to 6 hourly was prescribed for pain relief. Maternal age, height, gestation, cervical score,

length of first stage of labour, dose of oxytocin, mode of delivery, birthweight, Apgar score at 1 and 5 min and umbilical cord vein blood pH were recorded and analysed. Student's t-test was used for statistical analysis.

Results

The 121 patients in the study comprised 63 nulliparae and 58 multiparae; 30 of the nulliparae and 36 of the multiparae had a good cervical score ($\geq$ 6) and the others (33 nulliparae and 22 multiparae) had a poor cervical score ($\leq$ 5).

Eleven patients were delivered by caesarean section, all but two were nulliparae. Nine of these patients had been managed by the AIS system and subsequent manual override. The indications for caesarean section were cephalopelvic disproportion in eight patients, failed induction of labour in two and fetal distress in one. There was no statistically significant difference in the caesarean section rate between the two modes of management, probably due to the small numbers. Table 4.2-1 shows the distribution of the 110 patients who were delivered vaginally by parity, cervical score and mode of oxytocin infusion.

Table 4.2-1: Distribution of 110 patients delivered vaginally, by parity, mode of infusion and cervical score

Cervical score	⩽ 5		⩾ 6	
Parity	Nulliparae	Multiparae	Nulliparae	Multiparae
Mode of infusion				
Automatic infusion (AIS)	15	11	14	15
Manual titration (IVAC)	13	10	12	20

Of the 28 nulliparae with poor cervical scores, 15 were allocated to the AIS group and 13 to the IVAC group. Tables 4.2-2 a&b show the patient characteristics and outcome in these two groups. There were no significant differences between the two groups in maternal age, height, gestational age, cervical score, mode of delivery, birthweight, Apgar scores and umbilical cord vein blood pH. The length of the first stage of labour was longer in the AIS group although the difference was not significant. Manual override had been necessary in 53.3 % of the patients because the AIS system proved inadequate.

Table 4.2-2a: Patient characteristics and outcome in women with a poor cervical score (≤ 5)

	Nulliparae		Multiparae	
Infusion modality	AIS n=15	IVAC n=13	AIS n=11	IVAC n=10
Age in years	26.1(5.8)	25.5(5.3)	28.5(8.9)	30.5(8.7)
Maternal height in cm	156.9(11.0)	154.2(8.8)	154.5(11.1)	156.4(10)
Gestation in weeks	40.0(2.8)	40.0(2.7)	40.3(3.2)	40.0(3.6)
Cervical score	4.3(1.4)	4.5(1.0)	4.5(1.6)	4.5(1.4)
Length of first stage of labour in hours	11.2(7.5)	8.4(7.2)	10.2(4.6)*	4.9(4.0)*
Manual override (n)	8	-	3	-
Assisted delivery (n)	7	5	1	0
Mean Apgar score At 1 min	8.6	9.0	8.9	8.9
At 5 min	9.9	9.8	10.0	9.9
Umbilical vein blood pH	7.35(0.06)	7.34(0.09)	7.36(0.07)	7.35(0.08)
Birthweight in g	3392(891)	3320(801)	3072(1198)	3116(1038)

Results are mean (SD) where appropriate.

* $p < 0.01$.

Table 4.2-2b: Patient characteristics and outcome in women with a good cervical score ($\geq$ 6)

	Nulliparae		Multiparae	
Infusion modality	AIS n=14	IVAC n=12	AIS n=15	IVAC n=20
Age in years	26.3(7.5)	26.1(8.5)	27.9(7.9)	28.8(8.9)
Maternal height in cm	156.7(13.2)	153.7(7.7)	159.0(7.0)	157.0(11.8)
Gestation in weeks	40.2(2.6)	40.1(2.4)	39.8(2.7)	40.1(3.6)
Cervical score	7.5(2.5)	7.6(1.8)	7.3(1.9)	7.3(2.0)
Length of first stage of labour in h	9.1(3.3)**	4.6(2.7)**	5.0(7.0)	3.4(3.6)
Manual override(n)	3	-	2	-
Assisted delivery(n)	5	3	1	1
Mean Apgar score				
At 1 min	8.9	8.8	9.0	9.0
At 5 min	10.0	10.0	10.0	10.0
Umbilical vein blood pH	7.32(0.07)	7.33(0.09)	7.36(0.1)	7.39(0.12)
Birthweight in g	3130(747)	2965(645)	3395(975)	3297(933)

Results are mean (SD) where appropriate.
** $p < 0.001$.

Maternal characteristics and fetal outcome in the 26 nulliparae with good cervical score were not significantly different between the two management groups except for the first stage of labour which was significantly longer ($p < 0.001$) in the AIS group; manual override was necessary in

three patients (Table 4.2-2b).

In the 21 multiparae with poor cervical scores the maternal characteristics and fetal outcome were not significantly different between the two management groups except for the first stage of labour which was significantly longer ($p < 0.01$) in the AIS group, manual override was necessary in three patients (Table 4.2-2a).

Maternal characteristics and fetal outcome in the 35 multiparae with good cervical scores were not significantly different between the two management groups and although manual override had been necessary in two patients in the AIS group the length of the first stage of labour was similar in both groups (Table 4.2-2b).

Fetal distress necessitated alteration in the rate of oxytocin infusion in two patients in the peristaltic infusion group. Subsequently increments of oxytocin were reinstituted when the fetal heart rate became normal. In one patient in the AIS group fetal distress occured within 45 minutes of induction when uterine activity levels were < 1000 k Pas/ 15 min and the patient had received no oxytocin. She was delivered by caesarean section.

Discussion

Placental blood flow is temporarily restricted during uterine contractions (Borell et al.1965) although the retroplacental pool of maternal blood increases in volume (Bleker et al. 1975). A balance has to be achieved between

protection of the fetus and maintaining adequate progress in labour during oxytocin infusion. The danger of hypoxia is greater when there is diminished fetoplacental reserve and this varies between patients. The occurence of fetal distress does not depend on the stress of uterine contraction 'per se' but on the underlying fetoplacental function. No fetal distress was encountered in low-risk spontaneous labours with uterine activity levels > 2 500 k Pas/15 min (Chapter 2.1, Gibb et. al. 1984).

An early study of induction of labour proposed a regimen of artificial rupture of the membranes followed immediately by escalation of oxytocin in a geometric fashion doubling the dose every 10 min until satisfactory uterine contractions were observed clinically (lasting 45-50 seconds at 2-3 minute intervals) (Turnbull and Anderson 1968a). This geometric escalation was justified on the grounds that uterine contractility and oxytocin sensitivity are very variable before the onset of labour (Turnbull & Anderson 1968 b). Based on these observations an open loop automatic infusion system (Cardiff pump)was produced which doubled the dose rate every 12.5 min until acceptable contractions were attained after which the maintenance dosage was controlled manually. A low incidence of fetal distress, babies with good Apgar scores and a shortened induction delivery interval were reported with the use of this system (Francis et al 1970). But this system has not gained popularity and one should think that it did not produce the expected advantages in

other centres.

In order to minimise the possible harmful effects, effort continued to reduce the mean maximum or total dose of oxytocin (Beazley et al.1975; Pavlou et al.1978). Steer (1977) and Woolfson et al. (1976) suggested the use of uterine activity measurements to guide oxytocin titration for induction of labour. Based on these suggestions, oxytocin titration has been automated by a negative feedback closed loop automatic infusion pump to achieve "stable phase uterine activity" (Carter & Steer 1980) to optimize the induction-delivery time without compromising the chances of vaginal delivery or the condition of the fetus (Fig 4.2-1).

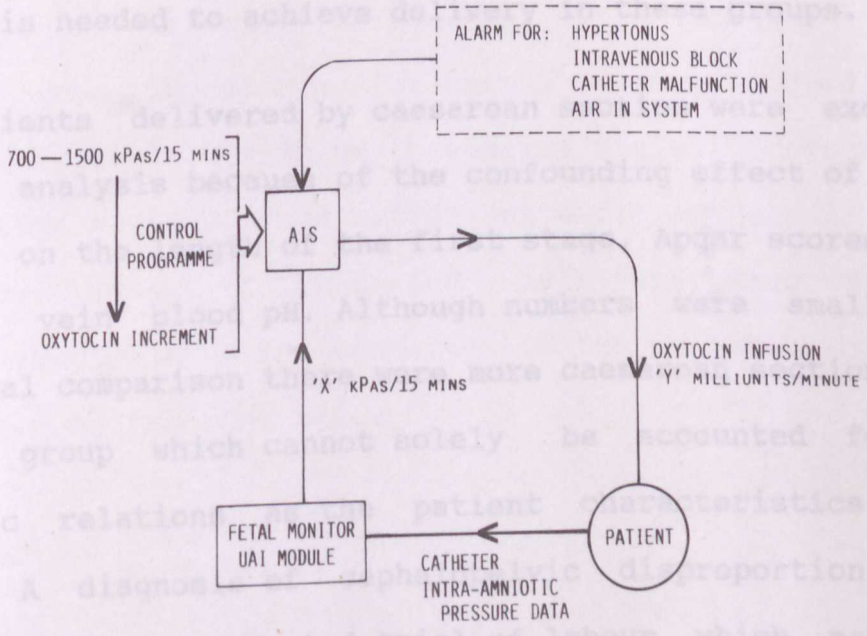


Fig 4.2-1. Principles of the negative feedback closed loop automatic infusion system.

The programme in the automatic infusion system which was used had a mechanism to achieve levels of 700 - 1 500 k Pas/ 15 min and to maintain the dose when a 'stable' phase uterine activity was reached. Since this was compatible with 50'th centile activity observed in spontaneous normal labour in nulliparare and 50'th to 75'th centile activity observed in multiparae, we decided to have oxytocin infusion for one group by this system (AIS). For the other group conventional manual mode of oxytocin titration using a peristalic infusion pump to achieve optimal frequency of contractions or 75'th centile uterine activity according to parity was used. The results were analysed according to parity and cervical score as it is known that labour is more difficult to induce in nulliparae and in patients with poor cervical score (Turnbull and Anderson 1968a) as more uterine activity is needed to achieve delivery in these groups.

Patients delivered by caesarean section were excluded from the analysis because of the confounding effect of this procedure on the length of the first stage, Apgar scores and umbilical vein blood pH. Although numbers were small for statistical comparison there were more caesarean sections in the AIS group which cannot solely be accounted for by fetopelvic relations as the patient characteristics were similar. A diagnosis of cephalopelvic disproportion also depends on a well conducted trial of labour which may not have been achieved in spite of manual override of the AIS.

A significantly longer labour was observed in the patients induced by the AIS group which is not surprising on account of the low levels of uterine activity achieved compared with levels in the peristaltic infusion group. The neonatal outcome was similar in both groups indicating that the low levels of uterine activity offered in one group did not offer any added protection. It appears that if manual override had not been used, more patients might have been delivered by caesarean section. It was difficult to justify continuation of the study on account of unacceptable prolongation of labour associated with oxytocin titration to achieve stable phase uterine activity or 50'th centile uterine activity observed in spontaneous normal labour. From this study we felt 50th centile activity was not the optimal target to achieve good results in induced labour. It appeared that oxytocin titration to achieve 75'th centile uterine activity seen in spontaneous normal labour according to parity or oxytocin titration to achieve optimal frequency of contractions would produce better obstetric outcome in terms of optimal length of labour and less operative delivery without compromising the condition of the neonate. This was the subject of the next study.

4.3 Obstetric outcome when oxytocin was titrated to achieve 75'th centile uterine activity observed in spontaneous normal labour according to parity compared with optimal frequency of uterine contractions in induced labour

External tocographic methods have shown close agreement with internal tocographic measurements in assessing frequency (Caldeyro Barcia et al.1950; Smyth 1957; Wood et al.1965) although the amplitude of the contractions and the basal tone cannot be measured accurately. With internal tocometry using an intrauterine catheter all these qualities of the contraction curve can be measured. The most sophisticated equipment can continuously compute uterine activity as the active contraction area (Steer 1977). Such measurement requires a uterine activity module to be incorporated in the fetal monitor, and it's use is claimed to give advantages in oxytocin titration for induction of labour (Steer 1977;Tromans & Beazley 1983; Willcourt 1983).

The possible advantages of titrating oxytocin to achieve preset active contraction area values over the standard practice of achieving preset frequency of contractions in induced labour has not been conclusively established in randomized trials. The previous study (Chapter 4.2) showed no benefit when the preset value was stable phase uterine activity or 50th centile uterine activity observed in spontaneous normal labour. This prospective randomized study evaluates the possible benefits of oxytocin titration to achieve 75'th centile uterine activity of spontaneous

normal labour according to parity compared with preset frequency of uterine contractions.

Patients and Methods

Patients admitted for induction of labour to the University unit labour ward in the Kandang Kerbau Hospital, Singapore were recruited for the study after informed consent. The recruitment was based on parity and cervical score as described in Chapter 4.2. Nulliparae were divided into two groups, one with a poor cervical score (< 6) and the other with good cervical score (> 5). Women in each group were randomly allocated, using sealed envelopes (selected after shuffling), to oxytocin titration to achieve preset frequency of contractions or preset uterine activity. Multiparae admitted for induction of labour were dealt with in the same manner.

On admission to the labour ward, the cervical score was assessed and forewater amniotomy was performed. An intrauterine 'Gaeltec' catheter was calibrated and inserted into the uterine cavity as described in Chapter 1.4. The catheter was connected to a Sonicaid FM3 R or FM 6 fetal monitor for computation of uterine activity. A scalp electrode was attached to the fetal scalp for continuous electronic monitoring of the fetal heart rate.

Mode of oxytocin titration

Oxytocin was increased every 15 min using an IVAC peristaltic infusion pump to produce infusion rates of 2, 4,

6, 8, 10, 12, 16, 20, 24, 32, 40, 48 mu/min. For titration of oxytocin infusion the patients were randomly allocated to one of two groups.

(1) Frequency group; Oxytocin titration was based on the frequency of painful uterine contractions (target 6 to 7 every 15 min lasting >40 secs).

(2) Uterine activity group; Oxytocin titration was based on uterine activity measurement. The oxytocin infusion rate was increased until the uterine activity measurement reached the 75'th centile of uterine activity in spontaneous normal labour according to parity (1750 k Pas/15 min in nulliparae - Chapter 2.1; 1500 k Pas/15 min in multiparae - Chapter 2.2).

Once the target frequency of uterine contractions or active contraction area profile was reached, the dose of oxytocin was maintained without further escalation until the patient was delivered except in circumstances where a reduction in dosage was necessary because of hyperstimulation of the uterus or abnormal fetal heart rate changes. Pain relief was achieved by pethidine 50 to 75 mg im 4 to 6 hrly when required or by inhalation of Entonox (mixture of 50% oxygen and 50% nitrous oxide). Epidural analgesia was not used.

The duration of the first stage of labour, maximum dose rate of oxytocin, total dose of oxytocin, mode of delivery, indication for operative delivery, Apgar scores at 1 and 5 min, cord artery blood pH values, whether the newborn infant

was intubated or admitted to the special care baby unit (SCBU), and the birthweight were recorded on a computerized coding sheet before the patient was transferred from the labour ward. The incidence of uterine hyperstimulation and fetal heart rate changes which necessitated reduction in oxytocin dosage was noted. The total uterine work was calculated by the summation of the active contraction area from the time of induction to the end of the first stage of labour. Student's t - test was used to evaluate the statistical significance in patient characteristics and obstetric outcome. The Mann-Whitney test was used to compare the total uterine activity in the different groups.

Results

The number recruited in each group, patient characteristics, duration of the first stage of labour, mode of delivery and neonatal outcome are shown in Table 4.3-1 a&b according to parity, cervical score, and mode of oxytocin titration. When the different groups were considered according to the mode of oxytocin titration; the age, parity, and cervical score were not significantly different. The nulliparae and multiparae with a poor cervical score who had oxytocin titrated to achieve preset frequency of uterine contractions were taller than those who had oxytocin titrated to achieve 75th centile uterine activity. The mean duration of the first stage of labour though not significantly different was slightly longer in the groups who had oxytocin titrated to achieve preset frequency of uterine contractions.

Table 4.3-1a: Maternal characteristics, length of first stage and neonatal outcome in nulliparae by cervical score and mode of oxytocin titration (based on uterine activity or frequency of contractions)

Cervical score	⩽ 5		⩾ 6	
Oxytocin titration to achieve preset	Ut.activity n=15	Frequency n=15	Ut.activity n=15	Frequency n=15
Maternal age(years)	26.3(4.3)	26.0(4.1)	26.1(5.1)	26.8(3.5)
Cervical score	4.4(0.8)	4.4(0.8)	6.9(0.9)	7.2(1.3)
Gestation (weeks)	39.6(2.0)	40.3(2.0)	39.8(1.4)	40.4(1.6)
Height (cm)	154.0(5.3)*	158.1(4.6)*	155.6(4.9)	155.1(4.0)
Duration of 1'st stage (hrs)	8.8(4.7)	9.4(4.1)	5.5(2.8)	7.1(4.0)
Mode of delivery				
Normal vaginal	7	9	11	9
Forceps	5	3	3	5
Caesarean section	3	3	1	1
Apgar score at 1 min	8.5(4.7)	8.4(1.3)	8.9(0.3)	8.9(0.8)
at 5 min	9.9(0.3)	9.7(0.6)	9.9(0.4)	9.8(0.8)
Cord artery pH	7.27(.08)	7.31(.12)	7.32(.07)	7.30(.06)
Birth weight (g)	2901(459)	2937(504)	3218(523)	3031(596)

Values are means (SD) where appropriate.

*p < 0.05, T=2.2627, d.f.28.

Table 4.3-1b: Maternal characteristics, length of first stage and neonatal outcome in multiparae by cervical score and mode of oxytocin titration (based on uterine activity or frequency of contractions)

Cervical score	≤ 5		≥ 6	
Oxytocin titration to achieve preset	Ut.activity n=14	Frequency n=10	Ut.activity n=15	Frequency n=15
Maternal age (years)	30.5(5.5)	30.6(3.7)	29.8(4.6)	30.8(4.2)
Parity	1.7(0.9)	1.4(0.5)	1.4(0.5)	1.6(0.7)
Cervical score	4.8(0.4)	4.6(0.5)	7.1(0.7)	6.8(0.9)
Gestation (weeks)	40.3(1.3)	39.4(0.5)	40.6(1.4)	39.9(1.5)
Height (cm)	154.6(4.1)*	159.1(4.7)*	155.5(7.3)	155.3(4.8)
Duration of 1'st stage (hrs)	5.0(3.2)	5.5(1.2)	3.7(1.9)	3.9(2.9)
Mode of delivery				
Normal vaginal	11	8	14	14
Forceps	1	0	2	2
Caesarean section	2	0	0	0
Apgar Score at 1 min	8.8(.6)	9.0	8.6(1.0)	8.9(.3)
at 5 min	9.8(.4)	10.0	9.6(1.0)	8.9(.3)
Cord artery pH	7.24(.09)	7.31(.08)	7.31(.06)	7.35(.08)
Birthweight (g)	3485(469)	3361(514)	3701(474)	3261(364)+

Values are means (SD) where appropriate.
*p <0.05, T=-2.49538. d.f. 22;
+ p <0.01, T=2.94492, d.f.28.

The mode of delivery was not significantly different when controlled for parity and cervical score. The neonatal outcome was similar when 1 and 5 min Apgar scores and cord artery blood pH values were considered. Except for multiparae with good cervical score there was no significant

difference in birth weights between the groups (Table 4.3-1b).

The mean maximum dose rate of oxytocin was higher in the uterine activity groups (Table 4.3-2 a&b) but the difference was significant only in nulliparae with a poor cervical score ($p<0.01$). The mean total dose of oxytocin was not significantly different when controlled for parity and cervical score.

Table 4.3-2a: Maximum rate and total dose of oxytocin and number requiring reduction of oxytocin dose in nulliparae by cervical score and mode of titration (based on uterine activity or frequency of contractions)

Cervical score	⩽ 5		⩾ 6	
Oxytocin titration to achieve preset	Ut. activity n=15	Frequency n=15	Ut.activity n=15	Frequency n=15
Maximum dose of oxytocin (mu/min)	20.4(13.0)*	8.4(4.1)	18.8(11.6)	11.6(9.3)
Total dose of oxytocin (mu)	7793.3 (6225.6)	4221.4 (3558.7)	4418.0 (4097.8)	4088.0 (4470.5)
Median total uterine activity (k Pas)	44 600	39 340	34 848	26 712
No. requiring reduction in oxytocin dosage for				
Hyperstimulation	5	2	4	3
Fetal heart rate changes	1	1	0	1

Values are means (SD) where appropriate.

* $p<0.01$, T=3.40951, d.f. 28.

Table 4.3-2b: Maximum rate and total dose of oxytocin and number requiring reduction of oxytocin dose in multiparae by cervical score and mode of titration (based on uterine activity and frequency of contractions)

Cervical score	≤ 5		≥ 6	
Oxytocin titration to achieve preset	Ut.activity n=14	Frequency n=10	Ut.activity n=15	Frequency n=15
Maximum dose of oxytocin (mu/min)	14.2(8.6)	10.3(8.7)	14.5(11.2)	9.6(7.3)
Total dose of oxytocin (mu)	3636.9 (4045.3)	2643.8 (2075.3)	2753.6 (1997.6)	2510.7 (3742.1)
Median total uterine activity (k Pas)	25 213	21 930	14 150	18 132
No requiring reduction in oxytocin dosage for Hyperstimulation	0	0	1	2
Fetal heart rate changes	1	0	1	0

Values are means (SD) where appropriate.

The median total uterine work needed to effect vaginal delivery was similar when controlled for parity and cervical score, immaterial of the mode of oxytocin infusion. The incidence of hypertonus and fetal heart rate changes which prompted reduction in oxytocin dosage was slightly but not significantly higher in the uterine activity group.

Discussion

In this study an intrauterine catheter was introduced in all groups to compute the total uterine work according to parity and cervical score and to equate any influence on the

uterine activity due to the presence of the catheter. The total uterine work to achieve vaginal delivery was similar when controlled for parity and cervical score with either mode of oxytocin infusion. This suggests that total uterine activity observed may be a functional index of cervical and pelvic tissue resistance with differing parity and cervical score and is discussed further in Chapter 4.4.

The length of labour, mode of delivery, Apgar scores of the neonates and cord artery blood pH values were similar when controlled for parity and cervical score between the uterine activity and the frequency groups. The mean maximum dose rate of oxytocin was higher in nulliparae with a poor cervical score in the uterine activity group. The mean total dose of oxytocin was consistently higher in the uterine activity groups but the differences were not significant. The incidence of uterine hyperstimulation or fetal heart rate changes causing reduction in the oxytocin dose was more common (though not significant) in the uterine activity groups. The mean maximum and total dose of oxytocin might have been less if the oxytocin had been titrated to achieve the stable phase or 50'th centile of uterine activity found in spontaneous normal labour according to parity rather than the 75'th centile. This was studied in Chapter 4.2 and it was found that, though episodes of transient hyperstimulation was low the patients had significantly longer labours in the group who had oxytocin to achieve 50th centile uterine activity whilst the mode of delivery and neonatal outcome

were similar to a group who had oxytocin to achieve 75th centile uterine activity. The previous study (Chapter 4.2) and the present study suggests that oxytocin titration to achieve preset uterine activity values based on spontaneous normal labour may not give any advantage over the traditional method of oxytocin titration to achieve optimal frequency of uterine contractions. Oxytocin titration to achieve stable phase or 50'th centile uterine activity tend to produce slower labours and oxytocin tiration to achieve 75th centile values cause hyperstimulation. If in most cases titration of oxytocin to achieve desired frequency of uterine contractions results in successful outcome of induced labour, the appropriate role of active contraction area measurements has to be still defined.

Caldeyro Barcia & Heller (1961) showed proportionately increasing uterine activity with increasing oxytocin dose, finally reaching a characteristic plateau for each patient which he called the maximal uterine activity beyond which further oxytocic stimulation produced hypertonus rather than an increase of uterine activity. Steer et al.(1975) confirmed this and called it 'stable phase activity'. They titrated oxytocin using an automatic infusion system to achieve this level and reported successful outcome of induced labour with oxytocin doses of only 2-3 mu/min (Steer et al.1985 a). The use of the same infusion system did not produce such good results in our centre as discussed in the previous paragraph and in Chapter 4.2 (Gibb et al.1985b).

In a busy clinical practice it is easier to assess clinically adequate uterine contractions by frequency than the maximal uterine activity phase or stable phase uterine activity. Steer et al.(1985 a) showed that manual titration using an infusion pump to achieve desired frequency of uterine contractions needed rates not exceeding 11 mu/min as was found by Caldeyro Barcia et al.(1957) and Arulkumaran et al.(1985 d) (Chapter 4.1). Oxytocin titrated in induced labour to achieve 75'th centile of uterine activity values observed in spontaneous normal labour required doses of 14-20 mu/min in nulliparae with a poor cervical score with a resultant 30 % incidence of hyperstimulation. This is in contrast to the findings of Toaff et al.(1978) who found no significant difference in the incidence of hyperstimulation whilst using physiological (2.6-13.2 mu/min) or pharmacological doses (2.6-422.4 mu/min) of oxytocin.

Currently, oxytocin induced hyperstimulation has become a major subject of litigation in the USA (Fuchs 1985). The ideal dose of oxytocin should produce the required amount of uterine activity to effect vaginal delivery in optimal time without compromising the fetus. Based on our present and earlier findings (Chapter 4.2 & 4.3) that similar amounts of total uterine activity are required to effect vaginal delivery when controlled for parity and cervical score, active contraction area measurements every 15 min could be used to maintain minimal effective uterine activity every 15 min associated with acceptable progress of labour (Steer et

al.1984). If fetal heart rate changes are seen with higher uterine activity values/15 min, the uterine activity can be reduced to lower but effective levels to maintain progress of labour. But this assumption has to be tested in practice. This study concludes that oxytocin titration in induced labour, set to achieve 75'th centile uterine activity values observed in spontaneous normal labour does not confer any significant advantage over oxytocin titration to achieve preset frequency of uterine contractions.

4.4 Total uterine activity and the concept of cervical and pelvic tissue resistance

Turnbull (1957) suggested that the resistance of cervix and pelvic floor is much less in multiparae because these structures have been stretched in the prvious labour. Crawford (1975) and Rossavik (1978) studied the cervical and pelvic tissue resistance indirectly by studying the work done by the uterus to overcome this resistance. Rossavik (1978) calculated the uterine work as the product of active pressure (in kilo Pascals) and the duration of contractions (in seconds) and termed it the uterine impulse based on force x time = impulse (Alfonso & Finn 1967). He confirmed the suggestion by Turnbull (1957) that the total uterine work needed to effect vaginal delivery was less in multiparae. Clinical experience and scientific evidence suggests that labour is more difficult when induced with a poor cervical score (Turnbull & Anderson 1967 & 1968a) and the total uterine work needed may be greater in patients with low parity. Caldeyro-Barcia & Poseiro (1960) recognised that if the intensity of contractions was low, more contractions were needed to effect vaginal delivery.

We indirectly studied the cervical and pelvic tissue resistance in induced labour by calculating the total uterine activity (sum of all active contraction areas) needed to effect vaginal delivery according to parity and cervical score in those patients studied in Chapter 4.2 in two groups according to the mode of oxytocin infusion.

Patients and methods

Selection of patients and management methods were as reported in Chapter 4.2. Uterine activity was quantified during induced labour using a transducer tipped catheter as described. Patients were allocated to one of two methods of oxytocin infusion depending on the availability of the equipment. The automatic infusion system (AIS) infused oxytocin according to it's closed loop programme to achieve uterine activity levels of 700 - 1500 k Pas/ 15 min. Manual override was used after 9 hours if labour progress was inadequate. The peristaltic infusion pump (IVAC 503) was operated manually to increase the dosage of oxytocin in a semi-arithmetic fashion until uterine activity was 2000 k Pas/15 min in a nullipara or 1500 K pas/15 min in a multipara or 6-7 painful contractions each lasting >40 sec in 15 min.

The total uterine activity (TUA) was calculated by cumulating all sequential 15 min uterine activity values for each individual labour until the catheter was removed at full dilatation of the cervix. These TUA values were grouped according to parity, cervical score and mode of oxytocin infusion for analysis of results.

Non-parametric statistical methods were used for data analysis as the distributions of oxytocin doses as well as the uterine activity levels by parity and cervical score displayed large heterogeneity of variance and were shown to

be skew. Hence, median values are presented for these variables and the Mann-Whitney U test was used for the comparison of maximum dose of oxytocin and of uterine activity levels (in various stages of labour) by the different methods. The median test was applied to TUA values.

Results

Of the 121 patients 63 were nulliparae and 58 were multiparae; 30 of the nulliparae and 36 of the multiparae had a good cervical score of ≥ 6 whilst 33 of the nulliparae and 22 of the multiparae had a poor cervical score of ≤ 5. Eleven patients (9%) were delivered by caesarean section of whom all but two were nulliparae. Nine of these patients had been managed by automatic infusion system and subsequent manual override. The indications for caesarean section were cephalopelvic disproportion in eight, failed induction of labour in two and fetal distress in one patient. These patients were excluded from the analysis.

The obstetric characteristics and the labour outcome in the 110 patients who were delivered vaginally have been detailed in Chapter 4.2. The maternal age, height, gestational age, cervical score, mode of delivery, birthweight, Apgar scores and umbilical cord venous blood pH values were not significantly different between the two infusion groups, when controlled for parity and cervical score. In nulliparae with a good score and multiparae with a poor score the duration of labour was significantly shorter in the peristaltic infusion group. In the nulliparae with a

poor cervical score, due to poor progress of labour with the AIS system manual override was undertaken in 53.3% of cases, thus the length of labour was not significantly different compared with the peristaltic infusion group. In multiparae with good cervical score the length of labour was short with both modes of infusion and was not significantly different in the two groups. Table 4.4-1 shows the median maximum dose of oxytocin according to parity and cervical score with different modes of infusion. The only significant difference was in nulliparae with a poor cervical score where the dose was significantly higher in the peristaltic infusion group.

Table 4.4-1: Comparison of median maximum dose of oxytocin given by automatic infusion (AIS) and peristaltic infusion (IVAC) system

Parity	Cervical Score	Infusion System	n=	Median maximum dose of oxytocin	Mann-Whitney U test
Nulliparae	≤ 5	AIS	15	4.9	U=21.5
		IVAC	13	10.8	p<0.001
	≥ 6	AIS	14	6.2	U=59.5
		IVAC	12	8.5	NS
Multiparae	≤ 5	AIS	11	4.0	U=39.5
		IVAC	10	8.0	NS
	≥ 6	AIS	15	4.3	U=111.0
		IVAC	20	7.8	NS

The uterine activity throughout labour was divided into five portions. The first represented the incremental phase. The rest was divided into four equal portions as described in Chapter 4.1.

The uterine activity showed an initial significant steep increase (incremental phase) followed by a long period

of little increase (stable phase) terminating in a steep rise (terminal phase). The incremental phase corresponded to the increase of oxytocin till the maximum dose was achieved. Most of the cervical dilatation occured in the stable and terminal phases. The terminal phase corresponded to the late first stage of labour. Table 4.4-2 compares the uterine activity in these different phases in patients grouped according to parity, cervical score and infusion system. The uterine activity was significantly higher in the incremental, stable and terminal phases of labour in the peristaltic infusion group than in the AIS group. These differences in uterine activity according to parity and cervical score are illustrated in Figs. 4.4-1&2. The total uterine activity performed by each individual patient according to parity, cervical score and mode of oxytocin infusion is given in Fig. 4.4-3. The median total uterine activity values in each of these groups is given in Table 4.4-3.

Table 4.4-2: Comparison of uterine activity (median values) in different phases of labour matched for parity and cervical score by automatic (AIS) and peristaltic (IVAC) infusion systems

		Median uterine activity (k Pas)				
		Incremental phase	Stable phase 1st 25%	2nd 25%	3rd 25%	Terminal phase 4th 25%
Nulliparae						
≤ 5	AIS n=15	886.5	1170.5	1225	1500	1810
	IVAC n=13	1290	1745	1815	1825	1930
		p<0.001	p<0.001	p<0.001	p<0.001	p<0.04
≥ 6	AIS n=14	730	1062.5	1100	1136	1769
	IVAC n=12	1364	1882.5	1950	1990	2468
		p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
Multiparae						
≤ 5	AIS n=11	719	1078	1140	1350	1653
	IVAC n=10	1193.5	1800	1970	1890	2103
		p<0.001	p<0.001	p<0.001	p<0.001	p<0.003
≥ 6	AIS n=15	679	1077.5	1060	1165	1515
	IVAC n=20	1012.6	1500	1625	1750	2333
		p<0.001	p<0.001	p<0.001	p<0.001	p<0.001

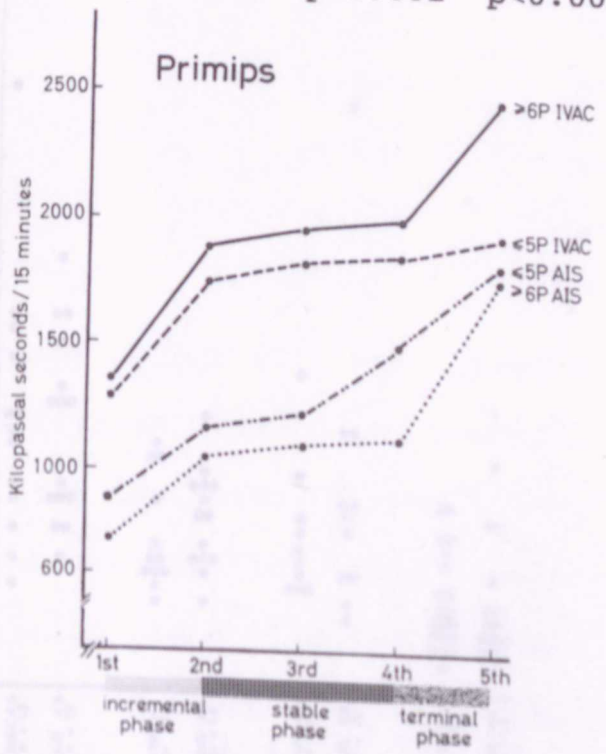


Fig 4.4-1. Uterine activity in induced labour in nulliparae according to cervical score and mode of oxytocin infusion.

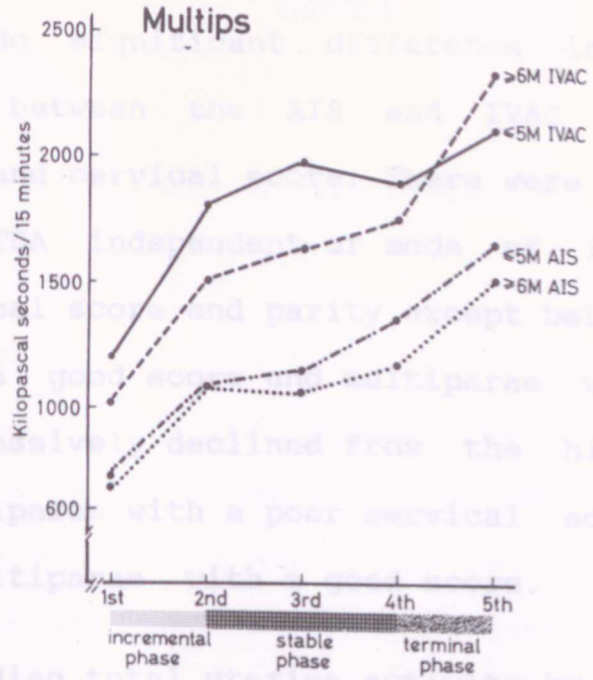


Fig 4.4-2. Uterine activity in induced labour in multiparae according to cervical score and mode of oxytocin infusion.

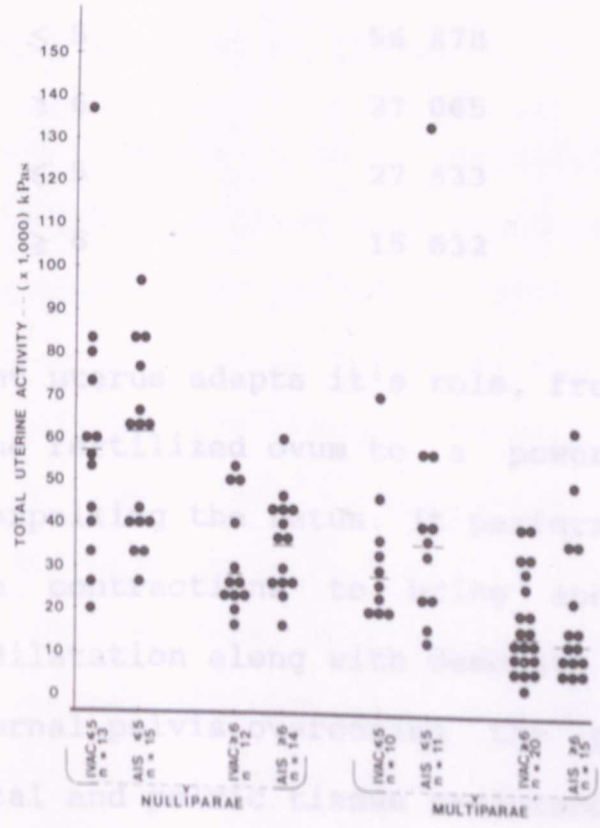


Fig 4.4-3. Total uterine activity in induced labour according to parity, cervical score and mode of oxytocin infusion.

There was no significant difference in the total uterine activity between the AIS and IVAC groups of comparable parity and cervical score. There were significant differences in TUA independent of mode of infusion but dependent on cervical score and parity except between that in nulliparae with a good score and multiparae with a poor score. TUA progressively declined from the highest level required in nulliparae with a poor cervical score to the lowest level in multiparae with a good score.

Table 4.4-3: Median total uterine activity by parity and cervical score in automatic (AIS) and peristaltic (IVAC) infusion systems

		Total uterine activity (k Pas)	
Parity	Cervical score	IVAC	AIS
Nulliparae	≤ 5	56 878	61 685
	≥ 6	27 065	35 619
Multiparae	≤ 5	27 633	35 155
	≥ 6	15 632	14 488

Discussion

The pregnant uterus adapts it's role, from that of a receptacle of the fertilized ovum to a powerful muscular organ capable of expelling the fetus. It performs work in the form of uterine contractions to bring about cervical effacement and dilatation along with descent of the head through the maternal pelvis overcoming the pelvic tissue resistance. Cervical and pelvic tissue resistance may differ in induced and spontaneous labour, according to parity, cervical score, presentation, position, maternal height and

birthweight of the baby. The total uterine activity required in each case may be considered to be proportional to the cervical and pelvic tissue resistance in the absence of unfavourable fetopelvic relationship.

The total uterine activity required to achieve vaginal delivery was similar in nulliparae with a good score and multiparae with a poor score in induced labour. The multiparae with a good score had to perform significantly less and nulliparae with poor score significantly more work compared to the other two groups. This supports the clinical observation that a multipara with a good cervical score when induced has a shorter and easier labour compared to a nullipara with a poor cervical score who has a longer and more difficult labour (Gibb et al.1985c).

Cervical and pelvic tissue resistance was not significantly different in a given parity and cervical score even when two ranges of 15-min uterine activity levels were maintained by different modes of infusion. The lower level was compensated for by the longer duration of labour. Neonatal condition was not significantly different irrespective of different uterine activity levels in both groups. It appears that if fetal compromise is encountered in induced labour, vaginal delivery may still be possible by maintaining a significantly lower level of uterine activity known to be associated with progress of labour. In such situations an intrauterine catheter and maintainance of

satisfactory uterine activity levels may be helpful. From studies of spontaneous labour both in nulliparae and multiparae (Steer et al.1984, Gibb et al.1984, Arulkumaran et al.1984) it appears that labour progress may be satisfactory if the uterine activity levels are maintained above 700 k Pas/15 min.

In induced labour if the progress is not satisfactory even after the uterus has performed more than 90'th centile of the total uterine work according to parity and cervical score, it may indicate possible cephalopelvic disproportion or malposition or failed induction of labour. The median total uterine work of these groups indicate that a nullipara with a poor cervical score has to do nearly four times, and nullipara with a good score and multipara with poor score nearly twice the total uterine work of a multipara with good score.

This study suggests that measurement of uterine activity in induced labour may prove useful in conditions of fetal compromise to decide whether to continue labour at lower but acceptable activity levels or to deliver abdominally if the compromise is evident at lower activity levels. If the total uterine work already performed is high in a labour with abnormal progress, such measurements will help to alert the obstetrician to the possibility of cephalopelvic disproportion, malposition or failed induction of labour.

5 UTERINE ACTIVITY IN PATIENTS WITH PREVIOUS CAESAREAN SECTION

5.1 UTERINE ACTIVITY DURING SPONTANEOUS LABOUR AFTER PREVIOUS LOWER SEGMENT CAESAREAN SECTION

5.2 OXYTOCIC AUGMENTATION IN DYSFUNCTIONAL LABOUR AFTER PREVIOUS CAESAREAN SECTION

5.3 TRIAL OF LABOUR AFTER PREVIOUS CAESAREAN SECTION

5.4 UTERINE ACTIVITY AND OTHER CLINICAL FEATURES IN PATIENTS WHO HAD SCAR DEHISENCE OR RUPTURE

5.1 Uterine activity during spontaneous labour after previous lower segment caesarean section

There is a gradual and steady increase in caesarean section (CS) rate in many countries and is a matter of concern. Recent reports from the UK (Yudkin & Redman 1986) and the USA (Gilstrap et al. 1984) have suggested that dystocia , previous CS, breech presentation and fetal distress are the major contributory factors. The National Institute of Health consensus statement (Consensus in Medicine 1981) suggests that this trend may be stopped or reversed while maternal and fetal outcome continue to improve. To achieve such objectives each factor should be studied and remedial steps undertaken.

In many centres a repeat CS is performed on most mothers who had a previous CS. This was due to the concept introduced by Craigin (1916). When he advocated this policy, the low transverse uterine incision was not widely practised and modern anaesthesia, blood storage techniques and antibiotics were not available. Subsequently, many authors (Gibbs 1980; Eglinton et al.1984; Silver & Gibbs 1987, Chua et al 1989) have reported 63 to 78% success rates of vaginal delivery in women with previous scars with little danger to the mother or fetus. Inspite of such reports, there is reluctance to allow a trial of labour because of difficulties in adequately assessing the uterine activity, cephalopelvic relationships and the integrity of the scar. Uterine activity profiles according to parity associated with satisfactory

progress of labour and unassisted vaginal delivery in parturients without a uterine scar have been reported previously (Gibb et al 1984, Steer et al. 1984, Arulkumaran et al.1984a), but little is known about the nature of uterine contractions expressed as uterine activity integral in women with a uterine scar.

Those delivered by CS in their first pregnancy at term after little or no labour will be technically multiparae but the uterine activity in a subseuent labour may be similar to labour in nulliparae. It may be postulated that a nullipara who had a delivery by CS in the late first stage of labour or a multipara who had a vaginal delivery before or after a CS should behave like a multipara in subsequent labours, but this has not been studied quantitatively. This study was conducted to define the uterine activity profiles in different groups of women with a previous scar and to compare them with that in women with a cephalic presentation but without a CS scar.

Patients and Methods

Patients admitted in spontaneous labour at term with vertex presentation to the University unit labour ward, in Kandang Kerbau Hospital who had had a previous lower segment CS and in whom a decision was made to allow a trial of scar were recruited.

This study was confined to those who progressed normaly in labour with a rate of cervical dilatation of 1 cm / hr or

more (alert line) or within a line drawn 2 hrs to the right of such a line (action line) on the partogram, resulting in an unassisted vaginal delivery of an infant in good condition. These women were divided into 3 groups: group A included those who had had a CS electively or in the early latent phase of labour and no previous vaginal delivery; group B included those who had had a section in the active phase of labour and no previous vaginal delivery; group C included those who had had a section and also a previous vaginal delivery.

When the patient was in established labour with the cervix effaced and 3 cm or more dilated, the membranes were ruptured if it was still intact and a Gaeltec catheter was introduced after calibration as described in Chater 1.4. The fetal heart rate was continuously monitored electronically and uterine activity quantified on-line. Rate of progress of labour was assessed by 2 to 3 hourly vaginal examination and related to the observed uterine activity. Pain relief was by pethidine 75-100 mg im every 4 to 6 hourly or by inhalation of a mixture of 50% oxygen and 50% nitrous oxide. Those who had epidural analgesia were not included for analysis. All were nursed in a lateral position in the first stage of labour. The observations were continued till full cervical dilatation when the catheter was removed.

Neonatal condition at birth was assessed by Apgar scores at 1 and 5 min and by umbilical cord artery blood pH

at delivery.

The uterine activity values were analysed collectively in relation to cervical dilatation. Centiles were derived for each cervical dilatation. Median levels were also derived for the whole labour from 3 to 9 cm. Uterine activity profiles of controls matched for height, birthweight and rate of labour progress were obtained from nulliparae (N 1, N 2 and N 3 for groups A, B and C respectively) and multiparae (M 1, M 2, and M 3 for groups A,B and C respectively) admitted in spontaneous labour with a vertex presentation and satisfying the other conditions of the study except a previous CS scar. The obstetric characteristics and neonatal outcomes in groups A, B and C were compared with each other and with those in their respective control groups using X 2 test. The cervical dilatation specific uterine activity profiles were compared using the Mann- Whitney U test. The median cumulative uterine activity needed to achieve full dilatation from a given cervical dilatation was calculated for each of the study groups and their controls. The cumulative uterine activity of the study groups was compared with the respective median cumulative uterine activity of the controls using the Mann-Whitney U-test.

Results

The mean age in different groups ranged from 27.1 to 29.2 years and the mean gestational age at delivery ranged from 38.7 to 39.6 weeks. These parameters did not differ significantly between study groups and controls. The mean

height of the women and the neonatal outcome in the different groups are shown in Table 5.1-1. The neonatal Apgar scores at 1 and 5 min and umbilical cord arterial blood pH values were similar. None of the babies had a 1 min Apgar score < 5 , a 5 min Apgar score < 7 or cord arterial blood pH < 7.15. There was no significant difference in the parity distribution and in birth weights between the study groups and their respective controls.

Table 5.1-1: Patient characteristics and neonatal outcome

Patient group	n=	Height in cm Mean (SD)	Cord artery pH Mean (SD)	Birthweight in g Mean (SD)
A	21	154.3(5.2)	7.30(0.07)	3240 (324)
N 1	21	155.2(3.4)	7.32(0.06)	3136 (289)
M 1	21	154.6(4.2)	7.31(0.04)	3217 (391)
B	22	153.2(4.7)	7.30(0.06)	3120 (286)
N 2	22	155.6(3.8)	7.28(0.04)	3240 (318)
M 2	22	154.8(4.2)	7.31(0.05)	3192 (340)
C	14	152.4(6.4)	7.31(0.05)	3225 (345)
N 3	14	155.2(3.7)	7.32(0.06)	3184 (367)
M 3	14	155.0(3.7)	7.33(0.04)	3218 (424)

Group A: Patients who had a previous lower-segment CS electively or in the latent phase of labour but no vaginal delivery.

Group N 1: Control group of nulliparae for group A.
Group M 1: Control group of multiparae for group A.

Group B: Patients who had a previous lower-segment CS in the active phase of labour but no previous vaginal delivery

Group N 2: Control group of nulliparae for group B.
Group M 2: Control group of multiparae for group B.

Group C: Patients who had a previous lower-segment CS but had a vaginal delivery prior to or after that event.

Group N 3: Control group of nulliparae for group C.
Group M 3: Control group of multiparae for group C.

The median uterine activity values in group A and the corresponding control groups , N 1 and M 1 are shown in Fig. 5.1-1. Considering the uterine activity at different cervical dilatations, group A behaved like nulliparae except at 3 and 4 cm dilatation. The uterine activity levels were significantly higher than those in control multiparae except at 3 and 4 cm dilatation, suggesting that the uterus behaves more like in a nullipara.

The women in group B exhibited similar uterine activity profiles as were found in the control multiparae (M 2) but lower activity than in the control nulliparae (N 2) except at 8 and 9 cm dilatation (Fig. 5.1-2).

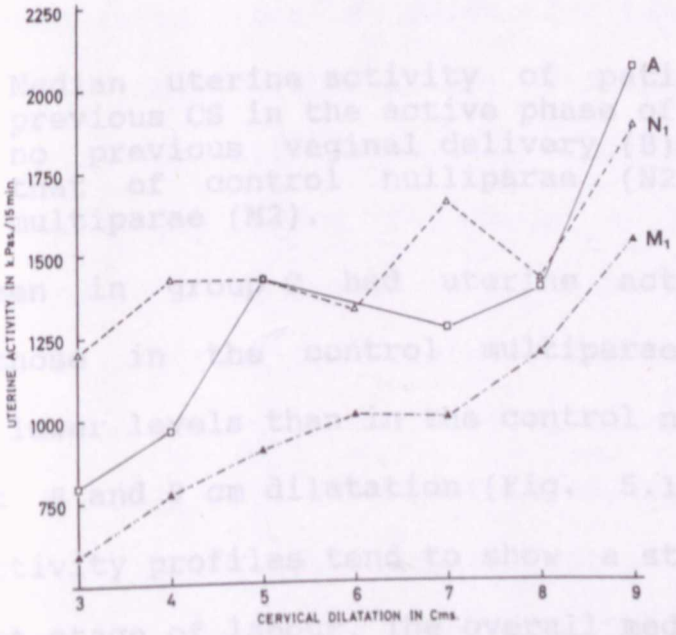


Fig 5.1-1. Median uterine activity profile in normal labour in those with a previous elective CS or CS in latent phase of labour and no previous vaginal delivery (A) compared with that of control nulliparae (NI) and control multiparae (MI).

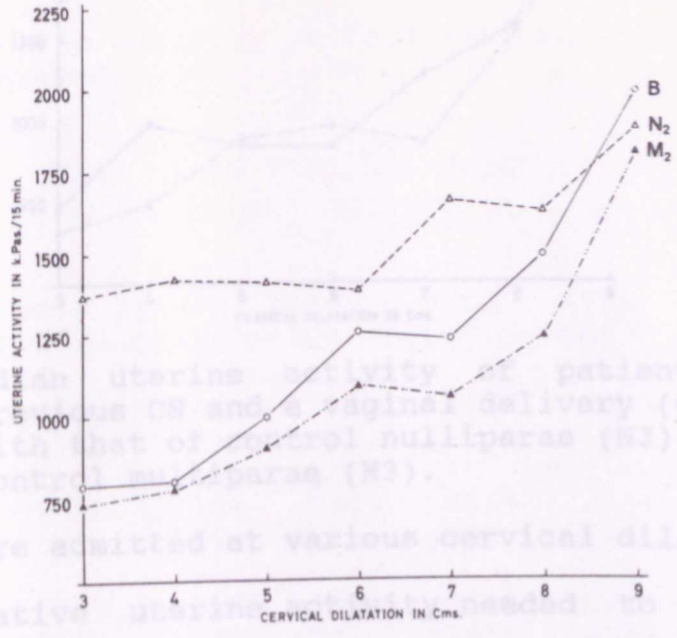


Fig 5.1-2. Median uterine activity of patients with a previous CS in the active phase of labour and no previous vaginal delivery (B) compared with that of control nulliparae (N2) and control multiparae (M2).

The women in group C had uterine activity levels similar to those in the control multiparae (M 3) but significantly lower levels than in the control nulliparae (N 3) except at 8 and 9 cm dilatation (Fig. 5.1-3). In all groups the activity profiles tend to show a steep rise in the late first stage of labour. The overall median activity (3-9 cm) in the three groups with a previous CS was between 1035 and 1320 k Pas/15 min.

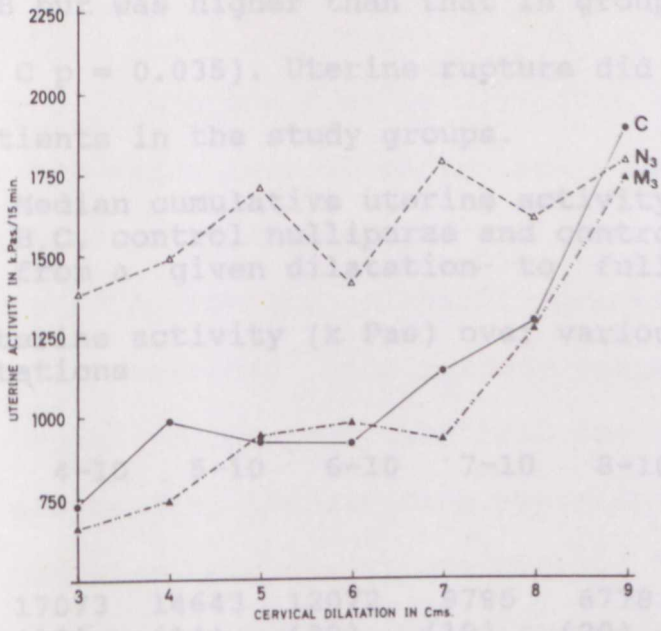


Fig 5.1-3. Median uterine activity of patients with a previous CS and a vaginal delivery (C) compared with that of control nulliparae (N3) and control multiparae (M3).

Women were admitted at various cervical dilatations in labour. Cumulative uterine activity needed to dilate the cervix was calculated from a given dilatation to full dilatation in all groups (Table 5.1-2). Similar values were derived for the control nulliparous and multiparous groups. There was a declining trend from group A to C in the cumulative uterine activity needed to achieve full dilatation from a given dilatation. The overall cumulative uterine activity of group A from a given cervical dilatation to full dilatation was not different from that in control nulliparae but significantly higher than that in control multiparae. Similar findings were observed with group B. Group C had cumulative uterine activity like that in the control multiparae. The overall median cumulative uterine activity for the whole labour did not differ significantly between

groups A and B but was higher than that in group C (A vs C p = 0.018, B vs C p = 0.035). Uterine rupture did not occur in any of the patients in the study groups.

Table 5.1-2: Median cumulative uterine activity in groups A, B,C, control nulliparae and control multiparae from a given dilatation to full dilatation

Cumulative uterine activity (k Pas) over various ranges of cervical dilatations

Patient group	3-10	4-10	5-10	6-10	7-10	8-10	9-10	Overall
A	19480 (5)	17073 (12)	14643 (14)	12072 (20)	9795 (19)	6778 (20)	4070 (21)	9830 (111)
N 1	15067 (11)	14946 (11)	12440 (16)	11196 (16)	9350 (20)	7500 (19)	5000 (20)	9340 (113)
M 1	10693 (8)	7395 (14)	7284 (16)	5601 (13)	4369 (17)	2980 (17)	2073 (20)	4454 (105)
B	16218 (12)	14577 (16)	12085 (18)	10550 (17)	7875 (19)	6225 (21)	3524 (22)	8790 (125)
N 2	16458 (8)	13550 (12)	12002 (14)	11082 (16)	9219 (19)	7219 (21)	4422 (21)	8642 (111)
M 2	12283 (10)	9423 (15)	9236 (18)	6090 (19)	4803 (18)	3748 (20)	2216 (22)	6446 (122)
C	13825 (6)	8969 (9)	9773 (12)	9836 (14)	7747 (14)	6108 (14)	2956 (14)	7280 (83)
N 3	15425 (6)	14946 (9)	10031 (10)	9939 (10)	6972 (13)	5242 (13)	2813 (13)	8403 (74)
M 3	10600 (6)	7473 (11)	7094 (11)	5254 (12)	4190 (9)	3682 (12)	2073 (14)	5290 (75)

The number in parenthesis indicates the number of 15 min observations from which median cumulative uterine activity was calculated.

For description of groups see Table 5.1-1.

Discussion

Integrity of a uterine scar is difficult to assess. For a given scar the force exerted on the scar may be better represented by the active contraction area than the frequency of contractions. In routine clinical practice, uterine contractions are monitored by clinical palpation and by external or internal tocography. The first two methods record the frequency accurately, the duration approximately but the amplitude of the uterine contractions poorly. The use of an intrauterine catheter provides more accurate information and enables active contraction area to be computed. Though the use of intrauterine catheters for managing labour in women with a previous scar has been reported (Flamm et al.1984), the uterine activity associated with normal labour progress has not been quantified. We have studied the uterine activity levels associated with acceptable progress of labour in women with previous CS.

The cervical dilatation specific uterine activity profile in group A was similar to control nulliparae and higher than control multiparae. This might be expected as the women in group A had not experienced full labour in their first pregnancy and would not have had cervical effacement or dilatation. Women in group B showed a cervical dilatation specific uterine activity profile of control multiparae. This may be because these women had previously undergone the process of cervical effacement and dilatation to the active phase of labour. The women in group C who had had a vaginal

delivery showed a uterine activity profile similar to control multiparae. In our study the cumulative or total uterine activities of groups A and B were similar to those in control nulliparae but higher than in control multiparae or in group C which may be attributable to the difference of previous vaginal delivery in the latter groups. The median values of cumulative uterine activity for cervical dilatation from 3 to 10 cm ranged from 14 000 to 20 000 k Pas in the three groups A, B and C.

When cervical dilatation specific median uterine activity profiles of groups A,B and C were compared the differences were minimal and was observed only from cervical dilatations of 5 and 6 cm. Women with a lower-segment CS scar progressed satisfactorily in labour, with uterine activity values between 1000 and 1300 k Pas/15 min. Cephalo-pelvic disproportion should be suspected if, despite such uterine activity, satisfactory progress in labour is not achieved in 3-4 hours and if the cumulative uterine activity has exceeded 20 000 k Pas. Further prolongation of labour or augmentation of labour with oxytocics will increase the cumulative uterine activity with an increased possibility of scar dehisence.

In all groups there was a steep rise of uterine activity in the late first stage of labour which was maintained in the second stage of labour. Such high activities for long periods may not be advisable in the presence of uterine scar. This supports the clinical practice

of well-timed prophylactic forceps delivery in women with a previous scar where there is a likelihood of undue delay in the second stage of labour.

In current obstetric practice women with a previous abdominal delivery frequently have a trial of labour in their subsequent pregnancy. There is no precise method of assessing the integrity of the uterine scar. However, the force applied on the scar may be adequatley assessed by measuring the uterine activity. The results show that labour in the first pregnancy that progresses to the active phase of the first stage of labour reduces the force exerted on the scar in labour in the subsequent pregnancy and is more similar to labour in multiparae than in nulliparae. An intact scar did not influence uterine activity because the patient who had had a previous vaginal delivery and a CS had similar uterine activity as control multiparae who did not have a scar.

5.2 Oxytocin augmentation in dysfunctional labour after previous caesarean section

It is not uncommon that in some centres a trial of labour in women with a previous lower segment CS scar is allowed but a decision is taken to terminate labour if the progress of labour is slow (dysfunctional). Clinicians are reluctant to augment labour even though the risk of scar rupture is reported to be small if progress of labour is satisfactory in response to oxytocin (Flamm et al 1984, ACOG 1985; Silver & Gibbs 1987). One reason for such reluctance is the difficulty in assessing the integrity of the scar prospectively and that the diagnosis of scar rupture is possible only after the event. In addition difficulty exists in determining whether the cause of unsatisfactory progress of labour is poor uterine contractions or cephalopelvic disproportion.

In Chapter 5.1 uterine activity profiles observed in spontaneous normal labour in women with and without scars were compared. Uterine activity profiles in women with scars and abnormal labour have not been described but is of considerable interest. This study investigates the obstetric and labour characteristics and the pre- and post-augmentation uterine activity profiles of patients who had a slow progress of labour with a previous CS scar. The observations in patients who delivered vaginally are compared with those who had CS for poor progress of labour despite adequate augmentation with oxytocin infusion.

Patients and methods

Patient selection, study criteria and methods have been described in Chapter 5.1. Chapter 5.1 describes uterine activity in those women who had normal progress of labour. This study describes uterine activity in women who had abnormal progress of labour. When the progress of labour crossed the action line, oxytocin was given intravenously at a rate of 2 mU/min. The rate was increased every 30 min using a peristaltic infusion pump (IVAC corporation, Sandiego, USA) to produce infusion rates of 2,4, 6, 8, 10, 12, 16, 20, 24 mU/min until the frequency of uterine contractions was one in every 2 to 2.5 min. Women who needed a CS for reasons other than failure to progress (e.g. fetal distress, cord prolapse) were excluded from the analysis.

Each patient had a computerized coding sheet in which age, height, parity, maximum dose of oxytocin infusion, progress of labour, mode of delivery, Apgar scores at 1 and 5 min, and whether the newborn was intubated or admitted to the neonatal intensive care unit were recorded. The frequency, amplitude and uterine activity represented by the active contraction area profile every 15 min were recorded. The mean of these values for 1 hr preceeding augmentation and the mean values obtained for 1 hr when the maximum dose rate of oxytocin was achieved were calculated. The values obtained from those who had satisfactory progress of labour (> 1 cm in 3 hrs) and an unassisted vaginal delivery were compared with those who had an unsatisfactory progress of labour (< 1

cm in 3 hrs) and a CS for failure to progress. Student's t test (two tail) was used for statistical analysis.

Results

The study group consisted of 63 women of whom 49 (78%) were delivered vaginally and 14 (22%) had a CS for failure to progress despite adequate uterine activity. The obstetric and labour characteristics of the two groups are given in Table 5.2-1. There were no statistically significant differences in parity distribution, mean gestation and mean height of the women. The mean infant birthweight was significantly greater (p=0.007) in the group who were delivered by CS for failure to progress in labour. The older women appear to be more likely to have a CS despite adequate augmentation. But analysis in maternal age subgroups revealed that only women aged > 35 years were more likely to be delivered by CS (Fisher's test p=0.038). The mean length of labour and mean cervical dilatation before augmentation were similar. The mean length of labour after augmentation was longer (p=0.007) and the mean maximum dose of oxytocin was higher (p=0.002) in those women who were delivered by CS.

Table 5.2-1: Obstetric and labour characteristics according to mode of delivery

Characteristic	Caesarean section n=14	Normal vaginal delivery n=49	p value
Age in years	31.1(4.0)	28.9(3.4)	0.037
Height in cm	153.7(5.5)	154.7(5.1)	NS
Birthweight in g	3598 (383)	3230 (444)	0.007
Gestation in wks	39.9(0.9)	39.6(0.2)	NS
Cervical dilatation in cm			
At time of augmentation	4.0(0.8)	4.2(1.1)	NS
At time of delivery	5.7(2.2)	10.0	0.000
Length of labour in hrs			
Before augmentation	4.8(2.3)	4.1(1.6)	NS
After augmentation	5.5(1.8)	3.8(2.0)	0.007
Mean maximum dose of oxytocin in mU/min	10.5(2.0)	7.8(2.9)	0.002

Results are mean (SD) values. NS - not significant.

The pre or post augmentation values for mean frequency and amplitude of contractions and mean uterine activity did not differ significantly between the CS and vaginal delivery groups (Table 5.2-2). The increase in mean cervical dilatation was 1.7 cm over a mean augmentation period of 5.5 hrs (0.31 cm/hr) in those patients who had a CS. In contrast the value was 5.8 cm in 3.8 (1.5 cm/hr) hrs in those who were delivered vaginally. There was no scar rupture in the study population.

Table 5.2-2: Characteristics of uterine activity according to mode of delivery

	Caesarean section n=14	Normal vaginal delivery n=49
Frequency of uterine contractions / 10 min		
Pre-augmentation	2.4(0.86)	2.5(0.71)
Post augmentation	4.1(0.75)	4.1(0.60)
Amplitude in mm Hg		
Pre-augmentation	30.3(6.7)	28.0(7.4)
Post-augmentation	40.9(9.9)	43.7(10.5)
Uterine activity integral in k Pas/15 min		
Pre-augmentation	890(247)	743(239)
Post-augmentation	1655(415)	1512(363)

Results are mean values (SD).

Discussion

The women in this study who had slow progress of labour had lower mean frequency, amplitude and UAI compared with the women reported in Chapter 5.1 who had a CS scar but had spontaneous labour with normal progress. There was no clinical evidence of cephalopelvic disproportion , and because the reason for failure to progress was thought to be poor uterine activity, labour was augmented. The post-augmentation frequency (4 in 10 min) and amplitude (41 - 44 mm Hg) were similar in the vaginal delivery and CS groups suggesting that an adequate uterine activity was achieved by the two groups. Presumably, those with heavier babies had cephalopelvic disproportion and failed to progress despite adequate uterine activity for a sufficient length of time.

When uterine activity was calculated in UAI units, means of 1512 k Pas/ 15 min in the vaginal delivery group and 1655 k Pas/ 15 min in the CS group were recorded (Table 5.2-2). That is 15 and 25 % higher, respectively, than the highest median uterine activity (1320 k Pas / 15 min) seen in women with a CS scar in spontaneous labour with normal progress (Chapter 5.1). When labour is augmented in routine clinical practice the oxytocin infusion rate is titrated to achieve a mean contraction frequency of 4 in 10 min. In our study this resulted in values of 167 Montevideo units (MU) (mean amplitude x number of contractions in 10 min) in the vaginal delivery group, and 179 MU in the CS group. When facilities for calculating the UAI are not available, computing uterine activity in Montevideo units may be used to assess whether adequate and not excessive uterine activity is produced as the result of augmentation because it is reasonable to believe that a higher uterine activity may increase the stress on the uterine scar. In addition, the duration of augmentation should be considered. If the progress of labour is poor in the presence of adequate uterine activity, prolongation of labour will increase the cumulative uterine activity with a probable increased risk of scar dehisence.

In our study all the CS were for the indication of failure to progress in labour due to cephalopelvic disproportion. In these patients, the cervix dilated 1.7 cm over 5.5 hrs (0.3 cm/hr) compared with 5.8 cm in 3.8 hrs (1.5

cm/hr) in those who were delivered vaginally. Silver & Gibbs (1987) also found significant differences in cervical dilatation rate subsequent to the use of oxytocin in patients who were delivered vaginally (1.82cm/hr) compared with those who were delivered abdominally (0.18 cm /hr).

The cervical dilatation rate for the next few hours after oxytocin augmentation appears to be an important factor in predicting mode of delivery. Management of patients with previous CS and dysfunctional labour should be based on achieving optimal uterine activtity after excluding obvious disproportion. Subsequent management should be rationalised based on the rate of progress of labour in the next few hours of augmentation.

5.3 Trial of labour after previous caesarean section

There has been considerable reduction in the morbidity and mortality associated with caesarean section with the improvement in anaesthesia, aseptic operative techniques, blood banking facilities and effective broad spectrum antibiotics. Despite this reduction, the morbidity and mortality is 10 times that of a patient delivered per vaginum (Ritchie 1986). This is of concern because there has been a steady rise in the caesarean section rate over the past decade (Consensus in medicine statement 1981, Derom et al. 1987). A significant contributing factor to this rise is the performance of elective repeat caesarean section in those with a previous Caesarean scar (Consensus in medicine 1981).

It has been generally accepted that the dictum 'once a Caesarean, always a Caesarean' is unnecessarily rigid, in patients who have a lower segment uterine scar. The fear of uterine rupture with it's potentially catastrophic consequences, both to mother and fetus is a major reason why a trial of labour has not been universally accepted as a reasonable alternative to routine repeat caesarean section. This is despite the fact that obstetricians have abandoned classical Caesarean section in favour of lower segment transverse section with lower morbidity and mortality. The increasing safety of Caesarean section, concern with perinatal mortality and morbidity and fear of litigation in case of adverse outcome contribute to the resistance in

permitting a trial of labour (Gibbs 1980). Dewhurst (1957) reported the risk of rupture of a classical section scar to be 2.2% for all cases, rising to 4.7% for those women who went into labour and 8.9% for those who delivered vaginally. The corresponding figures for the lower segment scar were 0.5 %, 0.8% and 1.2% respectively. The maternal mortality associated with ruptured classical scars was 5 % and fetal mortality was 73%. On the other hand, he recorded no deaths among 55 mothers with a ruptured lower segment scar and a fetal mortality of 12.5 %. Adaption of a policy to select appropriate cases for trial of labour, limited period of augmentation when necessary after excluding cephalopelvic disproportion (CPD) and managing labour as suggested in Chapter 5.2 should result in good obstetric outcome with minimal risk to the fetus or mother. Such a policy was in operation from 1984 and the outcome was studied for a period of 30 months.

Patients and methods

During the period October 1985 to April 1988, there were 7,059 deliveries in the Department of Obstetrics and Gynaecology, National University Hospital. Of these patients, 305 had a previous lower segment Caesarean section (LSCS). The case notes of these 305 patients were studied retrospectively. Data on patients' age, parity, gestation, indication for the procedure, and details of the neonatal outcome were collected in a computerised coding sheet.

Ninety eight (32.1 %) patients had an elective repeat

lower segment Caesarean section and 207 (67.9 %) had a trial of labour; 185 patients (89.4 %) were admitted in spontaneous labour, and 22 (10.5 %) were induced with oxytocin and artificial rupture of membranes.

In those admitted in spontaneous labour, if labour did not progress satisfactorily, oxytocin was used to augment labour. This was started at a rate of 2.5 mu/ min using a peristaltic infusion pump, and increased at a rate of 2.5 mu every half an hour to a maximum of 12.5 mu/min till there were 4 to 5 contractions every 10 mins. If the response to this rate of infusion was inadequate, the rate of oxytocin titration was increased at the discretion of the attending obstetrician. The labour was monitored throughout with continuous cardiotocography, and in cases where high doses of oxytocin was used, intrauterine pressure measurements were performed. Analgesia was provided with Entonox (50% oxygen and 50 % nitrous oxide) and pethidine 75 to 100 mg 4-6 hourly in most patients. Nineteen of the 207 patients (6.2 %) had epidural analgesia. Chi-square or student t test was performed for statistical analysis.

Results

Patients who had a previous lower segment Caesarean section comprised 4.3 % (305) of the total deliveries in this period. Ninety eight (32.1 %) of these patients had an elective repeat LSCS. The indications for the elective repeat LSCS were: clinical and or radiological evidence of cephalopelvic disproportion (23), two previous LSCS (30),

malpresentation/abnormal lie (13), and others (32) (eg. intra uterine growth retardation in the preterm period, placenta praevia, fetal compromise on antenatal tests of fetal well being etc).

Two hundred and seven patients had a trial of labour. Seventy nine (38.2 %) of these patients had their previous LSCS for failure to progress in labour due to CPD with or without malposition. Fifty of these patients (63.3 %) delivered vaginally (Table 5.3-1).

Table 5.3-1: Mode of delivery in relation to the indication for previous LSCS

Indication for previous LSCS	'Recurrent' CPD/ no progress	Non recurrent
Vaginal delivery	50 (63.3%)	94 (73.4%)
Emergency LSCS	29 (36.7%)	34 (26.6%)
Total	79	128

LSCS - lower segment caesarean section.
CPD - cephalo pelvic disproportion.

Of the 128 patients who had a nonrecurrent indication for their previous LSCS (eg. fetal distress, malpresentation, placenta praevia, cord prolapse) 94 (73.4%) delivered vaginally. There was no statistical difference in the vaginal delivery rates in the two groups.

Indications for emergency repeat LSCS in the 63 patients who had a trial of labour were: poor progress of labour (CPD or malposition) (39), fetal distress (9), malpresentation with failure to progress (6), and others (9). Cephalopelvic disproportion with failure to progress (18.8%)

was the most common indication for repeat emergency LSCS ($p<0.001$). Of those who had the previous LSCS for CPD/malposition with failure to progress (n=79), 29 (36.7%) needed emergency LSCS, of which 20 (69.0%) were for failure to progress. In those 128 with a nonrecurrent cause for their previous LSCS, 19 (55.9%) of the 34 patients who had emergency LSCS had it for failure to progress. This difference in the proportion of patients with the indication of CPD/malposition for repeat Caesarean section in the cases with recurrent and non-recurrent causes for CS was not statistically significant.

Of the 207 patients who had a trial of labour , 22 patients had labour induced whilst 185 were admitted in spontaneous labour, of whom 40.5 % (n=75) needed augmentation. Thus oxytocin was used in 46.9 % (n=97) of those who had a trial of labour. The outcome of labour in those who had oxytocin was not significantly different from those who did not require oxytocin to augment or induce labour (Table 5.3-2).

Table 5.3-2: Outcome of labour related to the use of oxytocin

	Oxytocin used n=97	Oxytocin not used n=110
Normal vaginal delivery	54.9 %	59.1 %
Instrumental vaginal delivery	15.6 %	11.4 %
Emergency LSCS	29.5 %	29.5 %

LSCS - lower segment caesarean section

Of the 75 patients who needed augmentation, 69.3 % (52 of 75) achieved vaginal delivery (Table 5.3-3). This was not significantly different from the 67.3% (74 of 110) vaginal deliveries in the group who were in spontaneous labour and needed no augmentation. There were more instrumental vaginal deliveries in those who had augmented labour, but this difference did not reach statistical significance.

The length of labour in those who needed augmentation (10.7 + 3.9 hrs) was significantly longer ($p<0.001$) than those who had induced labour (7.6 + 4.0 hrs). In the group who needed augmentation, there was no statistically significant difference in the duration of augmentation between the group who delivered vaginally (4.2 + 2.7 hrs), and the group who needed emergency LSCS (5.4 + 3.1 hrs).

Table 5.3-3: Delivery outcome in 185 patients who had spontaneous onset of labour

Type of labour	Augmented n=75	Not augmented n=110
Normal vaginal delivery	39 (52.0 %)	62 (56.4 %)
Instrumental vaginal delivery	13 (17.3 %)	12 (10.9 %)
LSCS	23 (30.7 %)	36 (32.7 %)

LSCS - lower segment caesarean section.

Evidence of hypoxia, as judged by five minute Apgar scores, was not statistically different when oxytocin was used to augment or induce labour compared to those who had spontaneous onset of labour with normal progress, or those who had an elective repeat LSCS (Table 5.3-4).

Table 5.3-4: Incidence of hypoxia in patients with previous LSCS

Type of labour	Spontaneous		Induced	Elective LSCS
	Augmented n=75	Not augmented n=110	n=22	n=98
Apgar score < 7 at 5 min	1 (1.3%)	2 (1.8%)	1 (4.5%)	3 (3.1%)

There was a trend towards more repeat LSCS with increasing birth-weight beyond 2,500 g (Table 5.3-5). This was especially reflected by the higher emergency caesarean section rates in those who had a trial of labour. This trend of emergency LSCS was not seen when birthweights were less than 2,500 g. Instead, the Caesarean sections performed in this subgroup of patients was mostly elective. The indications for elective and emergency Caesarean section in this subgroup were for reasons other than cephalopelvic disproportion or failure to progress in labour.

Table 5.3-5: Birth weight related to mode of delivery (%) in 305 patients with a previous LSCS

	< 2500 n=14	2501-3000 n=70	3001-3500 n=140	3501-4000 n=63	> 4001 n=18
Vaginal delivery	23.6	61.4	52.8	31.8	11.1
Emergency CS	19.3	10.0	18.6	27.0	66.7
Elective CS	57.1	28.6	28.6	41.2	22.2
Total CS	76.4	38.6	47.2	68.2	88.9

CS - Caesarean section.

There was no uterine rupture during the period of study. The incidence of scar dehisence in this study was 1.4 % (3 of 207). These 3 patients had an unsuccessful trial of

labour and had emergency LSCS for failure to progress. Scar dehisence was discovered at repeat LSCS. No scar dehisence was noted in patients who had an elective repeat LSCS. In those who achieved a vaginal delivery the integrity of the scar was not assesssed.

In all 3 cases of scar dehisence, the babies were delivered in good condition. There were no increase in haemorrhage, uterine atony or febrile morbidity of the mothers compared to the rest of the study population.

Discussion

Patients with one or more LSCS constitute a small but appreciable proportion (4.3%) of total deliveries. Appropriate management of these patients can reduce the Caesarean section rate as they are an important and self-repeating cause of abdominal delivery. Injudicious management of a patient with previous uterine scar can lead to scar rupture and it's potentially catastrophic maternal and fetal consequences.

Of the 305 patients, 32.1% had elective LSCS, 20.7% had emergency LSCS and 46.9 % delivered vaginally. This compares well with recent series elsewhere (Gibbs 1980, Meier & Porreco 1982, De Muylder 1985, Molloy et al. 1987).

Thirty of the 305 patients (9.8%) had 2 previous LSCS. These patients were electively delivered abdominally, accounting for 18.6% of the total LSCS performed during the study period. More specifically they accounted for almost a

third (30.6%) of all the elective LSCS performed. Other investigators have suggested that patients with more than one previous LSCS can be safely permitted a trial of labour (Meier & Porreco 1982, Porreco & Meier 1983, Paul et al 1985, Phelan et al 1987). In a recent series Phelan et al. 1988, demonstrated that the likelihood of successful vaginal delivery according to the number of prior Caesarean sections was as follows: with 1 LSCS, 1348/1637 (82%); with 2 LSCS, 107/149 (72%); and with 3 LSCS, 9/10 (90%). In this study, the rates of oxytocin administration (50%) were similar for patients with 1 and 2 or more Caesarean sections. Maternal and perinatal mortality and morbidity were low and was not related to the number of previous lower segment scars. A carefully monitored trial of labour in selected patients with 2 previous LSCS may reduce our Caesarean section rate without any increase in maternal or fetal morbidity.

In considering a trial of labour in a patient with a previous LSCS, the indication for the primary LSCS has been a significant factor. Discussion on recurrent versus nonrecurrent indication for LSCS abound in the litreature. Some series have given a trial of labour to these patients with a primary LSCS for CPD, while others have specifically excluded such patients (Lavin et al. 1982, Clark et al.1984, Ngu & Quinn 1985). However, more than two thirds (63.3%) of those patients with prior Caesarean section done for these reasons achieved vaginal delivery in our series. This suggests that blanket exclusion of patients from a trial of

labour after a previous LSCS for CPD or failure to progress in labour is not justified. There must be careful selection of these patients based on review of the events leading to the Caesarean section in the previous pregnancy, as well as factors affecting the feasibility of a trial of labour in this pregnancy. In this subgroup of patients (n=79), 29 had emergency Caesarean sections of whom 69% were due to recurrent CPD/failure to progress. But 55.9% of the emergency Caesarean sections (n=34) in the subgroup with a nonrecurrent indication (n=128) for their previous LSCS were for CPD/failure to progress. The difference was however not statistically significant, indicating that with careful selection, patients who had a previous LSCS for CPD/failure to progress can achieve similar results to those who had a previous LSCS for a nonrecurrent cause.

The use of oxytocin in patients with a uterine scar undergoing a trial of labour is of concern because of the possible increased risk of uterine rupture or dehisence with it's use (Meier & Porreco 1982, Lavin et al. 1982). However, more recent reports do not show an increased risk of uterine rupture with the use of oxytocin (Ngu & Quinn 1985, Horenstein & Phelan 1985, Molloy et al.1987, Phelan et al. 1987,). In this study, an appreciable number of patients achieved vaginal delivery (70.5%) when oxytocin was used judiciously. This was not different from the vaginal delivery rates in patients who did not require augmentation or induction. There was no maternal or fetal mortality in either

group. The total length of labour in those patients who required augmentation was significantly longer ($p<0.001$) than either patients who did not require augmentation or those who had induced labour. However, there was no difference in the mean length of labour or postaugmentation period between those who delivered vaginally or by caesarean section in the augmented group. The patients who required augmentation were reviewed at 3-hour intervals, and if progress was not satisfactory by the second review, emergency LSCS was performed. Such a policy of a limited period of augmentation is necessary to avoid the possibility of uterine rupture.

The incidence and type of uterine dehisence reported in our patients was similar to that reported in the litreature (Gibbs 1982, Lavin et al. 1982,Flamm et al. 1984). The bloodless dehisence is the commonest form of loss of scar integrity and has little clinical signs and does not cause much morbidity or mortality. Proper selection of cases for a trial of labour, judicious use of oxytocin and limitation of the period of augmentation are necessary to avoid scar dehisence. The 3 cases of scar dehisence in our series are examples of not following these guidelines and are discussed in Chapter 5.4.

The use of epidural analgesia in patients who had a previous uterine scar remains controversial (Gibbs 1980,Meier & Porreco 1982, Flammet et al, 1984, Molloy et al.1987). Epidural analgesia is avoided because of the fear that it may

mask abdominal pain caused by uterine rupture (Gibbs 1980). However the usefulness of lower abdominal pain and tenderness leading to the early diagnosis of uterine rupture is open to question (Lavin et al.1982). Epidural analgesia was requested by a small number of patients. Although the numbers were small there was no scar dehisence or rupture in these patients. Scar tenderness does not seem to be a reliable early sign of scar dehisence. None of the 3 patients who had scar dehisence had epidural analgesia or complained of abdominal pain between contractions or scar tenderness.

Our results suggest that with careful selection of patients and close monitoring in labour, a trial of labour is safe in patients with a previous lower segment Caesarean section scar. A successful trial of labour may be safely achieved even in patients with a recurrent indication for LSCS in the previous pregnancy.

The possibility of vaginal delivery in patients with more than 1 previous lower segment transverse Caesarean section needs further study.

Oxytocin may be used, if indicated, after careful selection of patients. Induction of labour in selected cases does not carry a high risk of uterine rupture, and permits an appreciable number of patients to deliver vaginally. In dysfunctional labour, oxytocin should be used only when uterine activity is assessed to be inadequate and disproportion is excluded. Careful monitoring, and titration

of oxytocin for a limited period of time, should allow vaginal delivery rates of 65-70%.

Two hundred and seven patients had a trial of labour. If all these patients had a repeat elective LSCS, then our overall Caesarean section rate would be 15.5%. Because a trial of labour was given, 144 of the 207 patients delivered vaginally and our Caesarean section rate was reduced to 13.4%, without a significant increase in maternal and fetal morbidity or mortality.

5.4 Symptoms and Signs with Scar Rupture - Value of Uterine Activity Measurements

Maternal and fetal morbidity and mortality with rupture of previous caesarean scar is less in current obstetric practice. This is mainly due to the lower segment caesarean scar, careful selection of patients for trial and limited period of labour especially when oxytocin is used. The classical symptoms and signs described and -anticipated with scar rupture are scar tenderness or pain, bleeding per vaginum, maternal tachycardia, hypotension, fetal tachycardia or bradycardia, sudden reduction in uterine activity and upward displacement of the head after having been engaged in earlier part of labour. Despite careful continued observation only few patients show symptoms and signs of scar dehiscence or rupture. Loss of integrity of the scar is identified more often than not at the time of abdominal delivery for other indications like dystocia or after vaginal delivery; eg. at exploration for postpartum bleeding from within the uterus which shows no signs of uterine atony. We describe here the clinical features observed and the factors that might have contributed to scar rupture in 9 patients with previous caesarean scar.

Patients and methods

The data was obtained from retrospective search from the computerised records available in the Department of Obstetrics and Gynaecology, National University of Singapore. The total number of deliveries over the past six years (1985

to 1990, both years inclusive), the number of caesarean sections (CS), the number of patients who had elective repeat CS and the number who had trial of labour with a previous lower segment caesarean section (LSCS) scar were identified. The case records of those patients who were diagnosed to have scar rupture during this period were scrutinised. The information regarding the type of labour, whether oxytocics were used, duration of labour, pain or tenderness over the scar, use of epidural analgesia for pain relief, maternal or fetal heart rate changes, maternal blood pressure, abnormal vaginal bleeding, station of the head, uterine activity profile and any other feature that might have led to the diagnosis of scar rupture were noted. When the uterine- myometrium had breeched but the peritoneum was intact it was termed incomplete scar rupture and when the peritoneum had also breeched, it was termed complete scar rupture. The findings were analysed to see whether there were any factors that might have contributed to the scar rupture. The incidence of symptoms and signs that are classically described with scar rupture were evaluated.

Results

There were 24 182 deliveries during the 6 year period of review and the CS rate was 12.5% (3026 cases). Those with previous LSCS accounted for 4.2% (1018 cases) of our

obstetric population of whom 722 (70.9%) who had only one previous CS scar had a trial of labour. Five hundred and six (70.0%) patients who had the trial of labour delivered vaginally.

There were 4 (0.55%) cases of incomplete scar rupture (patients 1 to 4 in Table 5.4-1) and 5 (0.69%) cases of complete scar rupture (patients 5 to 9 in Table 5.4-1). Their age group varied between 26 to 38 years and all except Case No. 9 (Gravida 5, Para 4) were in their second pregnancy.

There were no maternal deaths or severe morbidity. All women including one who had a bladder tear were discharged within 5 to 10 days of surgery, which is our normal post caesarean recovery period. There was one fresh stillbirth of a hydrocephalic baby (dead at the time of induction of labour) and one neonatal death giving a perinatal mortality of 1.78/1000 in those who had a trial of labour with a live baby on admission to the labour ward. Some of the obstetric features are given in Table 5.4-1.

Table 5.4.1. Type of labour, duration of oxytocin use, mode of delivery, indication for operative delivery, Apgar scores, birthweight of neonates, and possible signs or symptoms of scar rupture

Type of labour	Duration of oxytocin	Mode of delivery	Indication for op. del.	Apgar scores 1 min	Apgar scores 5 min	Bwt (gms)	Signs/ Symptoms
1. Induced	6	CS	FTP	0	0	3240	Nil
2. Augmented	1	CS	FTP	8	9	2895	Decr.in Ut.act.
3. Induced	15	CS	FTP	8	9	3920	Decr.in Ut.act.
4. Augmented	2	CS	FTP	6	8	3240	Nil
5. Augmented	4	CS	FD	1	2	3200	Prol. brady.
6. Augmented	7	CS	FTP	9	10	3340	Decr.in Ut.act.
7. Induced	6	Forceps delivery	Poor mat. effort	9	10	2800	Blood stained urine
8. Augmented	6	Normal vag.del.	Not applicable	5	9	2835	Post delivery ileus
9. Augmented	1	Normal vag. del.	Not applicable	9	10	4480	Post delivery haemoperi-toenum

CS - Caesarean section;
FTP - Failure to progress in labour;
FD - Fetal distress;
Vag. del. - Vaginal delivery;
Mat.- maternal;
Decr. in ut. act. - Decrease in uterine activity;
B. wt. - Birthweight
Prol. brady. - Prolonged bradycardia

There was no marked alteration in the pulse or blood pressure in any of the women. In the incomplete rupture group, Cases 1 and 4 had no symptoms or signs but case 4 did not have an intrauterine catheter. Cases 2 and 3 had decrease

in uterine activity which was shown by intrauterine pressure recordings. In all 4 cases a bloodless incomplete scar rupture with intact peritoneum was noticed at the time of CS which was done for failure to progress.

In the complete rupture group, Cases 7, 8 and 9 did not have intrauterine catheters and in these cases, the loss of integrity of the scar was diagnosed only after delivery. Case 6 had sudden decrease in uterine activity which was recorded by an intrauterine catheter but this was not observed in case 5.

Despite reduction in uterine activity in cases 2, 3 and 6, since there were no other signs or symptoms suggestive of scar rupture, labour was continued for a further period of time prior to CS for failure to progress. Incomplete rupture in cases 2 and 3 and a complete rupture in case 6 was noted.

Considering other symptoms and signs of scar rupture, case 5 was the only patient who complained of scar pain and had scar tenderness at which time a prolonged fetal bradycardia was observed. A decision for immediate caesarean section was made but there was a delay of more than 40 minutes. At surgery there was a posterolateral rupture from the left corner of the scar. The baby had Apgar scores of 1 and 2 at 1 and 5 min respectively and died on the third day. Mother had an uneventful recovery. In case 7 there were no

symptoms or signs till the second stage of labour when blood stained urine was seen at catherisation prior to and after delivery and careful vaginal examination revealed scar rupture extending into the bladder. The uterine rupture and tear in the bladder was repaired by laparotomy and she had an uneventful recovery. Case 8 had no recognisable problems at labour and delivery, but developed ileus, had tachycardia and mild temperature the day after delivery. At laparotomy old blood was seen in the peritoneal cavity and rupture of the uterus with mild bleeding from one corner of the rupture was noticed. Repair, peritoneal toilet and antibiotic cover allowed good recovery. Case 9 had normal delivery and had no symptoms, but haemoperitoneum was observed at minilaparotomy for sexual sterilization the next day. Uterine rupture with minimal bleeding was observed and the rupture was repaired. All nine patients were managed by repair of the uterine scar.

Factors that might have contributed to scar rupture were examined. All cases had oxytocin for augmentation or induction of labour and except cases 2, 4 and 9, the others had oxytocin for more than 4 hours. Case 1 had a hydrocephalic baby and it was a fresh still birth. Disproportion was known but the induction was performed to get the cervix adequately dilated to perform a destructive operation and to deliver her vaginally. The caesarean was done for failure to progress when incomplete scar rupture was observed. In Case 2, oxytocin was started after a prolonged

labour (12 hrs) despite adequate uterine activity of 2000 k Pas/15 min and frequency of uterine contractions of 4 in 10 mins. One hour after starting oxytocin reduction of uterine activity was noted. Cases 3 and 9 had not only big babies (4 kg) but case 3 had 15 hours of oxytocin and case 9 despite being multipara had oxytocin for failure to progress in the second stage of labour. Cases 4, 6 and 7 had an anteroposterior pelvic inlet < 11 cm by erect lateral X'ray pelvimetry. None of the 9 patients had a postoperative recovery suggestive of infection after their previous caesarean section that might have led to the possibility of a poorly healed scar.

Discussion

The signs of scar rupture of maternal tachycardia, hypotension and vaginal bleeding were not noticed in our patients. It may be that these signs develop late after a severe degree of scar rupture. Scar pain and tenderness was observed only in case 5 at the time of acute fetal bradycardia. None of the women had epidural analgesia which might have masked scar pain or tenderness. This indicates that scar pain or tenderness may be late in onset with the breech of a fibrotic LSCS scar and may appear only when some blood seeps into the myometrium. Although sudden reduction in uterine activity was observed in cases 2,3 and 6 the significance of such reduction was not taken seriously because of the absence of other symptoms or signs; the loss

of integrity of scar being noticed only when patients had caesarean deliveries for failure to progress much later. In many centres including ours intrauterine catheter is not used routinely in patients with a previous CS scar. Whether use of an intrauterine catheter will help early identification of scar rupture is a debatable issue. Based on recordings obtained with intrauterine catheter in cases with previous LSCS who had scar rupture, Rodriguez et al (1985) has stated that use of intrauterine catheter may be of no value but a recent report (Beckley et al 1991) suggests that it may be of value.

Our findings are more in agreement with Beckley et al (1991). There may be a few reasons for the discrepancy between these studies as well as the difference in observation in between subjects in the same study. Uterine activity reflected as increase in intrauterine pressure depends on the increase in uterine wall tension. Breech in the scar would affect wall tension and hence will reduce the build up of intrauterine pressure (Gee et al 1988). This was reflected by the marked decline in the amplitude of contractions once the scar has given way in cases 2, 3 and 6 and in the cases reported by Beckley et al (1990). There was no noticable reduction in the baseline pressure of the uterus or frequency of contractions in the cases in our series. There is no reason to expect reduction in frequency but the reason why the baseline pressure did not show any reduction is difficult to explain unless it was of a smaller magnitude.

Fig 5.4-1 shows the decline in uterine activity which was seen in case 6. The patient had no pain or tenderness over the scar, no bleeding per vaginum and no alteration in the maternal or fetal heart rate. It was construed that perhaps the catheter had slipped down into the lower uterine segment or into the cervix as the contractions experienced by the patient was still painful and was of the same frequency as before although the amplitude observed on the trace was low. According to the notes the catheter had been introduced anterior to the head. The catheter was withdrawn and reinserted posterior to the head when contractions with good amplitude and the same frequency were recorded (Fig 5.4-2). Labour was continued for another 140 minutes before the decision to perform a CS for failure to progress. The fetal heart rate and uterine contractions recording were normal prior to CS. At time of the CS, scar rupture with involvement of the bladder was noted. It is likely that uterine rupture might have been at the time when the abrupt decline in uterine activity was noted. The same may apply to cases 2 and 3.

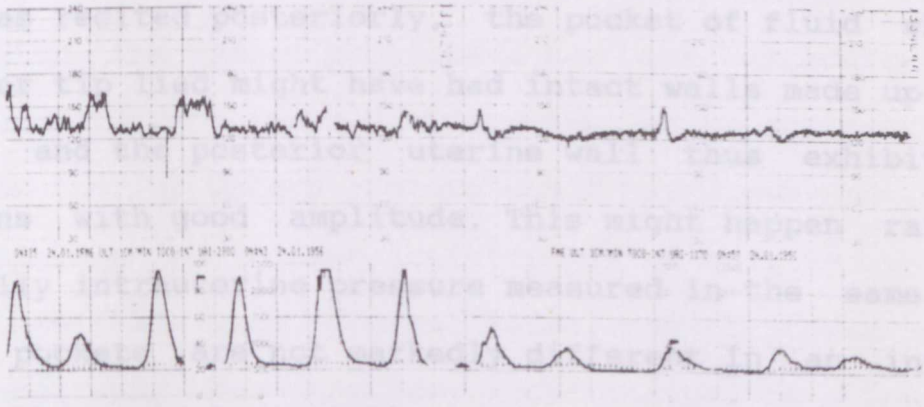


Fig 5.4-1. Cardiotocographic trace showing sudden decline in the uterine activity -affecting only the amplitude of contractions and not the frequency, baseline pressure or fetal heart rate.

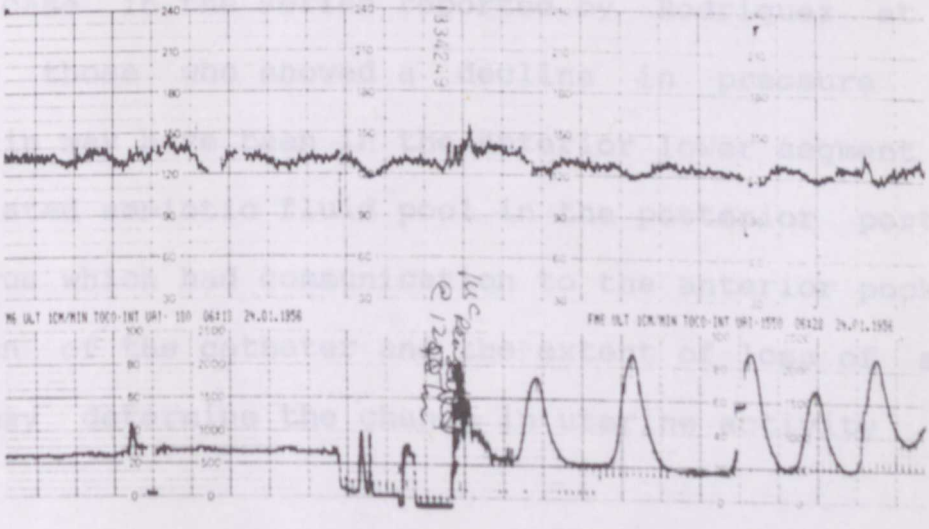


Fig 5.4-2. Cardiotocographic trace showing return of the amplitude to high levels whilst the other parameters remain the same after reinsertion of the catheter posterior to the head.

In case 6, the catheter was initially introduced, anterior to the head and it showed reduction in amplitude of contractions and this might be due to the inability to build up pressure due to loss of integrity of the wall. When the catheter was recited posteriorly, the pocket of fluid where the catheter tip lied might have had intact walls made up by the fetus and the posterior uterine wall thus exhibiting contractions with good amplitude. This might happen rarely as generally intrauterine pressure measured in the same or different pockets are not markedly different in an intact uterus (Arulkumaran et al 1991).

It may be, that in cases of scar rupture where uterine activity was not reduced, the catheter may have been introduced posterior to the head and was in an isolated pool of fluid. Posterior approach is the commonest and may have been the case in the series reported by Rodriguez et al (1989). In those who showed a decline in pressure the catheter tip may have been in the anterior lower segment or in an isolated amniotic fluid pool in the posterior portion of the uterus which had communication to the anterior pocket. The location of the catheter and the extent of loss of scar integrity may determine the change in uterine activity observed.

Paul et al (1985) found a similar incidence of scar dehisence or incomplete rupture in those with a previous CS scar whether they had a trial of labour and had an emergency

CS or had elective CS without a trial of labour. This might be another reason for having observed no change in uterine activity in patients who had an incomplete rupture as this might have been present even prior to the onset of labour. With contractions there may have been some build up of pressure with the intact peritoneum but not effective to cause cervical dilatation and at the time of CS for failure to progress the incomplete rupture would have been noticed. Sudden reduction in uterine activity may be easy to notice and more reliable with internal tocography compared with external tocography where a sudden reduction may be accounted by loosening of the belt or alteration in position of the patient. Of the 6 cases where scar dehisence or rupture was diagnosed at the time of CS, 3 (50%) had sudden reduction in uterine activity and 1 had sudden alteration of the fetal heart rate. In these 6 cases there were no clinical signs or symptoms except in case 5 where there was scar pain and tenderness at the time of acute fetal bradycardia. This suggests that use of an intrauterine catheter and continuous fetal heart rate monitoring may provide early warning signs of a ruptured scar compared with other clinical symptoms or signs which may develop with further loss of scar integrity.

Of the 9 cases in our study the scar rupture was diagnosed postdelivery in cases 7 to 9 who had a vaginal delivery. It is likely that the chance of scar rupture is greater in the late first and second stage of labour because of the steep and significant increase in uterine activity at

this stage both in spontaneous and augmented labour (Arulkumaran et al 1989a & b). This supports the old practice of senior obstetricians advocating an appropriately timed prophylactic forceps delivery in patients with previous CS.

The selection of cases, conduct of labour and place where the trial is conducted is of importance. There should be facilities and personnel to act swiftly to perform a CS within 10 to 15 min of decision making. Acute fetal bradycardia of > 10 mins from whatever cause have higher chance of severe acidosis (Ingemarsson et al 1985) and hence needs delivery within 10 to 15 minutes of decision making. There was a 40 minutes delay from time of decision to delivery of the fetus in case 5 which resulted in poor condition of the neonate at birth and subsequent demise.

In patients with a previous CS scar who needed augmentation the uterine activity has been reported to be greater than those with a CS scar but in spontaneous normal labour. Those who are likely to deliver vaginally following augmentation show good progress of labour within the first few hours of augmentation (Arulkumaran et al 1989). Similar findings have been reported by Silver and Gibbs (1987). In our series all cases had oxytocin and it was used for 6 hours or more in most cases despite poor progress. If oxytocic augmentation is undertaken for failure to progress after excluding disproportion, the decision to continue labour should be based on the observed progress of labour in

the first 3 to 4 hours of augmentation. Adhering to such a policy in patients with previous CS scar is likely to reduce the incidence of scar rupture. Use of an intrauterine catheter passed anterior to the head to lie in a pool close to the area of the scar may help in early identification of loss of scar integrity.

6. UTERINE ACTIVITY IN LABOUR - CONCLUSION

Uterine contractions are prerequisite to vaginal delivery. Unless mechanical difficulties such as fetopelvic disproportion or malposition arise, efficient uterine contractions and expulsive efforts of the mother should result in unassisted vaginal delivery in the majority of women. Throughout the world many births take place, especially in rural areas in the developing countries, where uterine contractions are not monitored in labour. In hospitals and centres where more skilled assistance is available uterine contractions are assessed by external palpation intermittently at regular intervals. However research has been in progress to identify better methods of measuring and quantifying uterine activity for the last few decades (Chapter 1.1 & 1.2). Currently, advances in technology has made it possible to develop catheters and equipment to perform online quantification of uterine activity (Chapter 1.4 a). This modern technology has been used without verifying whether these methods provide reliable measurements and without studying cost benefit analysis whether such measurements improve the obstetric outcome in labour.

Uterine contractions temporarily impede replenishment of the retroplacental pool of blood necessary for oxygen transfer to the fetus. Uterine contractions may also compress the cord depending on it's position and the amount of amniotic fluid present. To detect possible deleterious

effects caused by these events the fetal heart rate is auscultated intermittently or the heart rate pattern observed continuously by electronic fetal heart rate monitoring. Any changes in the fetal heart rate are interpreted in relation to the uterine contractions. If there are no fetal heart rate changes suggestive of fetal hypoxia and the rate of cervical dilatation is satisfactory, there may be little need to monitor uterine contractions in labour. But normal or abnormal progress of spontaneous labour cannot be predicted prospectively. If the progress is found to be abnormal, recorded information about preceding uterine contractions may be of value.

If poor uterine contractions are the sole cause of failure to progress in labour, augmentation of uterine contractions should result in vaginal delivery. In this situation assessing contractions by external tocography may appear adequate. However, internal tocography, an invasive and expensive technique giving accurate measurements and the possibility of online quantification may be better in identifying poor contractions and in assessing the uterine activity achieved with augmentation. Treatment based on accurate measurements should produce better obstetric outcome. Although such advantages may be anticipated there are no studies to substantiate this speculation. Similarly internal tocography may be expected to result in a better outcome in induced labour and in those in labour with a previous caesarean section scar especially when oxytocn is

used. Better obstetric outcome can be defined in terms of optimal length of labour, lower dose of oxytocin, less operative delivery rates and more babies with good Apgar scores and cord arterial blood pH values at birth.

Reliability and reproducability of intrauterine pressure measurements

New transducer tipped, solid state catheters which do not need a fluid column with inherent problems are used to measure intrauterine pressure. However there is controversy about the reliability and reproducibility of the readings. There are also claims that catheters placed in the same uterus can give rise to different pressure readings. We compared the catheter systems Fibreoptic Vs Gaeltec (Chapter 1.4 b) to verify whether different solid state catheters give similar readings followed by comparison of Gaeltec Vs Gaeltec (Chapter 1.4 c) in the same and different amniotic fluid pockets within the same uterus. Although there appear to be some difference in pressure from contraction to contraction, these differences are not great and the cumulative active pressure for a given labour derived from the two catheters placed in the uterus does not differ enough to make much difference in clinical management. Based on these findings we used Gaeltec catheters for our subsequent studies.

Uterine activity in spontaneous normal labour

Uterine activity in spontaneous normal labour should

form the basis for management of uterine activity in augmented or induced labour. Spontaneous labour with normal progress showed a wide range of uterine activity. In nulliparae median uterine activity ranged from 855 k Pas/ 15 min (10'th centile) to 2375 k Pas/ 15 min (90'th centile)(Chapter 2.1). In multiparae the uterine activity was lower than that in the nulliparae and ranged from 623 k Pas/ 15 min (10'th centile) to 2146 k Pas/ 15 min (90'th centile) (Chapter 2.2). There was no difference in the range of uterine activity between the ethnic races studied when controlled for parity, rate of progress of labour and certain physical characteristics like the height of women and size of the neonates (Chapter 2.3). The uterine activity profile was similar with breech presentation when controlled for the rate of progress of labour, parity and height of women (Chapter 2.4). Although different ranges of uterine activity was seen according to parity which was not influenced by ethnicity or presentation, the range of uterine activity observed with satisfactory progress of labour was so wide (855 to 2375 or 623 to 2146 k Pas/15 min) quantification of uterine activity would be of no value in predicting progress of labour in a prospective manner. Management by augmentation is appropriately based on progress in cervical dilatation.

Incoordinate uterine contractions are defined based on irregular frequency of contractions or on the appearance on tocographic tracing, indicating an irregularity of shape of contractions. Wide variation of incoordinate activity was

observed in association with normal progress of labour (Chapter 2.1). Incoordinate uterine contractions should not be synonymous with inefficient contractions. Similarly coordinate contractions need not always be efficient. In an appreciable number of patients minor degrees of incoordination was found in early labour. In those cases where incoordination of contractions was observed, the pattern of incoordination generally persisted throughout labour (Chapter 2.1) Incoordinate uterine contractions are not an indication to use oxytocics unless they are found to be inefficient. The use of oxytocics may or may not correct the incoordination but should increase the efficiency. The use of oxytocin may stimulate the appearance of incoordinate uterine contractions in a patient who had coordinate uterine contractions, but if the contractions had been inefficient it may improve their efficiency. Though internal tocography is likely to delineate incoordinate uterine activity better, internal tocography is not required in cases suspected to have incoordinate uterine contractions because this phenomenon is not directly linked to efficiency of contractions.

Uterine activity in augmented labour

Infrequent uterine contractions may be inefficient but efficiency of the contractions should be judged based on the amount of expected work performed. The practice of augmentation is based on observed cervimetric progress of labour (or in the second stage the descent of the head) in

conjunction with assessment of uterine contractions. Prior to augmentation, signs of malpresentation, fetopelvic disproportion and evidence of fetal compromise have to be considered.

Based on the cervimetric progress and the use of alert and action line concept, 19% of nulliparae and 9% of multiparae admitted in spontaneous labour to our unit required oxytocin augmentation for slow progress of labour (Chapter 3.1). When oxytocin augmentation is undertaken discussion arises as to what should be the target uterine activity and for how long should one continue to give oxytocin to achieve the desired results. The next question is whether the obstetric outcome will be better if internal tocography is used with quantification of uterine activity. Our studies show that augmentation for at least 8 hours (Chapter 3.1) with a target uterine activity of one contraction every 2 to 2 1/2 min rather than one every 3 min may result in optimal outcome (Chapter 3.2). This does not require internal tocography except in the obese or restless patient where external tocography does not produce optimal recordings. Oxytocin titration to achieve preset active contraction area values did not result in better obstetric outcome compared with achieving a target frequency of 4 to 5 clinically adequate contractions (duration > 40 secs) every 10 min (Chapter 3.3). Furthermore there is no advantage in titrating oxytocin using intrauterine catheters and quantifying uterine activity compared to oxytocin titration to achieve a desired frequency of contractions based on

external tocography in dysfunctional labour (Chapter 3.4).

Uterine activity in induced labour

Induction of labour is common in modern obstetric practice and in our unit it has been 7.2% of all deliveries over the past 5 years (1986 -1990). Artificial rupture of membranes and oxytocin infusion has been the commonest method employed. In our practice oxytocin is titrated to achieve 4 contractions in 10 mins after rupture of membranes. Quantification of uterine activity in these labours suggested that the active contraction area profiles was higher in induced labour compared with spontaneous labour (Chapter 4.1). In order to regulate the oxytocin to achieve optimal levels of uterine activity, and to avoid any ill effects to the fetus, oxytocin infusion was titrated to achieve 50'th centile uterine activity observed in spontaneous normal labour (Chapter 4.2). The results revealed no advantage with such managemenmt compared with oxytocin titration to achieve optimal frequency of contraction (4 to 5 in 10 mins). In many cases the progress of labour was slow necessitating further escalation of oxytocin dose to achieve optimal frequency of uterine contractions which resulted in acceptable progress of labour. When oxytocin was titrated to achieve 75'th centile activity compared with optimal frequency of contractions (Chapter 4.3), each method gave equally good results indicating that such quantification of uterine activity offers no advantage in induced labour.

From the studies described in Chapter 4.2 it was found that a specific amount of total uterine activity had to be performed by the uterus depending on the parity and cervical score inorder to achieve vaginal delivery (Chapter 4.4). The total uterine activity is a reflection of cervical and pelvic tissue resistance which has to be overcome to achieve vaginal delivery. There appears to be some advantage in appreciating the concept of total uterine activity according to parity and cervical score. If fetal heart rate changes are observed during induction of labour, with high uterine activity, it may be possible to reduce the uterine activity to low levels known to be associated with progress of labour and to achieve a vaginal delivery rather than terminating the labour by operative abdominal delivery. Furthermore, if the expected total uterine activity according to parity and cervical score has been exceeded but little progress has been made, it may suggest cephalopelvic disproportion or failed induction of labour.

Uterine activity in patients with previous caesarean scar

Patients with previous caesarean scar exhibited lower uterine activity levels if they had a previous vaginal delivery compared with those who had no vaginal delivery. Those who had no vaginal delivery but had the caesarean done electively or in the latent phase of labour in their previous pregnancy had a higher uterine activity level compared with the women who had surgery performed in the active phase of

labour (Chapter 5.1). Patients who required augmentation had higher uterine activity levels compared with those who had normal progress of labour and needed no augmentation (Chapter 5.2). Those who were likely to deliver vaginally showed satisfactory progress in the first few hours of augmentation compared with those who needed caesarean for poor progress in labour. Applying a policy of careful selection and conduct of labour with a limited period of augmentation, a satisfactory outcome was achieved in women with previous caesarean scar (Chapter 5.3). Internal tocography compared with external tocography is unlikely to enhance the success rate of vaginal delivery without additional fetal or maternal morbidity. Although intrauterine pressure measurements will not help to predict impending rupture it may help in early identification of loss of integrity of scar in some cases (Chapter 5.4).

Summary

Internal tocography and quantification of uterine activity by active contraction area measurements is of no value in spontaneous normal labour. In augmented labour, internal tocography was associated with no improvement in duration of labour, dose of oxytocin, incidence of operative deliveries or neonates in poor condition at birth compared wth external tocography. Whether internal tocography offers any advantage over external tocography in difficult cases of augmentation, ie. those who do not show satisfactory progress of labour in the first few hours of augmentation needs further study. Obstetric outcome was not improved with the

use of internal tocography and quantification of uterine activity in induced labour. The knowledge of total uterine activity (TUA) computed with internal tocography may be of value in selected cases where fetal heart rate changes are observed with high uterine activity or in those who fail to progress despite having achieved the total uterine activity according to parity and cervical score. However the cases that are likely to benefit from such an exercise may be too few in number to justify routine internal tocography in induced labour. In those with previous caesarean section scar the uterine activity in augmented labour is higher than that observed in spontaneous normal labour. Those who are likely to deliver vaginally show satisfactory progress within the first few hours of augmentation. A limited period of augmentation should limit TUA and may reduce the chance of scar rupture. Internal tocography may be of value in detecting excessive uterine activity which may not be obvious with external tocography. Sudden decline in uterine activity may be the earliest sign to indicate loss of integrity of previous caesarean scar. Where difficulty arises in recording uterine contractions by external tocography as in an obese or restless patient internal tocography is of value. This thesis concludes that "routine" use of internal tocography and quantification of uterine activity compared with external tocography does not lead to better obstetric outcome in spontaneous, augmented or induced labour. There may be a limited role for selective use of internal tocography where

recordings on external tocography are unsatisfactory, in cases of difficult augmentation or induction and in those with previous caesarean scar.

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