PLACENTAL LOCALIZATION BY INHALATION
OF RADIOACTIVE CARBON MONOXIDE

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Many different radioisotope techniques have been used for placental localization since 1950 when Browne and Veall (1) published their results, using 24Na. The usual procedure is to inject intravenously a labeled intravascular substance which is then detected by a scanning procedure. The two intravascular substances which have been used are albumin and red cells. Albumin has been labeled with 131I (2,3) 182I (4–6), 99mTc (7,8) and 51Cr (9). Red cells labeled with 51Cr (10) have been used. Recently the use of 113mIn (11) has been proposed. The relative merits of the various substances are related to two factors: convenience in use and radiation hazard. 123I-HSA and 51Cr-HSA are convenient to use because of their comparatively long half-lives. By using 182I-HSA and 99mTc-HSA the radiation dose is reduced considerably because of the 2-hr half-life of 182I and the 6-hr half-life of 99mTc, but their short half-lives also require the albumin to be labeled for use each day. The advantage of 113mIn over 99mTc-HSA is that the former material may be autoclaved. However, some care in adjusting the pH during the preparation of the material for injection is required. 24Na has a relatively high radiation dose/µc compared with 99mTc and is unsuitable for automatic scanning due to the difficulty of collimating high-energy gamma rays (2.75 and 1.37 Mev) and to the rapid clearance of 24Na from the blood. A disadvantage of 51Cr-labeled red cells is the necessity and inconvenience of in vitro labeling followed by reinjection into the patient. In this communication we describe the use of 14C-monoxide for placental localization. In vivo labeling of the red cells was performed by administering the gas for a brief period by inhalation. The radiation dose is comparable with 99mTc-HSA.

METHOD

14C-monoxide is produced by bombardment of boron as boric oxide with deuterons in the Medical Research Council Cyclotron (12). Seven hundred fifty microcuries of the gas are withdrawn into a syringe and after allowing time for the decay of 15N which is also produced as a 16% impurity, 500 µc of 14CO containing 60 µc of 15N are injected into a 3-liter bag containing oxygen. The patient breathes this gas mixture for about half a minute through a well-fitting face mask. The mask and bag are removed and the patient is scanned immediately. Both

FIG. 1. AP dot scan obtained from color dot scan showing placenta in right lateral position. Xiphisternum is indicated by arrow.

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a gamma camera (Nuclear Chicago) using an 11-in. diameter \( \times \frac{1}{2} \)-in. thick sodium iodide detector and a dual-detector scanner whose detector crystals are 3½-in. diameter \( \times \) 3-in. thick sodium iodide have been used for localization of the placenta.

Using the camera, two AP views were taken routinely and one lateral view was also taken, the patient remaining in the supine position. The time for each view was approximately 4 min. A 4½-in.-thick multihole collimator was used to improve resolution (13) because of the comparatively high energy of the annihilation radiation emitted by the \(^{11}\text{C}\). The total number of counts recorded on each view was 50,000.

The scanner was operated at a speed of 3 cm/sec with a time constant of 0.3 sec. Two opposed 19-hole high-energy focusing collimators were used, the distance between the collimators being 32 cm. The maximum counting rate was approximately 200 cps. One AP and one lateral scan were performed. The lateral scan was carried out by turning the patient on to the appropriate side to bring the placenta proximal to the lower detector. The total scanning time taken for two views was 25 min. A color dot scan was produced by the scanner.

**RADIATION DOSE CALCULATIONS**

\(^{11}\text{C}\) has a physical half-life of 20 min and emits positrons with a maximum energy of 0.97 Mev which yield annihilation gamma rays of 0.51 Mev. The effective half-life of clearance in the blood is 18 min, and the whole-body dose is 0.011 mrads/\(\mu\)c (14). Thus the total whole-body dose due to 500 \(\mu\)c \(^{11}\text{C}\)-monoxide in the blood is 5.5 mrads. The additional dose to the lungs during rebreathing is 5 mrads. The fetal dose is estimated at 4 mrads, and the dose to the fetal blood as 6 mrads. The fetal whole-body dose is due to gamma radiation received by the mother's trunk in the pelvic region. The dose to the fetal blood is calculated by assuming that one-tenth of the fetal blood is in the placenta. The fetal blood thus received one-tenth of the radiation dose to the placenta as well as nine-tenths of the fetal whole-body dose. A total blood volume of 4 liters, a placental mass of 750 gm and a placental blood volume of 250 ml were assumed in calculating the radiation dose to the placenta.

This radiation dose is approximately equal to that due to the administration of 500 \(\mu\)c of \(^{99}\text{m}\text{Tc}\)-HSA and is about one-third of that due to the administration of only 8 \(\mu\)c of \(^{51}\text{Na}\).

The additional radiation dose due to the inhalation of 60 \(\mu\)c of \(^{12}\text{N}\) along with the 500 \(\mu\)c of \(^{11}\text{CO}\) is 0.8 mrads to the maternal lungs and is negligible to the whole body and fetus.

**FIG. 2.** A: Anterior view of abdomen taken with gamma camera. Placenta is seen in upper part of picture. Pubic symphysis is indicated by arrows. B: Right lateral view of same patient. Umbilicus (A) and iliac crest (B) are marked. Placenta is seen close to anterior wall of abdomen. Increased activity at bottom left of picture is due to liver.

**RESULTS**

AP and lateral gamma-camera pictures are shown in Fig. 1. The placenta is readily seen and lies in the upper anterior region. A 100-\(\mu\)c \(^{57}\text{Co}\) source was used for anatomical marking and is indicated by the arrow. An AP dot scan is shown in Fig. 2.
Successful gamma-camera pictures and scans with $^{11}$CO have now been obtained in 50 patients. The technique, involving a low radiation dose, is simple and is performed both as an in-patient and out-patient procedure. Placentas, whether sited anteriorly, posteriorly or laterally were all readily detected by either the camera or the scanner. An advantage of the scanner is that the size of the picture obtained is the same as the area scanned which makes the identification of the placental position more accurate. Lateral views of the abdomen are more easily obtained with the gamma camera because they do not involve changing the position of the patient. However, both methods are very satisfactory, provide the clinician with a permanent and easily interpretable record and are of value in the diagnosis of placenta previa in cases of antepartum hemorrhage. A significant advantage of this technique over the $^{99m}$Tc-labeled albumin method is the lack of accumulation of activity in the bladder which may confuse the diagnosis of placenta previa.

CONCLUSIONS

With the availability of small isotope-producing cyclotrons, the use of $^{11}$C-monoxide for the localization of the placenta may well have wide application. The combination of low radiation dose, complete absence of handling and labeling problems and the atraumatic administration by 30-sec inhalation makes it an attractive alternative to other substances previously used for placental localization.

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REFERENCES