BIOPHYSICAL MONITORING OF THE FETUS

(A) Intrapartum Monitoring of the fetus
(B) Oxytocin Challenge Test

by

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Introduction

Successful decrease in maternal mortality and morbidity, perinatal mortality and the need to restrict family size by permanent female sterilisation requires an Obstetrician to deliver infants of better cerebral potential. To improve the quality of life at birth, we should have the means to detect existing fetal hypoxia at its earliest and avert permanent cerebral damage.

Intermittent stethoscopic auscultation of the fetal heart tones for diagnosis of fetal distress has been traditional. Profound alterations in the heart rate and short term variations can easily be missed because of intermittent sampling and averaging techniques. Presence of meconium passage, long thought to be another sign of fetal distress, is found to be a result of increased vagal tone rather than fetal asphyxia. As labor imposes intermittent rhythmic stress on the feto-placental unit, continuous intrapartum electronic monitoring can prove most useful in the care of a laboring woman.

Principles of Fetal Cardiotachometry

Continuous, beat by beat, surveillance of the fetal heart rate and uterine contractions provide reliable, reproducible and prognostic information about the condition of the fetus during labor. With this technique, the interval between consecutive heart beats is converted to a rate according to the formula

$$\text{Rate (beats per minute)} = \frac{60}{\text{interval (seconds)}}$$

and it is plotted on a moving strip, chart recorder being calibrated in beats per minute. This rate is plotted as if all the beats in one minute were separated exactly by that interval. Compared to intermittent auscultation, this technique allows evaluation of 100 per cent of heart beat information from an accurate, retrievable record. The beat to beat variability appears to reflect minute, continuous readjustments between sympathetic and parasympathetic tones. The study of pattern of the fetal heart rate in relation to the uterine contractions is the study of cardiotachometry.

To pick up the fetal heart rate, the

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most accurate technique is by utilization of fetal electrocardiogram obtained directly from a wire electrode on the fetal presenting part. Uterine activity is obtained by a pressure catheter passed transcervically into the uterine cavity alongside the presenting part. Alternatively, fetal heart rate information is obtained by either ultrasonic or acoustical transducers strapped on the maternal abdomen. Ultrasonic transducers use the Doppler principle, whereas the acoustic transducers have very sensitive microphones. Contractions may also be measured externally by means of a pressure sensitive guard ring tocodynamometer placed over the uterine fundus. Though more accurate, the internal pick-up methods suffer from a disadvantage that they are "invasive" methods.

Comparison of Fetal Cardiiac Decelerations during Labour
(From Schifrin, B. in Operative Obstetrics, 1976, Eds.: Douglas, R. G., Stromme, W. B.)

Parameter	*Early Deceleration*	*Variable Deceleration*	*Late Deceleration*
Proposed etiology	Head compression	Cord compression	Decreased fetomaternal exchange
Clinical factors	Primigravida, 4-8 cm.	Occurs anytime, frequently during second stage; most common pattern	Maternal hypotension; increased uterine activity; toxemia—placental dysfunction
Onset (relative to uterine contractions)	Early	Variable	Late
Shape	Uniform	Variable	Uniform
Average drop	Usually remains above 100 bpm; proportional to uterine contractions	Usually drops below 100 bpm, occasionally to 50-60 bpm: not proportional to uterine contractions	Usually remains above 100 bpm; proportional to uterine contractions
Average duration	Less than 90 seconds	Variable	Less than 90 seconds; increases if pattern persists
Base line changes	None	None; tachycardia if prolonged	Tachycardia; fixed heart rate of prolonged
Effect of maternal hyperoxia	None	None	Modifies pattern; may obliterate it
Effect of atropine	Obliterates pattern	Modifies pattern	No effect
Effect of position change	None	May have marked effect	May correct pattern if related to maternal hypotension
Acid-base changes	None	Acidosis in moderate to severe patterns; rapid correction if not prolonged	Acidosis, slow

Material and Methods

At the K.E.M. Hospital, Bombay, biophysical monitoring of the fetus has been applied to selected cases, as a routine, to judge the degree of fetal distress with each uterine contraction by assessment of the graphic record. This allowed precise determination of operative intervention, whenever required.

A total of 109 cases subjected to intrapartum monitoring were analysed regarding fetal distress detection.

Clinical Assessment of Clinical Fetal Distress	
Fetal heart tachycardia	36
Fetal heart bradycardia	15
Fetal heart irregularity	18
Fetal heart irregularity + meconium	20
Meconium	4
Clinically normal FHR*	16

* 6 previous L.S.C.S., 8 abnormal presentation, 1 B.O.H., 1 post-datism.

Thirty-six of these had fetal tachycardia, 15 had bradycardia, 18 had irregular fetal heart rate. Meconium stained liquor was present in 4 cases. Meconium staining with fetal heart irregularity was present in 20 cases. Six cases with previous cesarean section, 8 with abnormal presentation and 1 each of postmaturity and bad obstetric history were detected to be having fetal distress during routine intrapartum monitoring.

These high risk pregnancy and high risk labor patients and cases showing evidence of clinical fetal distress were biophysically monitored with the cardiotachograph HP 8021A, using external pick up methods (ultrasound and pressure sensor) in 80 of our cases. In the remaining 29 cases, Hon's scalp clip electrode or a spiral electrode was used to pick up fetal electrocardiographic signals. Intermittent or continuous records were obtained on the double channel record paper driven at a speed of 1 cm/min. The basal fetal heart frequency, the type of its waveform, and the type of fetal cardiac decelerations were studied to judge the optimum time of surgical intervention. In cases where the ominous pattern was observed, an initial line of medical treatment for acute fetal distress was employed and its response observed. This treatment included change in patient position, oxygen, intravenous fluids to correct hypoglycemia and hypotension and at times, temporary employment of uterine relaxants. Once such an ominous pattern is recognised, all preparations for an operative delivery are also rapidly made. The cases with progressively worsening, cardiotachographic signs were subjected to rapid operative deliveries.

Results

The basal fetal heart frequency, the waveform and the type of decelerations were scrutinized during intrapartum surveillance for the process of decision making.

Fifty-four of our cases had no decelerations of the fetal heart. Forty-four of these had vaginal deliveries, out of which 5 were assisted breech deliveries. The remaining 10 had to be subjected to operative deliveries for reasons like arrest of labor, cephalopelvic disproportions, etc.

Thirty-five records exhibited early deceleration patterns. Vaginal delivery was possible in 28 of these cases, though in 8 cases the delivery had to be assisted by forceps or vacuum. Seven patients showing early decelerations were subjected to cesarean section for various reasons; one of these was extremely severe early deceleration with increasing areas of deceleration.

Correlation Between Mode of Delivery With FCD.

Fourteen out of 16 cases with late deceleration had 1 minute Apgar between

FCD (Fetal Cardiac Deceleration)

	Nil	Early	Late	Variable
Spontaneous vaginal	39	19	—	—
Forceps/vacuum	8	9	7	—
L.S.C.S.	2	7	8	1
Breech Extraction	—	—	1	1
Assisted breech delivery	5	—	—	2

All the cases exhibiting late fetal cardiac deceleration had to be subjected to operative deliveries—8 cesarean section, 7 forceps extractions and in 1 case, breech extraction.

The 4 cases showing variable deceleration were delivered by L.S.C.S. and breech extraction—one each and two by assisted breech deliveries.

One minute Apgar score of the infants whose mothers were put on the monitor were studied as regards the analysis of the record.

All the 54 infants who did not show any form of decelerations had 1 minute Apgar of more than 6, 34 of which had Apgar 9 or 10.

Out of 35 cases where early decelerations were diagnosed, 3 infants had 1 minute Apgar less than 5, whereas 18 had between 6 and 8 and 14 had more than 8. All the 3 infants where the Apgar was less than 5 had exhibited very deep early decelerations, the nadir of the dip going deeper than 100 bpm.

6 and 8. The remaining 2 were very depressed—1 minute Apgar being less than 5.

The outcome of the 4 cases with variable deceleration was poor in the majority of the cases. Only one patient delivered by L.S.C.S. had Apgar of 7. The remaining 3 were breech deliveries.

The Reading of the Records

Depicted are some photographs of the records that were obtained during the course of our study.

Photograph 1 characteristically exhibits early fetal cardiac deceleration or head compression pattern. The fetal heart frequency is normal, with normal beat to beat variability and the onset of the uterine contractions coincides with the onset of deceleration.

Mrs. F. M., Case 37, photograph 2, gave a true picture of late fetal cardiac deceleration. There is basal fetal tachycardia with normal beat to beat variability, but the onset of fetal cardiac deceleration is

Ap Sc.	Basal FHR			Wave form				Deceleration			
(1 min)	120	120-160	160	Si	NU	U	Sa	Nil	Early	Late	Variable
5 or less	4	—	4	4	1	—	3	—	3	2	3
6- 8	—	48	5	—	22	30	1	20	18	14	1
9-10	—	42	6	—	10	35	3	34	14	—	—

(Si = Silent pattern; NU = Narrow Undulatcry pattern; U = Undulatory pattern; Sa = Saltatory pattern).

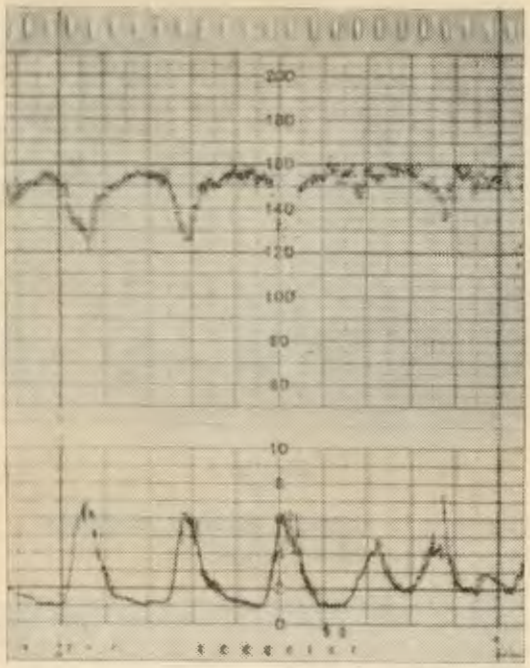

Fig. 1.

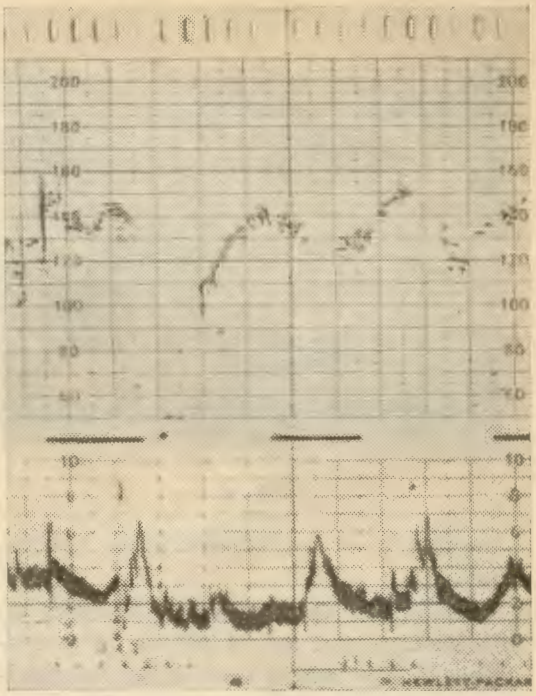

Fig. 2.

delayed by a period more than 30 seconds from the onset of the uterine contractions. This is true uteroplacental insufficiency pattern.

The record of Mrs. T. K., Case 49, photograph 3, exhibits beat to beat variability of more than 25 bpm. This may be suggestive of occult cord compression.

Photograph 4, a tracing from Mrs. B. B., Case 10, shows deceleration of variable shapes ranging from regular V to U to irregular V. Also, there is basal tachycardia. This is umbilical cord compression pattern.

Fetal bradycardia is seen in a panel depicted in photograph 5. There is no fetal cardiac deceleration. There is an isolated fetal cardiac acceleration with some fetal activity. This is a reassuring sign, telling the obstetrician about the healthy sympathetic system of the fetus.

Similar to fetal bradycardia, fetal tachycardia is also not suggestive of UPI when not associated with any baseline

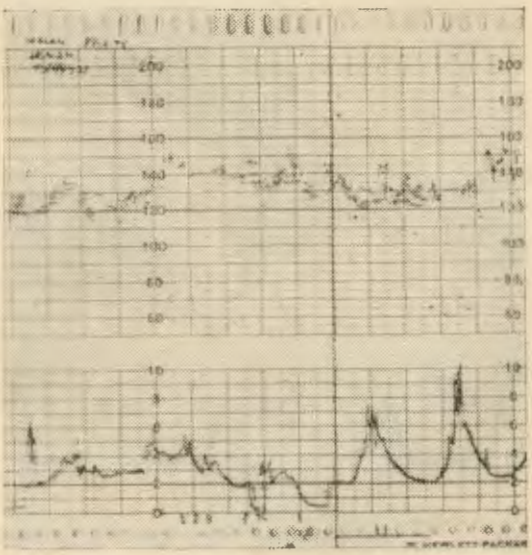

Fig. 3.

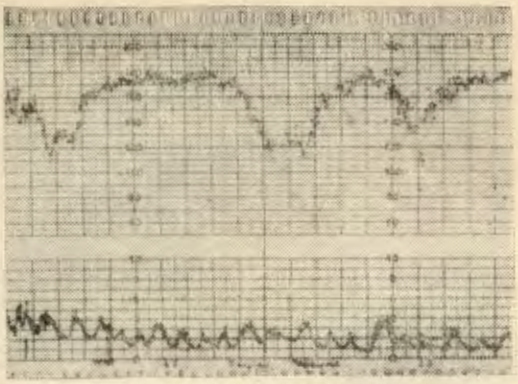

Fig. 4.

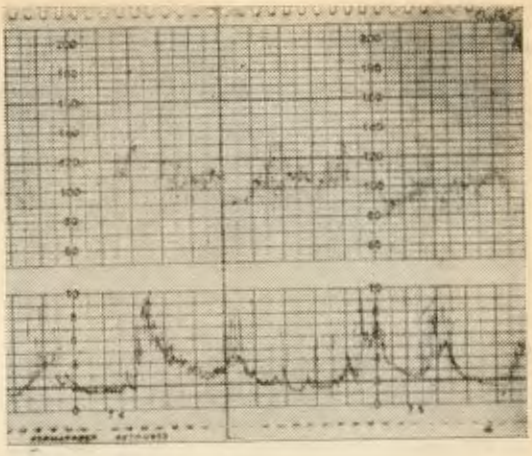

Fig. 5.

irregularity or any deceleration (photograph 6).

One of the most ominous patterns an obstetrician can get is shown in photograph 7. The loss of beat to beat variability or the silent waveform without any response to uterine activity suggests a very deep fetal asphyxia.

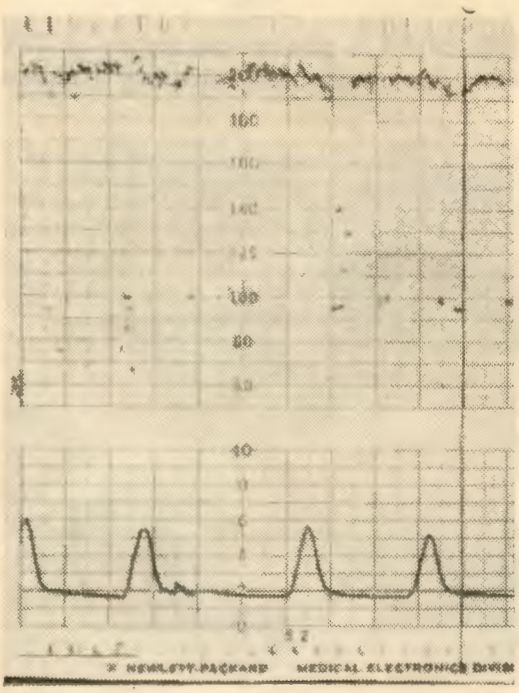

Fig. 6.

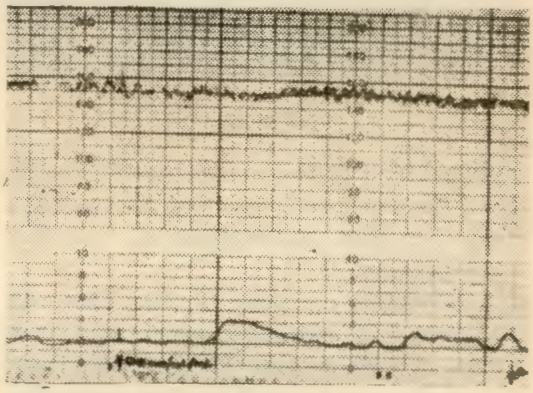

Fig. 7.

Discussion

Observation of fetal bradycardia occurring with a uterine contraction and its late recovery after the contraction wave passes off has been in use for some time now in clinical obstetrics, for early diagnosis of fetal distress. This method is clinically quite useful. Employment of continuous cardiotachometry obtains information from the fetal cardiac response to the uterine contractions and from fetal cardiac

behaviour in between the contractions. An essentially normal pattern is prognostic of good infant in 99% of cases. There is a good correlation between the Apgar scores at birth and the patterns observed. Today, we have better understanding of fetal distress because of CTG. Cardiotachometry is probably the only method available for automatic documentation without human, errors. So far, we had to limit ourselves to selected cases owing to limited resources. In future, with better resources, continuous beat to beat surveillance of the fetal heart during labor will be essential for total labor care.

OXYTOCIN CHALLENGE TEST

(An aid in Antenatal Monitoring)

Introduction

The object of antenatal monitoring is to ensure optimum quality of life. It is signally important for the obstetricians to recognise that many of the disasters resulting in death or in permanent damage to the baby could be avoided if early access to the fetus and its environs could be improved.

It is a well established fact that uterine contractions cause intermittent decrease in intervillous space blood flow and therefore diminish the oxygen transfer from the mother to the fetus. Investigations utilizing the response of the fetal heart rate (FHR) to uterine contractions (UC) (occurring either spontaneously or with oxytocin stimulation) during the antepartum period have given some indication of uteroplacental respiratory insufficiency.

There is a suggestion that the appearance of late fetal cardiac deceleration prior to labor may be an early warning sign of decreased utero-placental respiratory reserve and indeed, may precede other signs of trouble such as falling estriol excretion or appearance of meconium in the amniotic fluid.

At the K.E.M. Hospital, Bombay we have studied 78 women as a part of intensive antepartum service with 112 oxytocin challenge tests (OCT). This new test has helped us in improving perinatal mortality and the quality of life at birth.

Material and Methods

Patients selected for OCT were brought to a special study area and were sedated 30 minutes prior to starting the test with Diazepam 5 mg. I.M. Complete physical and obstetric examinations were made giving particular attention to maternal blood pressure and cervical ripening. To be certain the maternal blood pressure was checked for supine hypotension every 15 minutes. The initial record of cervical ripening and Bishop score would help in subsequent management of the pregnancy, should the OCT be positive.

Continuous fetal heart rate (FHR) and uterine contractions (UC) were obtained with a Hewlett Packard Cardiotochograph 8021A with the help of an external ultra sound array transducer and an external labor transducer. A 10 minute basal recording was obtained and analysed regarding the basal FH pattern, FH rate and its relation to painless uterine activity, if any.

An intravenous infusion of 0.5 mu/ml/min. Pitocin in 5% Dextrose was started in an arm vein. The rate was doubled every 10 minutes until painful uterine contractions occurred at the rate of 3-4 contractions every 10 minutes, or till late deceleration of FHR was observed. In the latter instance the test was abandoned after confirmation of the

ominous pattern in the subsequent couple of contractions. If no ominous pattern was obtained, the test was continued for 30 minutes.

Each record was analysed and evaluated by one of the authors as positive, negative or suspicious for late deceleration. An uterus refractory to oxytocin stimulation resulted in a failed OCT. The result obtained was scrutinised against other antenatal investigations such as urinary estriol estimations, amniotic fluid studies, amnioscopy, etc. Whenever possible, the test was repeated within 10 days of the first test. A test resulting in a pattern suspicious for late FCD was repeated within 48 hours.

Pregnancy toxaemia and postdated gestation occurred in most of the cases—28 and 30 respectively. Twelve tests were for suspected intra uterine growth retardation (IUGR), 4 for pregnancy complicated by diabetes, 14 tests were carried out as an investigative procedure for bad obstetric history (BOH) as yet undetermined etiology, and 18 tests were done for isoimmunised Rh negative pregnancies. Non-toxaemic hypertension became the primary indication for 4 tests, whereas 2 tests were performed for a subjective feeling of decreased fetal movements.

Break-up of primary indications for OCT

Toxaemia	.. 28
Postdatism	.. 30
IUGR	.. 12
Diabetes	.. 4
BOH	.. 14
Rh negative (isoimmunised)	.. 18
Non-toxaemic hypertension	.. 4
Decreased fetal movements	.. 2

The Reading of the Record

The records were analysed and classified as positive, negative, failed OCT or suspicious for late FCD.

Case 9 shows a typical negative OCT. The UC frequency is at least 3 in 10 minutes, there is no late FCD even with this UC frequency and there is a good base line variability (photograph 8).

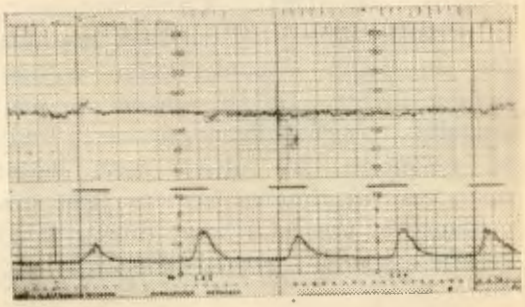

Fig. 8.

Case 6 shows fetal cardiac acceleration of isolated variety. This is usually associated with fetal activity. Such accelerations present with fetal activity indicate fetal well being. Thus, when present, they help in reassuring the perinatologist (photograph 9).

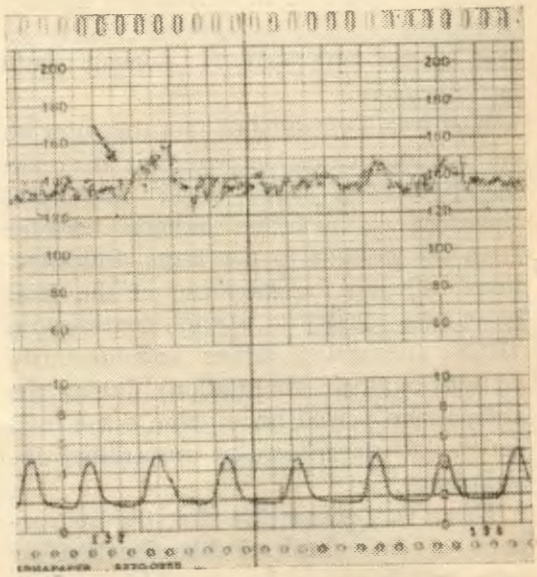

Fig. 9.

Case 1 shows a change from a saltatory pattern of basal fetal heart rate to an undulatory pattern. This is a negative test (photograph 10).

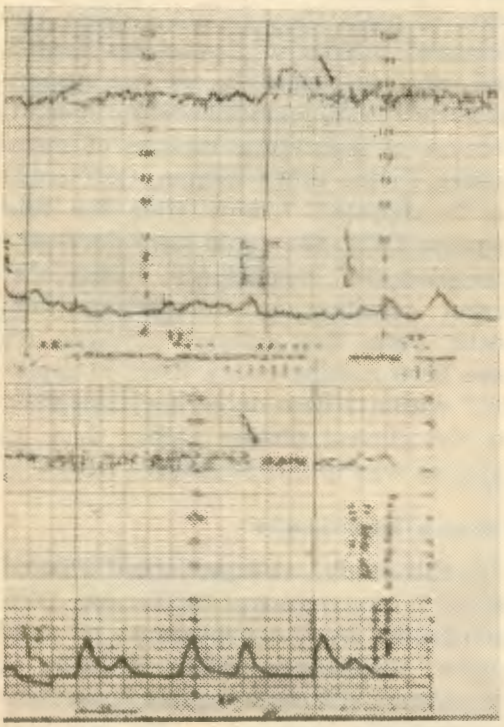

Fig. 10.

The test is called 'suspicious for late FCD', when there are definite, but inconsistent decelerations and these do not persist with UC. Fetal jeopardy is also suspected when there is a minimum variability of the fetal heart, i.e. silent pattern.

The criteria for calling an OCT positive are well depicted in Case 2 (photograph 11). Here the baseline variability is normal, but there is a definite late FCD in the last panel. The subsequent contraction was also observed in this case and had produced such a late deceleration that the patient had to be offered a routine of emergency clinical fetal distress work-up.

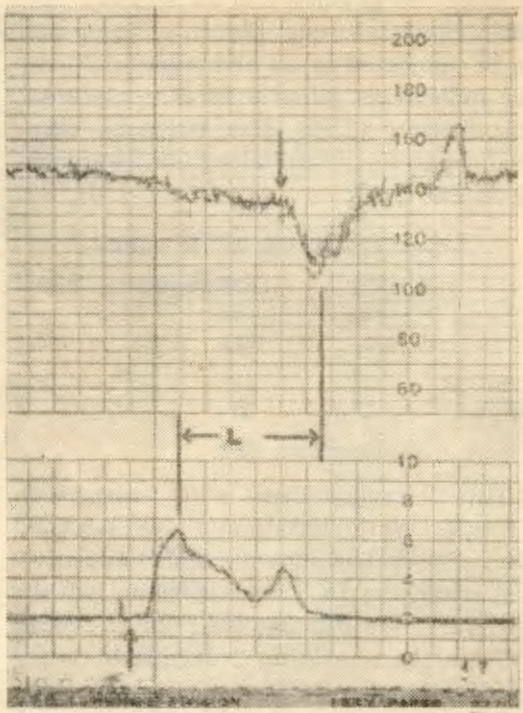

Fig. 11.

Results

Analysis of the records by the criteria mentioned above, gave us 95 negative tests, 12 positive tests, 3 cases showed a pattern suspicious for late FCD, and in 2 cases, we failed to achieve uterine activity by Pitocin infusion.

All the cases subjected to the OCT were followed up during labor, regarding the mode of delivery, the indication for operative delivery, if any, and for 1 minute and 5 minute Apgar scores.

Ten out of 12 cases with positive tests were offered cesarean section within 24 hours of the test. The remaining 2 women, with Bishop scores more than 8, were induced, controlling the labor with continuous intrapartum cardiotachometry, and they delivered vaginally within 24 hours.

Sixty-one patients had 95 negative oxytocin challenge tests. Eleven of these had to be subjected to an abdominal delivery for indications other than uteroplacental insufficiency (UPI) like previous cesarean operations, cephalopelvic disproportions etc.

Labor follow up of 78 women

	OCT +ve (12)	OCT —ve (61)	Suspicious (3)	Failed (2)
L.S.C.S.	10	11*	3	2
Vaginal	2	50	—	—

* Indications other than UPI.

Three pregnancies with suspicious patterns were terminated by L.S.C.S. One of them had shown a shift to positive test when the OCT was repeated within 48 hours. We did not wait for a repeat OCT in the remaining 2 women because, in these cases, OCT suspicious for late FCD were associated with falling Estriol levels in the 24 hour urine samples.

Both the failed OCTs were delivered by cesarean sections. One of the cases had repeated postmature pregnancies. The indication for L.S.C.S. in the other, referred by a private obstetrician was, unfortunately not known.

The '1 minute infant Apgar' scores and the OCT results were as in the following table:

'Apgar Score—OCT Result' Relationship

Infant Ap. Sc. (1 minute)	OCT +ve	OCT —ve	Suspicious	Failed
0–3	—	2	—	—
4–5	4	—	—	—
6–7	2	9	1	2
8–10	6	50	2	—

Four out of 12 patients with OCT negative, delivered infants of Apgar less than 5. Two of these cases were offered vaginal deliveries. The remaining cases had Apgar more than 5.

All but 2 infants whose mothers had negative OCTs, had a 1 minute Apgar score of more than 5. The 2 cases who delivered infants of Apgar less than 3, had very sad stories. In one, we suspected intra uterine fetal pulmonary infection because of premature rupture of membranes. In the other woman, OCT could not be repeated 7 days after the first negative OCT. She could have developed uteroplacental insufficiency during that period resulting in intrauterine fetal death. From this instance onwards, we have been making every effort to repeat OCT within 7 days or earlier, depending on the clinical picture rather than 10 days, as was decided earlier.

Adverse Experiences

In this study, we experienced 2 failed OCTs, 2 false negative OCTs, one OCT complicated by the appearance of antepartum hemorrhage within 24 hours of the test and in 2 cases the labor onset was inadvertently hastened. We refrained from carrying out OCT if women had previous vertical scars on the uterus, with suspected placenta praevia and where premature labor was expected even with a minute dose of pitocin.

Conclusion

The introduction of the cardiotachometer into an obstetrician's armament has helped him to pick up certain hitherto unrecognisable pregnancy abnormalities and has enabled him to reduce the pregnancy loss considerably. The oxytocin challenge test has immense value in the timely prediction of the nature and gravity of fetal jeopardy due to uteroplacental respiratory insufficiency. The surveillance of a pregnant patient by a

watchful obstetrician, helped by modern bioelectronics, will result in infants of better intellectual potential. This will satisfy the parents, and in all probability, will help us to a better generation.

Acknowledgements

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