PLACENTAL LOCALIZATION AND ASSESSMENT OF FOETAL WHOLE BODY AND GONADAL RADIATION FOLLOWING $R^{131}ISA$ PLACENTOGRAPHY

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Accurate localization of the placenta is rapidly becoming of the utmost importance in the modern practice of obstetrics. In the diagnosis and treatment of placenta praevia and the performance of amniocentesis, knowledge as to the site of placental insertion is imperative. Furthermore, the situation of the placenta plays a definite role in labour and delivery.

Antepartum Haemorrhage

Placenta praevia is, according to Macafee,[1] one of the most dangerous complications of pregnancy. During the century ending 1939, the maternal mortality fell from 30% to 5%, the foetal mortality, however, remained between 50 - 60%. In the 25 years since 1939, it has become possible to achieve a maternal mortality of nearly nil and to reduce the foetal mortality to 10%. The major contributions in this field are the advent of blood transfusion, antibiotics, obstetric flying squads, a change in attitude to and greater respect for antepartum haemorrhage by medical practitioners and midwives, and better hospital facilities.

Macafee[2] has been able to reduce the foetal mortality remarkably by adopting an expectant attitude towards antepartum haemorrhage and wherever possible avoiding the delivery of premature infants before 37 weeks. Stallworthy[3] has stressed the importance of the clinical signs of placenta praevia, the high head, unstable lie, and the 'anterior' positioning of the presenting part, and has been able to diagnose placenta praevia in 16·5% of cases without any previous vaginal bleeding. Mallik and Flanagan[4] drew attention to the posterior pointing cervix, or sacral os, as a diagnostic sign in unsuspected cases of placenta praevia.

Localization of the placenta has played a major role in differentiating between antepartum haemorrhage due to placenta praevia or accidental haemorrhage of a fundally inserted placenta. Macafee[2] has pointed out that both the maternal and foetal prognoses are better in cases of bleeding due to placenta praevia than bleeding due to other causes. Unnecessary hospitalization can be eliminated once localization of the placenta has been achieved.

Amniocentesis

The work of Bevis[5] focused the attention on this method of estimating increases of the blood pigments, bilirubin and oxyhaemoglobin, of sensitized Rh-negative women. Walker *et al.*,[6] by using a similar technique, were able to predict the state of the unborn child in 92% of cases, by determining the spectral absorption curves of the amniotic fluid. In severely affected cases with a history of a previous stillbirth and the husband homozygous, induction at 35 weeks or even earlier can offer a foetal survival rate of 90%,[8] prematurity being once again the most important factor of the neonatal death rate.

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Intra-uterine Blood Transfusion

In Rhesus incompatibility the perinatal mortality due to gross prematurity can be prevented to some extent by means of intra-uterine transfusion as described by Liley,[7,9] enabling the child to survive *in utero* until the hazards of premature extra-uterine existence are lessened. Wood *et al.*[10] have advocated amniocentesis with the injection of a 50% solution of hypertonic glucose as a most effective method of inducing labour in cases of missed abortion and in cases beyond 12 weeks' gestation where therapeutic abortion is indicated.

In such patients accurate localization of the placenta before the above procedure is obvious.

Uterine Action

Csapo *et al.*[11] suggested that the situation of the placenta in the uterus is one of the important factors controlling uterine activity. As a rule high or fundal insertion of the placenta coincided with slow, prolonged labour and irregular uterine activity, whereas rapid progress and regular uterine contractions occurred in cases with low (not praevia) or mid-uterine insertion of the placenta. They attributed this to a local effect of progesterone release on the myometrium. Booth *et al.*[12] could not confirm these observations, but found, as has Bieniarz,[13] that toxaemia was twice as frequent in patients with the placentae located in the fundus. Fell[14] stated that with breech presentations the placenta is often found attached to the fundal region.

Ranny[15] had reason to perform manual removal of the placenta 62 times during 1,500 deliveries; of these 72% were situated in the cornual regions, the underlying myometrium being very thin and atonic. He attributed the retention of the placentae to this fact. One may well ask how the actual insertion of the placenta can be accurately determined, since there is ample proof that the placenta usually separates within three minutes following delivery of the infant.[16-18] Manual removal of the placenta immediately after clamping of the cord usually shows the placenta still partially adherent and thus the placental site can be accurately determined to a certain extent. This procedure does not increase the total and puerperal morbidity by more than 0·5%.[19] It may be well worth while to take note of these facts in conducting deliveries in patients where the placenta has been localized beforehand.

METHODS OF DETERMINING THE SITE OF PLACENTAL INSERTION

1. Auscultation

Auscultation has been one of the oldest methods known. However, this has proved to be very unreliable, and modern acoustic equipment may well lead to renewed interest in this aspect.

2. Visualization

Visualization of the placenta before its separation, or direct inspection of the placental site at caesarean section, is another method.

3. Palpation

Palpating the placenta during digital examination (EUA), or during manual removal of the placenta, offers an alternative method, as does digital examination of the site of insertion after delivery of the placenta (less accurate).

4. Ultrasonic Techniques

Donald and Duggin[20] and Taylor *et al.*[21] have attempted to demonstrate the placenta with this method, but as yet have not progressed beyond the experimental stage.

5. Aortography

Hartnett[22] described successful placental angiography by means of translumbar injection of a radio-opaque dye into the aorta. Sutton[23] developed the percutaneous technique of forced retrograde femoral arteriography, and Seldinger[24] introduced a refinement to this method by replacing the needle with a polythene catheter. Basson and De Villiers[25] and Borell *et al.*[26] obtained excellent results with this method, stressing the advantage of radiographic arteriography in earlier pregnancy (28 - 34 weeks).

Disadvantages include: (i) the radiation hazard of the foetus; (ii) haematomata and possible thrombo-embolic sequelae; (iii) keeping the patient in hospital overnight.

6. Placentography

(i) *Indirect*

Amniography was first described by Menees *et al.*[27] After injecting strontium iodide into the uterine cavity they were able to identify the placenta as a shadow of lesser density by its characteristic shape. Lennon and Reid[28] performed amniography using 3 - 5 ml. of lipiodol and 20 ml. of a 70% pyelosil solution.

Cystography. In 1934 Ude, Weum and Urner[29] originated this method and evaluated the thickness of the anterior wall of the lower segment following injection of contrast medium into the bladder. This procedure was often complicated by urinary infection.

Air insufflation of the rectum. Sohrne[30] found cystography only reliable with anteriorly situated placentae and supplemented this method by injecting air into the rectum as well as into the bladder.

X-ray tomography was described by Lloyd and Samuel.[31] Out of a total of 5 cases they correctly diagnosed 2 cases of placenta praevia.

(ii) *Direct*

Soft tissue placentography. The crescentic thickening of the peripheral soft tissue shadows usually visible in lateral views of the abdomen, was first commented upon by Snow and Powell[32] as a possible indication of the placental site. Dippel and Brown,[33] Reid,[25] Hartley[34] and Percival and Murray[35] developed this method to near perfection. This method, however, comes in for strong criticism because of the potential radiation dangers to the foetus and its gonads.[36] It is only accurate in the hands of extremely competent radiologists, who are not always available.

Displacement of the presenting part due to low implantation of the placenta. This method was described by Ball and Golden[37] in 1941. It is only applicable with a vertex presentation of a normal-sized foetus, just before the onset of labour, the distance between the presenting vertex and the pubis being increased from 3 cm. to 4 cm. in an anteriorly placed placenta. A posterior placenta praevia gives a difference of 3·4 cm. between vertex and promontorium instead of 1·7 cm.

The more common factors that can influence the accuracy of the above methods are a full bladder, loaded rectum, lax abdominal muscles, pelvic tumour, breech and malpresentation.

7. Thermal Placentography

This is based on the sensing and recording of the long wave-length infra-red emission from the human body. Birnbaum and Kliot[39] using a Barne's Thermograph[38] scanned 70 patients at or near term. Seventeen cases were excluded from this study because of the difficulties of follow-up. Their findings were confirmed in 53 cases and they obtained accurate readings in 96% of cases. This method has the advantage of not exposing the mother or the foetus to any form of radiation or manipulation.

8. Radioisotopes

The use of radioisotopes to localize the placental site depends on the fact that a considerable volume of maternal blood passes through the placenta during pregnancy. The total uterine flow is estimated at 750 ml./min. and the flow through the intervillous spaces of the placenta as 250 ml./min.[40]

This method was originally described by Browne and Veal[41] in 1950, using radioactive ^{24}Na, a non-persistent, tracer element with a half-life of 16 hours, readily diffusible and rapidly excreted. Weinberg *et al.*[42] confirmed the work of Browne and Veal and met with the same difficulty of the rapid diffusion of the sodium. They thereafter substituted radioactive iodinated human serum albumin (RISA).

Hibbard[43] in a series of 178 patients, localized the placenta incorrectly in only 2 cases; one patient had a placenta membranacea, the other a bilobulate placenta. Albumin, a protein with a large molecular weight, remains essentially intravascular and it may be labelled with various isotopes of iodine with either a shorter physical half-life than ^{131}I, such as ^{132}I, or a pure gamma emitter, e.g. ^{125}I.

Because of the geographical remoteness of the Republic from centres producing RISA, only R^{131}ISA is at present available to us. ^{131}I has a physical half-life of just over 8 days and the entry of ^{131}I liberated from the RISA into the thyroid of both mother and child must be blocked by the administration of Lugol's iodine to the mother before and for 2 weeks after the examination.

Paul *et al.*,[44] using ^{51}Cr-tagged erythrocytes, performed radioisotopic examination on 106 women, confirming the placental site at caesarean section or by manual removal of the placenta in all but 2 of the vaginal deliveries. Only one misdiagnosis was made in a woman with an extremely vascular fibromyoma, the patient weighing 270 lb. ^{51}Cr emits no beta rays, has a half-life of about 28 days, and is excreted by the maternal kidney and does not enter any specific organ or tissue.

Localization by Radioisotopes

Localization of the placental site by radioisotopes provides a method of immediate bedside localization with relatively simple equipment. This method is indicated

throughout the entire third trimester of pregnancy, regardless of maternal obesity, lax abdominal muscles, malpresentation, hydramnios and pelvic tumours.

The patient lies comfortably on her back on a hospital bed or trolley. Two microcuries R^{131}ISA are injected intravenously. One probe is placed over the heart to monitor baseline activity. The problem of establishing an accurate baseline from which to calculate the percentage of radioactivity over the abdominal segments, has been overcome by using the Picker Dual Ratemeter, Model 5846, as used by Wheeler and Dolan.[45] Five minutes are allowed to elapse in order to permit thorough mixing of RISA with the maternal blood. (If insufficient activity is registered a further 2 or 3 microcuries are injected.)

The other probe is then placed over 9 marked positions on the abdomen and the radioactivity registered. The patient is then turned onto her side and the radioactivity monitored over a further five marked positions. With the patient on her other side, the corresponding five positions are monitored. It is usually difficult to get accurate localization of the posteriorly implanted placenta. We found that by monitoring the various lateral positions, this problem can be overcome and greater accuracy of posterior placental localization be obtained.[46] If the central or total placenta praevia is excluded, 70% of the remainder of placenta praevia are posteriorly situated placentae. This fact contributed markedly to our modification of the technique.

RADIATION EXPOSURE

Weinberg *et al.*[42] state that the average placental crossing of RISA is about 1·74% of the administered dose. From a dose of 5 microcuries of R^{131}ISA injected into the mother, the radiation dose to the foetus was calculated to be 5 milliroentgens. If the foetal thyroid is not blocked by Lugol's iodine, the radiation dose to the foetal thyroid, according to Hibbard and Herbert,[47] will be about 4·9 rads, 2% of the administered activity being concentrated in the foetal thyroid. Thus Lugol's iodine solution must always be used as a thyroid-blocking agent before doing a placentogram. Of 5 microcuries injected into the mother, an average of 0·006 microcuries of ^{131}I cross the placenta. The total body and gonadal dose to the foetus will be 0·005 r. Radiographic placental localization, using the conventional 2 film method, results in a total foetal body dose of 2·4 rads. Hibbard,[43] by using 50 microcuries of ^{132}I with a half-life of 2·4 hours, reduced the radiation to the maternal and foetal gonads to 1/200 and the thyroid to 1/8 of that incurred in taking two X-ray films.

Whole Body Counter

A whole body counter is essentially a sensitive detector of radiation, well shielded from extraneous radiation and large enough to accommodate the adult human body comfortably.

The Atomic Energy Board's whole body counter situated at the Pretoria General Hospital has a thallium-activated sodium iodide crystal, similar to those used for ordinary radioactive iodine uptake studies, only very much larger (8 in. diameter and 4 in. thick). The detector is housed in a room 8 ft. × 7 ft. × 8 ft. The walls, ceiling and floor are all constructed of 8-in. thick steel. The inside of the walls is lined with 3 mm. of lead in a plywood-lead laminate. Most of the normal background radiations arising from the earth, building materials and cosmic rays are absorbed by the steel shielding.

The whole body counter can detect minute quantities of radioactive isotopes. This is due to the greatly reduced background radiation within the counting room, the large volume of the detector and the ability of the multichannel analyser and associated electronic equipment to recognize most gamma ray-emitting radioactive isotopes individually. In a counting time of 20 minutes it is possible to detect as little as 0·5 nanocurie of ^{131}I in an infant. This figure can be compared with the 130 nanocuries activity of radium present in an average illuminated wrist watch.

Normally an adult is counted sitting in the Marinelli chair under the detector, i.e. the subject resembles an elongated W with the detector above the abdomen and more or less equidistant from the chest, abdomen and thighs. Infants are placed directly under the detector.

RESULTS

With this whole body counter we have assessed the ^{131}I content of mothers and infants following R^{131}ISA placentography. These mothers were counted immediately after placentography. The infants were counted as soon as possible after birth, and usually within 24 hours of birth, except cases 2 and 4 that were counted within 48 hours of birth. The radioactivity measurement results are shown in Table I.

TABLE I. RESULTS OF RADIOACTIVITY MEASUREMENT

	Dose in nanocuries		
Cases	*Mother*	*Infant*	*% of mother's dose*
1		31·8	
2	2,740	31·3	1·1
3	3,450	31·3	0·9
4	2,890	9·2	0·3
5	520	30·3	5·8
6	2,180	10·1	0·5
7	3,960	42·4	1·1
8	3,520	163·2	4·6

The doses to the mothers are underestimated, since the calibration source does not have as high a self-absorption as the pregnant female body.

The doses of the children are overestimated, since a virtual point source is used in their calibration. A study is under way to estimate the exact quantity of ^{131}I present in the infant's body, as well as the exact amount of ^{131}I that is taken up by the foetal thyroid; this will be reported later.

Comparison between ionizing radiation doses absorbed by the foetus from R^{131}ISA placentography and other placental localization using X-ray techniques, is shown in Table II. The indications for placentography in 61 patients

TABLE II. IONIZING RADIATION DOSES ABSORBED BY THE FOETUS

	X-ray techniques				
Procedure	*Pelvimetry —inlet* mR	*Obstetric —lateral* mR	*Abdomen —PA* mR	*Total dose* mR	*R^{131} ISA placentography* mR*
Average dose to:					
Foetal gonads	2,800	200	150	350	5
Total body	800	250	150	400	5

*X-ray doses obtained from Bewley *et al.* (1957) [48] and Weinberg *et al.* (1963).[42]

are shown in Table III, the accuracy of prediction in Table IV and the diagnosis and method of delivery in Table V.

TABLE III. INDICATIONS FOR PLACENTOGRAPHY IN 61 PATIENTS

Antepartum haemorrhage	28
APH and malpresentation	22
High head	4
High head and previous caesarean section	2
High head and ? carcinoma of cervix (subsequently confirmed Ca)	1
Unstable lie and breech presentation	1
Unstable lie and hydramnios	1
Unstable lie and pendulous abdomen	1
IUD, CCF Rh antibodies	1
Total	61

TABLE IV. ACCURACY OF PREDICTION

Correct placement of placenta confirmed at caesarean section or manual removal of the placenta	35
Clinically correct, but not proved	24
Incorrect placement of the placenta	1
Placenta not detected (placenta membranacea)	1
Total number of placentographs	61
Therefore accuracy of this series 96·73%	

TABLE V. DIAGNOSIS AND METHOD OF DELIVERY

Diagnosis	*Spontaneous vag. del.*	*C/S.*	*C/S & hyst.*	*Hypert. gluc.*	*Breech & hyst.*	*Int. vers. & br. extr.*	*Breech del.*	*Forceps del.*
Placenta praevia	2	5	1	0	1	1	0	0
Fundal placenta	33	6	1	1	0	0	5	5

The maternal mortality was nil.

Foetal mortality. Four infants were lost and in none of these cases could death be attributed to the RISA placentographs.

(*a*) One patient who had previously left the hospital on her own responsibility was readmitted with obstructed labour due to retention of the hydrocephalic head of the infant, who was subsequently stillborn.

(*b*) Two stillbirths were due to abruptio placenta and gross prematurity.

(*c*) The neonatal death was due to gross prematurity in a patient with a history of repeated abortions who presented as an unbooked case and delivered shortly after admission.

The placenta was incorrectly placed praevia in a patient who was proved to have a carcinoma of the cervix, and subsequently delivered spontaneously. The deviations of positions 7, 8, 9 were attributed to the extreme vascularity of the tumour. This case will be fully described in a following paper.

Caesarean section was performed in 11 cases for the following indications:

(*a*) Repeat caesarean section was performed in 3 cases for cephalo-pelvic disproportion (CPD).

(*b*) Cervical dystocia, CPD, maternal and foetal distress 3 cases.

(*c*) Placenta praevia 3 cases (confirmed).

(*d*) Severe APH, abruptio placenta, persistent high head, foetal distress. At operation abruptio of fundal placenta confirmed, but succenturiate lobe of placenta was found to be praevia, as diagnosed by RISA (to be described in a following paper).

(*e*) Postmature, breech presentation, failed induction, caesarean section, placenta accreta (position confirmed), hysterectomy.

(*f*) Transverse lie and foetal distress 2 cases.

(*g*) Carcinoma of the cervix—caesarean section, Wertheim.

Forceps delivery was performed in 5 cases:

(*a*) Severe foetal distress on readmission. On examination: fully dilated, prolapsed cord—forceps delivery, result good.

(*b*) Cardiac lesion—2 cases.

(*c*) Pyelonephritis—1 case.

(*d*) Foetal distress second stage—1 case.

Breech delivery—7 cases:

(*a*) An internal version and breech extraction past a grade 2 placenta praevia was necessary in 1 case, with good results.

(*b*) Severe abruptio placenta and gross prematurity—2 cases. Both stillbirths.

(*c*) Examination of patient presenting with postpartum haemorrhage after spontaneous breech delivery showed a ruptured uterus. Hysterectomy was performed.

(*d*) Two uncomplicated breech deliveries.

(*e*) Retention of hydrocephalic head. Stillborn.

One patient was admitted with a confirmed intra-uterine death and missed abortion. She gave a history that the previous infant was severely affected by Rh antibodies, necessitating repeated exchange transfusions. The patient was 28 weeks pregnant with right-sided hemiplegia owing to cerebral embolus from atrial thrombosis due to rheumatic carditis with severe mitral stenosis and incompetence. The placenta was located on the posterior uterine wall. Amniocentesis was performed, aspirating 200 ml. liquor and injecting 250 ml. of 50% glucose and 250 mg. intravenous Terramycin. Subsequent spontaneous abortion occurred within 24 hours.

Our experience in 61 cases of placentography gave a result of 96·73% accuracy.

SUMMARY AND CONCLUSIONS

1. The indications for placentography are reviewed.

2. Accepted procedures for localization of the placenta are discussed.

3. The advantages of radioisotopic placental localization are detailed.

4. The radiation dose to mother and foetus are assessed by means of whole body counting.

We feel that RISA placentography is a safe and accurate method of placental localization.

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