RADIOACTIVE IODINE UPTAKE BY THYROID OF BREAST-FED INFANTS AFTER MATERNAL BLOOD-VOLUME MEASUREMENTS

E. P. Bland J. Selwyn Crawford M. F. Docker R. F. Farr
Birmingham Maternity Hospital and Department of Physics, United Birmingham Hospitals

Summary

Investigations of two patients have shown that when routine blood-volume studies, using serum-albumin labelled with iodine-125 are done on a mother at the time of delivery, a considerable amount of radioactive iodine may be transmitted to the infant in the breast-milk. This is likely to increase by a factor of 10 the risk that the child will subsequently develop cancer of the thyroid.

Introduction

Knowing the amount of blood lost and the change in circulating blood-volume in relation to surgery is a valuable index to efficient supportive therapy. Several workers 1-3 have found that blood-loss at caesarean section tends to be considerably greater than estimates based upon clinical impression had led many obstetricians (and anaesthetists) to expect. When the new Birmingham Maternity Hospital was opened we decided to include measurement of blood-loss and preoperative and postoperative blood-volumes in our battery of patient-monitoring routines. The methods and results will be described elsewhere, but it is necessary to point out here that, in order to assess the degree of accuracy of blood-volume estimates, we made preoperative and postoperative measurements in several cases of postpartum sterlisation (P.P.S.), since only rarely is more than 200 ml. of blood lost at this operation.

Blood-volume was assessed with the aid of the Pitman model 125 blood-volume computer. Solutions containing approximately 5 μCi of iodine-125 were given by intravenous injection immediately before operation and about 1 hour after the end of operation. We recognised the need for caution in using radioactive materials in obstetric medicine, and at the outset our concern was that a significant amount of iodine-125 might reach the infant by the transplacental route. However, a review of published work on the use of iodine isotopes for placental localisation 4,6 and consultation with the Medical Research Council satisfied us that the administration of 5 μCi to the mother before delivery would not pose a hazard to the infant, and we had no reservations about the inaugurating the monitoring service.

Some time after the initiation of the service, our attention was drawn to a paper by Czerniak et al. 6 referring to the presence of radioactive iodine in the colostrum and the milk of mothers who, just before labour and delivery, had been given iodine-131 as a test of thyroid function. Further search of the literature revealed that Miller and Weetch 7 and Weaver et al. 8 had referred to the hazard to breast-feeding infants of administering radioactive iodine to the mother. We felt that this matter required immediate investigation. Before we made this decision, four patients (two undergoing caesarean section and two undergoing P.P.S.) had breast-fed their infants after being given iodine-125: the necessary instruments became available to us shortly after a fifth breast-feeding mother had been delivered by section and our sixth case in this category had a P.P.S. on a date when we were ready to undertake a full investigation. The first patient received a dose of 10 μCi, the second received 6 μCi; in both cases the dose was given in two equal portions.

Investigation

The first patient started to feed her child 3 days after administration of the radiiodine, the second was already feeding at the time of administration. Measurements were done on 5 ml. samples of milk taken at frequencies varying from one to five per day. An automatic sample changing gamma-counter was used to measure the concentration of radioactive iodine present in the milk. The figure shows that the concentrations of iodine in the first milk received by the infants were 0.7 and 0.15 μCi per litre, respectively. In case 1 the concentration fell exponentially, the peak concentration having been passed when feeding was commenced. In case 2 the concentration reached a maximum 24 hours after the operation, the peak concentration being 0.3 μCi per litre; thereafter the concentration fell exponentially.

Using data obtained during the 8 days that the patients were available for observation, and assuming that the infants received five feeds per day, each of 60 ml., it was possible to show by extrapolation that the total intake would be 0.5 μCi in the first case and 0.6 μCi in the second.

We tried to assess the amount of iodine present in the

DR. BECKER AND OTHERS: REFERENCES—continued
Concentration of iodine-125 in the milk of two patients, one of whom was delivered surgically, the other having been surgically sterilised.

thyroid of the mothers and children. To avoid any anxiety to the mothers the measurements could not be made with the apparatus usual in these tests, but improvised arrangements were made using a portable gamma monitor. However, measurements were inconclusive.

Measurements made on one sample of milk showed that 70% of the radioactive iodine was in an inorganic form. This agrees with other published work.

**Maternal Whole-body Dose**

Assuming a maternal mass of 60 kg, and an effective half-life of 11 days for iodine in a protein-bound condition, we used the formula:

\[ D = 2.25C \exp(1.44T_{eff}) \]

\[ D = \text{Dose (rads)} \]

\[ C = \text{Concentration of isotope in (μCi per litre)} \]

\[ T_{eff} = \text{effective half-life of the isotope.} \]

We calculated that the whole-body dose received by the first patient was 5 mrad and that received by the second was 6 mrad. This ignores the presence of any inorganic iodine, the concentration in the administered dose being less than 2%.

**Maternal Thyroid Dose**

If all of the iodine had been in an inorganic form when administered, 30% would have been absorbed by the thyroid. Here it would have an effective half-life of 16 days and, assuming a thyroid mass of 20 g, it would deliver a dose of about 6 rad. On the other hand, if all the protein-bound iodine was so eliminated, the 2% of inorganic iodine would deliver a dose of about 120 mrad.

**Whole-body Dose to the Infants**

Assuming a body mass of 3 kg, and an effective half-life in the body of 40 days for free iodine, and 11 days for protein-bound iodine, the whole-body dose to the infants would have been 15 mrad and 18 mrad. Here we are assuming that the protein-bound iodine remained so bound.

**Thyroid Dose to the Infants**

In these calculations the thyroid masses were considered to be 3 g, and the thyroid uptake was assumed to be 50% and assumed not to vary during the period under consideration. The thyroid doses were calculated to be 2.0 and 2.5 rad, respectively, assuming effective half-lives of 9 days in the infant's thyroid. This took account of the inorganic iodine alone, and the actual dose may have been up to 30% higher if the protein-bound portion had been liberated. However, an additional factor should be taken into account when computing the radiation hazard. Gross et al. found that the effective damaging dose to the thyroid cells is greater than the measured dose received by the whole gland by a factor of between 2 and 5. This is because of the inhomogeneity in distribution of the nuclides in the thyroid tissue. In view of this the effective dose received by the neonatal thyroid under discussion here is about 10 rad.

**Discussion**

The significant hazard is that provided by the thyroid dose to the infant.

Dolphin re-examined the data of Hempelmann et al. derived from the follow-up of children who had been irradiated for thymic enlargement in early infancy. Of the 2878 children studied 19 had had malignant tumours and 22 benign tumours of the thyroid, but none of them had died from these tumours. The incidence fitted a model with a latent period of about 20 years. Dolphin deduced, on a non-linear threshold hypothesis, a cancer risk from irradiation of the thyroid of about 100 per million per rad. On this hypothesis a dose of 10 rad would produce a cancer incidence of 1 per 1000 children irradiated.

This may be compared with the natural incidence of thyroid cancer in the relevant age-group of 10-30 years, of about 5 per million per year, or 1 per 10,000 individuals. The risk of death is of course in both cases much less than the risk of cancer.

It is important to compare the dose given in this procedure with the doses given during X-ray examinations of the fetus and newborn. In X-ray pelvimetry doses of about 500 mrad, and in X-ray placentography doses of about 300 mrad are delivered to the fetus. And in X-ray examinations of the thorax doses of between 0-03 and 3 rad are given to children.

Thus when a mother breast-feeds after a blood-volume test done at about the time of delivery, quite a large dose of radioactive iodine is given to the infant compared with the doses delivered during other procedures. There are three ways of reducing this hazard: firstly, by delaying breast-feeding of the infant for at least 10 days after administration of the nuclide; secondly, by using a suitable nuclide which is not accumulated in the thyroid tissue; and, thirdly, by using material to prevent the radioactive iodine from accumulating in the thyroid—such disturbance of the neonatal thyroid may, however, be considered undesirable.

We thank Miss A. J. Turner and Mrs. D. E. Field of the medical physics department for their help.

Requests for reprints should be sent to J. S. C., Birmingham Maternity Hospital, Birmingham 15.

**REFERENCES**

2. Wallace, G. ibid. 1967, 74, 64.

*References continued at foot of next column*