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Papers contributed by staff members
of the
Servicio de Fisiología Obstétrica
Hospital de Clínicas
Montevideo, Uruguay

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TEST OF FETAL TOLERANCE TO INDUCED UTERINE CONTRACTIONS FOR THE DIAGNOSIS OF CHRONIC DISTRESS[1]

S. V. Pose, J. B. Castillo, E. O. Mora-Rojas, A. Soto-Yances, and R. Caldeyro-Barcia[2]

The uterine contractions of normal labor pro duce a reduction of blood flow in the uterine vessels and in the intervillous space both in women (2, 4, 8) and in monkeys (21). It has also been demonstrated in both species (1, 18, 19, 20) that they produce a fall in the pO_2 values of fetal tissues (Figure 1) and in the percentage of hemoglobin saturation in the fetal blood (22). These results are in accord with the working hypothesis that dips II[3] are pro duced by transient fetal hypoxia caused by uterine contractions (8, 11, 15). Dips II will be produced as a consequence of vagal stimula tion when fetal pO_2 falls below a critical level. This level is of 18–20 mm Hg measured in the capillary blood of the fetal scalp (11) (Figure 2).

In normal pregnancies (Figure 2A) the pO_2 in the fetal tissues is high, about 24 mm Hg (11) between contractions, in the capillary blood of the fetal scalp. Under these normal condi tions the falls produced by normal uterine con tractions of labor do not reach the critical level

required to stimulate the vagus nerve and dips II are not produced. The "fetal reserve" of oxygen is high.

In cases of fetal hypoxemia the "base line" of fetal pO_2 is lower than normal (Figure 1) and closer to the critical level (B and C in Figure 2). A transient reduction of the fetal pO_2 similar in amplitude to that produced by the contractions of normal labor will drive it below the critical level and a dip II will occur.
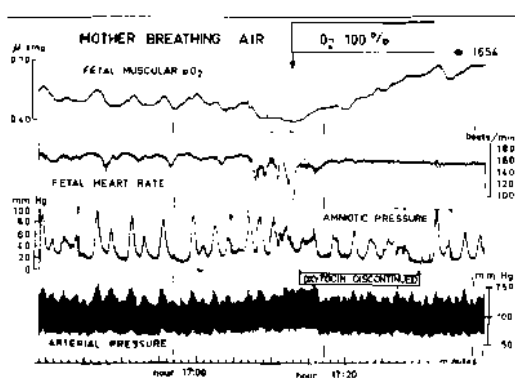

FIGURE 1. Records of fetal muscular pO_2 (polarographic method), FHR, and amniotic fluid pressure. Nullipara, labor induced with intravenous infusion of oxytocin at 2 mU/min. Three different levels of fetal pO_2 can be observed: (1) when mother breathes room air and uterine tonus is normal; (2) during period of hypertonus in amniotic fluid pressure; and (3) when mother breathes pure oxygen. Dips II are evident in first period, ampli tude increases during second period, and they are not present in third one (1).

[3] Transient falls in fetal heart rate occurring immedi ately after a uterine contraction in such a way that the bottom of the dip occurs 30 to 60 seconds after the peak of the contraction (8, 9, 10). Hon's term "late de celeration" (15) is a synonym. Dips II are considered a sign of fetal distress (8, 9, 10, 11, 15, 16).
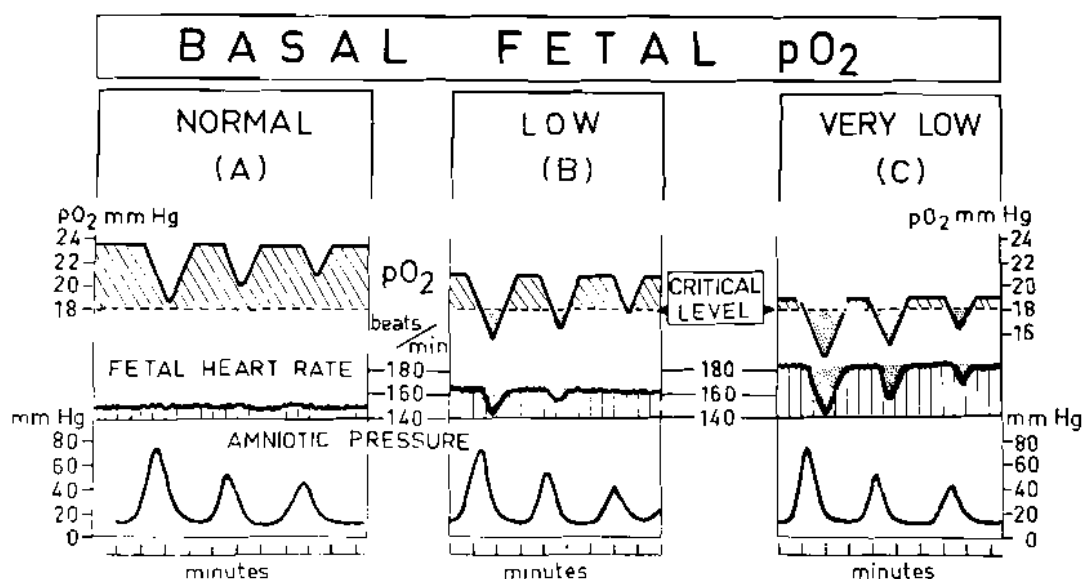
FIGURE 2. Highly schematic representation of working hypothesis concerning effects of uterine contractions on fetal pO₂ and FHR (dips II). Each contraction causes a transient fall in fetal pO₂, proportional in amplitude to rise in amniotic fluid pressure caused by contraction. Basal fetal pO₂ is that recorded between transient falls. A, normal conditions, similar to those of third period in Figure 1. B and C, abnormally low pO₂ as in periods 1 and 2 of Figure 1. In cases of chronic fetal distress, the condition of fetus could be similar to those in B and C.

The "fetal reserve" of oxygen is lower than normal.

The high perinatal mortality observed when the mother suffers from toxemia of pregnancy or chronic arterial hypertension, and perhaps also in cases of very severe diabetes mellitus, can be explained at least partially by a chronic insufficiency of feto-maternal exchanges. In consequence, it is logical to assume that the fetal reserve of oxygen may be lower than normal. In these conditions, if uterine contractions similar to those of normal labor are artificially induced, they will cause dips II.

Material and methods

Thirty-three experiments were performed in twenty pregnant women between the thirtieth and fortieth weeks of gestation. Nineteen of these patients had associated pathology that can produce chronic fetal distress, such as arterial hypertension, toxemia of pregnancy, and diabetes mellitus (Table 1).

In all the cases the amniotic fluid pressure

and fetal heart rate (FHR) were recorded simultaneously. In twenty-eight of these records the fetal heart rate was obtained by an external method (Figure 3), based on the Doppler effect with ultrasonic waves (13). The FHR was obtained beat to beat with an integrator (model Elemedix, Uruguay). In six cases in which the

TABLE 1. Maternal pathology capable of producing chronic fetal distress in 20 subjects tested [a]

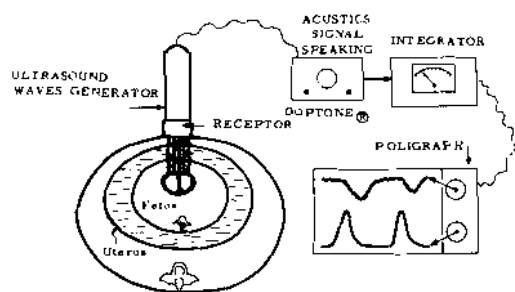| PATHOLOGY	NUMBER
Diabetes Class B	2
Diabetes Class D	6
Diabetes Class F	1
Chronic hypertensive disease	2
Chronic hypertensive disease with toxemia superimposed	3
Acute toxemia	1
Tetralogy of fallot	1
Sickle-cell anemia	1
Systemic lupus erythematosus	1
Rh isoimmunization	1
Myasthenia gravis	1

[a] See text.

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Figure 3. Method employed to record FHR using ultrasonic waves (Doppler effect).

interruption of pregnancy had already been indicated, the FHR was obtained using the R wave of the fetal ECG recorded with an electrode placed in the fetus through the abdominal wall of the mother, as previously described by Caldeyro-Barcia et al. (8, 9). In two of these patients, simultaneous records of FHR using both techniques were obtained (Figure 4). These records were very useful for demonstrating the accuracy of the external method.

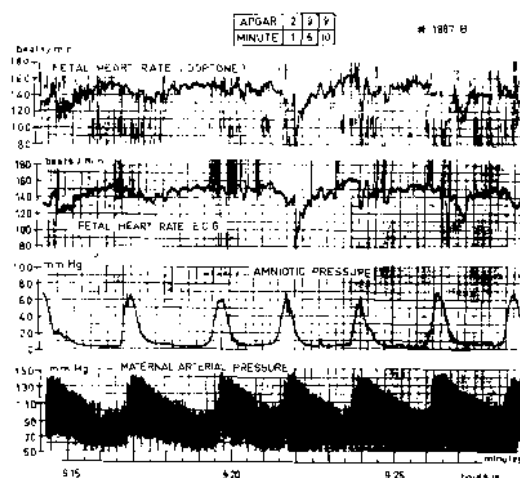After a continuous recording of one hour

Figure 4. Diabetic (Class D) multipara, age 40, thirty-sixth week of pregnancy. Polyhydramnios. Induction of labor with oxytocin infusion commenced at hour 1:53, presently 4 mU/min. Artificial rupture of membranes at hour 5:16; outflow 3,000 ml of amniotic fluid. Cervical dilatation 4 cm, station -5. Cesarean section at hour 11:05. Female newborn 2,560 g, crown-heel length 46 cm. Simultaneous record of FHR using both external method (upper row) and one electrode placed in fetus (second row).

(Figures 5 and 7), uterine contractions similar to those of normal labor were produced by the administration of oxytocin in a continuous intravenous infusion (Figures 6, 8, 9, 11, 12, and 15) at rates ranging from 4 to 16 mU/min depending on the uterine response. The induced uterine contractility was maintained for 30 or more minutes. However, as soon as dips II appeared, the oxytocin infusion was immediately discontinued (Figures 6, 8, 9, 11, and 12). FHR and amniotic fluid recordings were continued in all cases until uterine contractility recovered the values observed in the basal conditions. Prior to the oxytocin administration special attention was paid to the characteristics of the uterine cervix so as to avoid uterine stimulation if the cervix was ripe and induction of labor was not previously indicated.

In ten of our patients the test was repeated one or more times (maximum of four records in the same patient) at a one-week interval (Figures 4, 7, 8, 9, 11, 12, and 13). In all the patients the indications for the time and procedure for delivery were decided by the attending physician according to clinical considerations, regardless of the result of the test.

After delivery the condition of the newborn was evaluated by the Apgar score at the fifth minute of life. The fact that cesarean section was the method of delivery used in fourteen
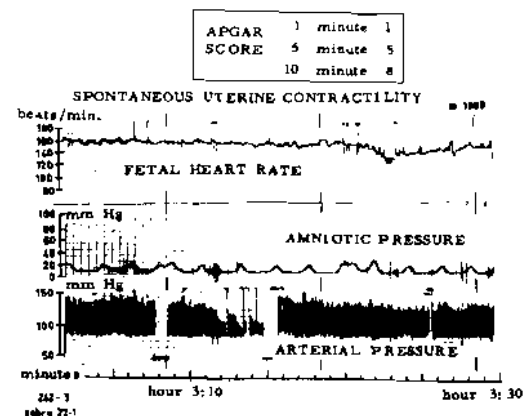

Figure 5. Diabetic (Class D) primipara, age 36, thirty-eighth week (265 days) of pregnancy. Records obtained before uterine contractions were induced (see also Figure 8 and 9).
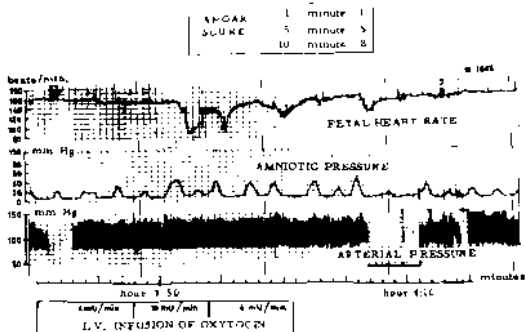
FIGURE 6. Continuation of record in Figure 5. Positive test. Cesarean section performed at hour 5:50. (See also Figure 9.)

FIGURE 10. Urinary excretion of estriol in same patient as Figures 7 to 9. Moment of fetal death is illustrated.
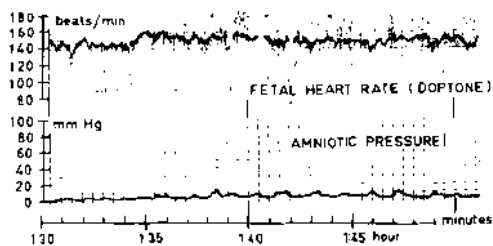

FIGURE 7. Juvenile diabetic (Class F), age 25, thirty-second week (224 days) of pregnancy. Record obtained before induction of uterine contractions. (See also Figures 8 to 10.)
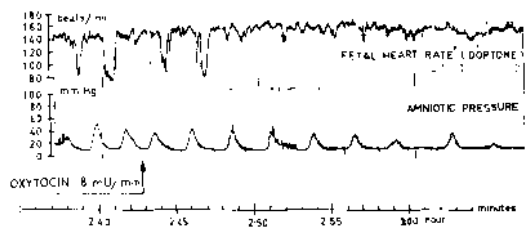

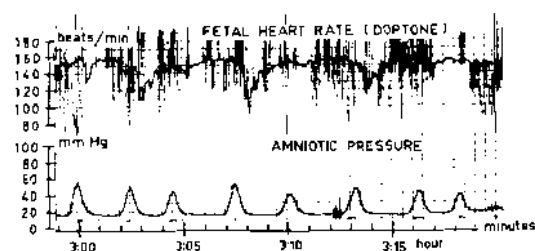FIGURE 8. Continuation of record in Figure 7. Positive test.
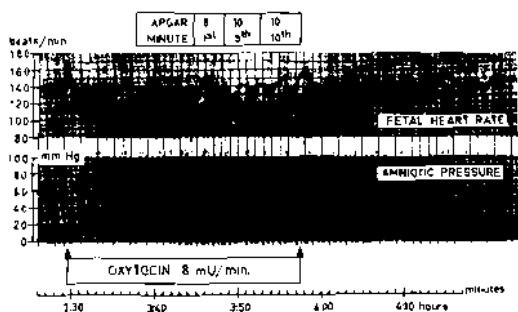
FIGURE 11. Chronic arterial hypertension treated with bed rest and reserpine. Thirty-fourth week (236 days) of pregnancy. Positive test. Cesarean section at 38 weeks (265 days). Two additional positive tests were obtained at 34 and 36 weeks. (See also Figures 12 to 14.)

FIGURE 9. Same case as in Figures 7 and 8. Second positive test obtained in thirty-third week (231 days) of pregnancy.

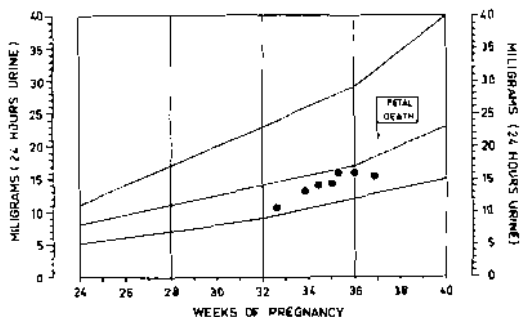FIGURE 12. Same case as in Figure 11. Record obtained at thirty-seventh week (262 days). Fall in FHR is similar to those described by Hon (14, 15) in cases of cord compression.

FIGURE 13. Same record as in Figures 11 and 12. Falls in FHR produced by compression of fetal neck. In cesarean section performed immediately after record, two tight loops of umbilical cord were found around neck.

FIGURE 14. Estriol excretion in same patient as Figures 11 to 13.

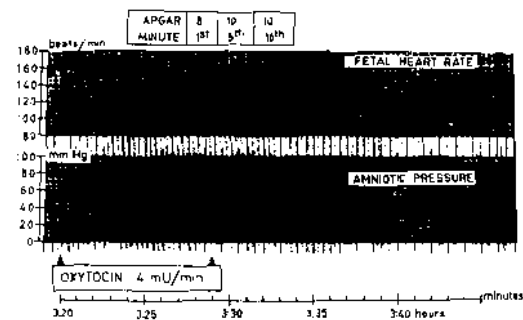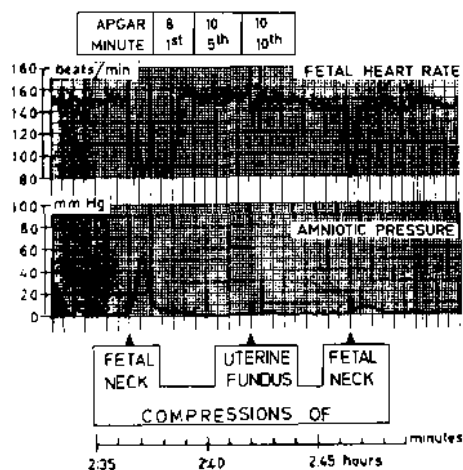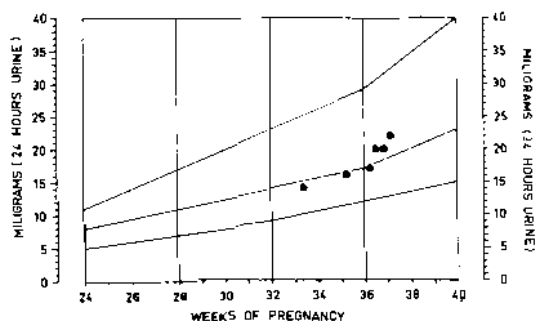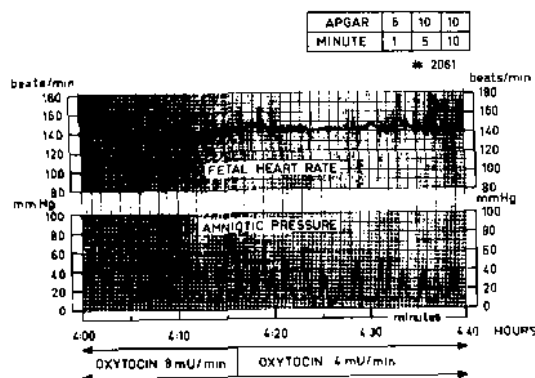FIGURE 15. Diabetic (Class D) primipara, age 23, thirty-five weeks (245 days) of pregnancy. Normal uteroplacental angiography at day 232. Negative test. Cesarean section following test. See also Figure 16.
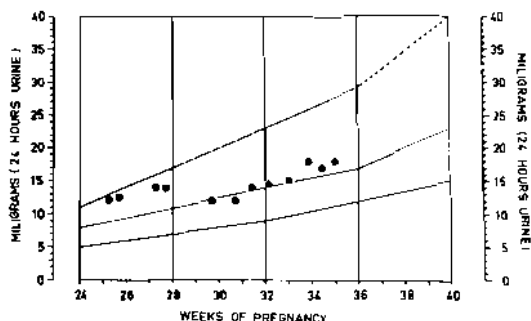
FIGURE 16. Urinary estriol excretion in same patient as Figure 15.

of the twenty cases was an additional consideration in selecting the fifth-minute score, in order to overcome the possible effect of general anesthesia of the mother on the newborn.

In seven patients (Table 2) a uteroplacental angiography was performed according to the technique established by Bieniarz (2, 3).[4] In seven patients the urinary elimination of estriol in 24 hours was measured using the colorimetric technique of Brown (5) (Table 2, Figures 10, 14, and 16).

Results

Interpretation of the test

The test was considered *negative* when uterine contractions with a peak pressure of 35 mm Hg or more did not cause dips II (Figure 15). It was considered *positive* when dips II were produced (Figures 4, 6, 8, 9, 11, and 12). In

TABLE 2. Correlation between results of tolerance test and condition of newborn[a]

RESULT OF TEST	APGAR SCORE, 5TH MINUTE		
	0–6	7–10	TOTAL
Positive (dips II present)	6	2	8
Negative (dips II absent)	0	12	12
Total	6	14	20

[a] $p < 0.001$.

[4] The angiographies were obtained by Dr. E. Curuchet and interpreted by Drs. J. Bieniarz and H. Julio.

the positive cases, 38 per cent of the contractions with a peak pressure between 15 and 75 mm Hg produced dips II. One attempt was made to study the possible correlation between the intensity of the contractions and the production of dips II. In the positive tests the contractions of a peak pressure higher than 15 mm Hg were grouped in intervals of 10 mm Hg (Figure 17). In a few cases, weak contractions of 15 to 25 mm Hg produced dips II; among all the cases analyzed, 12 per cent of the contractions of this intensity caused dips II. The percentage rose to 39 per cent in the group with contractions of 25–35 mm Hg and to 49 per cent in the group with 35 to 45 mm Hg. There is no significant difference between this last percentage and those of the groups with contractions of higher peak pressures.

Table 2 illustrates the correlation between the results of the test and the condition of the newborn. In all twelve patients in whom the test had been negative, the newborns were vigorous (Apgar score 7–10). In six of the eight patients who had one or more positive tests, the newborns were depressed (Apgar score 6 or less). The correlation between the condition of the newborn and the test was highly significant (p < 0.001).

The group of six depressed newborns includes three cases of fetal death. In two of these the fetus died in utero between the thirty-sixth and thirty-seventh weeks of pregnancy, three and seven days respectively after the last test was

performed (Figures 7 to 10 illustrate one of these cases). Neither patient was in labor at the moment of the fetal death. In the third patient, the fetus died during induced labor at the thirty-sixth week of gestation, three days after a positive test. This was a case of chronic arterial hypertension with superimposed toxemia.

In two of the eight positive tests a vigorous newborn was obtained. One of these patients was a diabetic Class D (White's classification) for whom induction of labor was indicated by the attending physician. Dips II appeared during labor four hours after the onset of the induction; at this time the intensity of the contractions was higher than normal (hypersystolia) (Figure 4). Since no free period of time elapsed between the test and the onset of labor, the result of the test was classified as positive. The other case was one of chronic hypertensive disease with superimposed toxemia. Three positive tests were obtained at the thirty-third (Figure 11), thirty-fifth, and thirty-seventh (Figure 12) weeks of pregnancy. In the last of these the falls in FHR proved similar to those described by Hon (14, 15) for cases of cord compression. In this patient, the compression of the fetal neck through the abdominal wall produced variations in FHR indicating a possibility that the cord was coiled around it (Figure 13). At cesarean section performed immediately after this record, two loops of the cord were found to be tightly wound around the fetal neck.

Uteroplacental angiography

In three of the seven cases studied with this method (Table 3), insufficient uteroplacental circulation (2, 3) coincided with a positive test and a depressed newborn (the records in Figures 5 and 6 correspond to one of these cases). In two other patients, a normal angiography coincided with a negative test and a vigorous newborn (Figure 15). There was no correlation in the results of the other two cases, which showed normal angiographies but had positive tolerance tests. Of these patients, one delivered a vigorous newborn (the fetus with a loop of
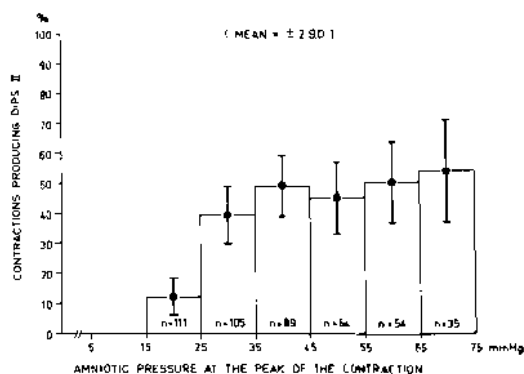

Figure 17. Percentage of uterine contractions producing dips II in cases classified as positive (see text).

TABLE 3. Results of uteroplacental angiography and/or urinary elimination of estriol in 10 patients

CASE NUMBER	MATERNAL PATHOLOGY	RESULT OF TEST	UTEROPLACENTAL ANGIOGRAPHY	URINARY ESTRIOL	APGAR SCORE, 5TH MINUTE
1868	Diabetes D	Positive	Insufficient circulation	—	5
1941	Acute toxemia	Positive	Insufficient circulation	—	Intrapartum fetal death
2031	A. hypertension + toxemia	Positive	Insufficient circulation	Below normal	5
2027	Diabetes F	Positive	Normal	Normal	Intrauterine death at 37 weeks
1935	A. hypertension + toxemia	Positive	Normal	Normal	10
1980	Myasthenia gravis	Negative	—	Below normal	10
2036	A. hypertension	Negative	—	Normal	7
2037	A. hypertension	Negative	— —	Normal	9
2053	Diabetes B	Negative	Normal	—	8
2061	Diabetes D	Negative	Normal	Normal	10

cord around the neck shown in Figures 11, 12, and 13); the other fetus, of a diabetic patient, Class F, died *in utero* (Figures 7, 8, 9, and 10).

Urinary elimination of estriol in 24 hours

This technique is recently being used in our laboratory. Our normal values are very similar to those published by Brown (5).

We studied the urinary excretion of estriol in seven patients (Table 3). In three positive tests, the estriol values were low in one patient and normal in two. The low value corresponded to a depressed newborn. One normal value belonged to a patient with two positive tests and fetal death *in utero* (Figures 7, 8, 9, and 10). The other normal value was from the case with a positive test, nuchal cord, and vigorous newborn (Figures 11, 12, 13, and 14).

In four cases with negative tests and vigorous newborns, estriol values were normal in three (Figures 15 and 16). In the remaining case the estriol excretion fell progressively from 12 to 7 mg in 24 hours in the four determinations made between thirty-fourth and thirty-sixth weeks, at which time labor was induced.

Passage of meconium

The presence of meconium was determined at the time of the amniotic puncture, during labor or cesarean section. It was found in two cases. In one of them, meconium appeared three days after a positive test, during induced labor and before fetal demise. The other case had a negative test and a vigorous newborn; the mother suffered from sickle-cell anemia.

Discussion

The fact that uterine contractions like those of a normal labor produce dips II (positive test) may be explained by a lowering in the fetal oxygen reserve (1, 11, 18, 19, 20) probably due to a decrease in feto-maternal exchanges. In these circumstances it is logical to expect that the fetus will not tolerate the aggression of labor. To avoid intrapartum fetal distress, these fetuses should therefore be delivered by cesarean section.

With the results obtained from this study, it may be concluded that a positive test indicates a high probability of a depressed newborn, even if a cesarean section is performed. Taking this in connection with the fact that two fetuses died three and seven days after a positive test, it may be stated that most probably the fetus is in a precarious condition. It cannot be established for how long the fetus will be able to endure this situation.

In cases in which the interruption of pregnancy before term is indicated because of asso-

ciated maternal pathology, a doubt arises as to the most appropriate time for such an interruption. Ideally, it should be deferred as long as possible, to avoid the risks of prematurity. A positive test of fetal tolerance to uterine contractions is an additional argument in favor of the interruption of pregnancy. A negative test indicates a good chance of obtaining a vigorous newborn. Spontaneous or induced labor may be allowed. However, this does not mean that fetal distress will not occur during labor. In the case shown in Figure 4 signs of fetal distress (dips II) appeared even when the fetus had tolerated uterine contractions of labor during four hours.

Uteroplacental angiography and the test of fetal tolerance to uterine contractions seem to complement each other. The advantages of the test are that it is simpler to perform and that it can be repeated several times in the same patient, thus making possible an early discovery of fetal distress during pregnancy.

The experience in our laboratory with the values of urinary excretion of estriol is insufficient. The fact that in two cases there was no agreement between the estriol values and the condition of the newborn, even though suggestive, does not provide enough support to the viewpoint of those (17) who minimize the importance of estriol excretion in the management of chronic fetal distress.

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