It is concluded that Cushing's syndrome is due to pituitary overactivity which is prompted by a hypothalamic disorder that disturbs rather than disrupts the normal homeostatic link between pituitary and adrenal.

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REDUCING RADIATION HAZARDS IN THE RADIUM WARDS

BY

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Many authors have reported measurements of radiation dose received by hospital personnel, and some of them (Mayneord, 1951; Leetz, Masch, and Mohr, 1958; Clarke, 1960; Quimby, 1960; Zeitz and Zolg, 1960; Koren, Maudal, Flatby, and Berteig, 1960; Ellis 1961) have found, as we have, that one of the most difficult aspects of radiation safety in a hospital is the protection of ward nursing staff during the therapeutic use of radium. Large quantities of radioactive material are used, and such patients must receive nursing attention many times, under circumstances which prevent shielding according to laboratory standards.

Substantial radiation doses may be received in such circumstances, and official reports such as the Code of Practice (Ministry of Health, 1957) or the Recommendations of the International Commission on Radiological Protection (1960) give little help in reducing them.

During the past few years we have conducted a detailed study of this problem as it affects a ward in this hospital, where most gynaecological radium treatments are carried out.

Ward Routine

Ward nurses need to be near to the radium patient for the following procedures: (a) in theatre; during transfer of the patient to the ward, and during post-operative recovery; during removal of the radium at the end of treatment. (b) During radiographic localization. (c) During bed-making, washing, and care of pressure areas. (d) Attention to catheter, and emptying drainage. (e) During the taking of temperature, blood-pressure, pulse, and respiration rates; locker inspection. (f) Giving fluids and meals. (g) In emergencies such as vomiting and renewal of the catheter.

In the 10-bedded ward during the period covered by this survey about 60 radium treatments were given. It is not usual for more than one patient to be under treatment with radium at a time, but the precautions

discussed below will still be applicable, *mutatis mutandis*.

Only on rare occasions in this ward, even at the start of the survey, has any member of the nursing staff received a dose as high as 300 mr in a week, or a total exceeding 1 r in 13 weeks. Even so, doses received during the nursing of radium patients were higher than those received by other nursing staff, and therefore (following the Recommendations of the I.C.R.P. that all doses be kept as low as possible) efforts have been made to reduce them.

The radiation received by the staff as a whole will depend partly on the nursing attention required by the patient, partly on the techniques used, and partly on the amount of radium inserted and the duration of treatment.

In order to eliminate these last two variables we have expressed the radiation received as milliroentgens per 1,000 milligram-hours of radium treatment; the total dosage received by the nursing staff during a period of over three years is shown, quarter by quarter, in Fig. 1. The radiation received has been evaluated separately for the sister in charge of the ward, her deputy (a staff nurse), and junior nurses, and these are shown in Fig. 2. A steady reduction is apparent, as is made clear in Table I.

Expressing doses in mr/1,000 mg. hours of radium treatment is of little value ordinarily, but it does enable

TABLE I.—Radiation Records on a Radium Ward for a Period of Over Three Years (Doses in Milliroentgens per Thousand Milligram-hours of Radium Treatment)

Measurements Made in	Total Radiation received by Nursing Staff	Radiation received per Person		
		Sister	Staff Nurse	Junior Nurses
1958	213	22	32	29
1959	187	12	25	21
1960	161	13	15	16
1961	78	7	14	10

*Now at King's College Hospital, London.

comparisons to be made between radiation protection methods in spite of wide variations in the amount and type of radium nursing in this ward.

Fig. 1.—Total radiation received by the ward nursing staff.

Fig. 2.—Average radiation dose per person.

Reduction of Radiation Hazard

The use of work-study techniques was considered for analysing the ways in which radiation is received, and a start was made using the self-observation method. A report sheet was drafted which enabled each nurse, after a visit to a radium patient, to record the purpose and duration of the visit. Occasional unobtrusive observation has confirmed the general accuracy of the times recorded. When such a report sheet is summarized and compared with the doses received, it is often possible to assess which procedures are more associated with radiation hazards. An example of such an analysis is given in Table II. This related to a patient under treatment for carcinoma of the uterine cervix with 45 mg. of intracavity radium for 96 hours. She was seriously ill, and needed almost constant nursing and medical attention; in fact, she died 48 hours after treatment ended. Table II also includes the film badge doses recorded by each nurse at two positions—at the breast-pocket level and on the waist-band. The latter is at a level which is well shielded by the lead screens used

TABLE II.—Time Spent During Nursing Procedures on Patient A, in Minutes Per Person, During a 96-hour Treatment

Procedure	Sis-ter*	Staff Nurse	Junior Day Nurses					Night Nurses		Total
			A	B	C	D	E	F	G	
Bed-making ..	—	28	56	14	—	6	45	20	25	194
Temperature, pulse, respiration ..	—	—	10	6	—	—	4	25	2	47
Washing ..	—	—	5	5	5	—	5	—	40	60
Urine drainage ..	30	30	10	17	5	1	—	35	25	153
Water, meals ..	—	—	—	9	6	11	22	20	15	83
Pressure areas ..	—	—	—	5	—	14	—	5	20	44
Post-operative recovery ..	—	—	30	—	—	—	—	—	—	30
Radiography ..	—	—	10	—	—	—	—	—	—	10
Vomiting ..	—	15	10	—	10	4	—	—	—	39
Setting up drip ..	—	15	60	—	25	—	—	—	—	100
Removal of radium ..	—	20	—	—	—	—	—	—	—	20
Social ..	10	25	—	—	—	7	—	—	—	42
Total ..	40	133	191	56	51	43	76	105	127	822
Dose (mr) at top pocket ..	50	100	140	40	20	†	50	40	60	
„ „ waist ..	<20	<20	<20	<20	0	†	<20	<20	<20	

* During this treatment sister was off-duty for 2½ days.

† Film badges not returned.

(see below), while the former will be shielded much less, if at all.

A similar analysis is shown in Table III relating to a different patient. She was under treatment for only 60 hours with 65 mg. of radium, requiring only the minimum of nursing attention. This is reflected not only in the shorter nursing times but also in the lower doses recorded.

TABLE III.—Time Spent During Nursing Procedures on Patient B, in Minutes Per Person, During a 60-hour Treatment

Procedure	Sister	Staff Nurse*	Junior Day Nurses					Night Nurses		Total
			J	K	L	M	N	O	P	
Bed-making ..	—	—	3	10	—	5	—	3	3	24
Temperature, pulse, respiration ..	10	—	—	—	—	—	—	10	3	23
Washing and pressure areas ..	—	—	10	5	5	5	—	5	10	40
Urine drainage ..	35	—	10	20	10	—	5	20	20	80
Water, meals ..	—	—	—	—	—	—	3	10	10	63
Post-operative recovery ..	—	—	30	—	—	—	—	—	—	30
Radiography ..	—	—	—	—	—	—	10	—	—	10
Vomiting ..	—	—	—	15	—	—	—	15	5	35
Removal of radium ..	—	—	—	—	—	—	—	20	—	20
Blood-pressure ..	—	10	—	—	—	—	—	10	10	30
Total ..	45	10	53	50	15	10	18	93	61	355
Doses (mr) at level of top pocket ..	70	<20	<20	90	<20	40	<20	30	<20	

* During the treatment staff nurse was off duty for 1 day.

The following steps, put into operation gradually over the period studied, have been responsible for the reductions noted in radiation hazards.

(a) Where practicable, anaesthetics are used which result in a short post-operative recovery time.

(b) Radiographic localization used to be carried out in the x-ray department, involving a nurse and a porter accompanying the patient there and back. The radiation exposure has been reduced by carrying out this procedure in the ward, and although the films are not of comparable quality they are adequate. Ideally, of course, the patient should be radiographed as she leaves the theatre, and we hope this can be arranged in the future.

(c) Radiation exposure while actually nursing the patient can be greatly reduced by the use of mobile lead screens, as proposed by Englander (1959), Ellis (1961), and others. We have designed screens (Fig. 3) to carry "formica"—

covered lead screening $\frac{1}{2}$ -in. (2 cm.) thick, 1 ft. (30 cm.) high, and 3 ft. (90 cm.) long, the centre portion being thickened to 2 in. (5 cm.). Dimensions were chosen which would protect the average nurse from thigh to thorax while carrying out her nursing procedures. There is no doubt that this is the time when such protection is most needed.

FIG. 3.—Mobile lead screen in position.

(d) It has been necessary to impress on junior student nurses that speed is essential when they are close to the patient. It is now intended that some such instruction shall be included in a lecture on radiation hazards in the course at the preliminary training school.

(e) A Foley catheter is normally used with continuous drainage. The collecting-bottle needs to be emptied only at midday and midnight, and is fixed to the side of the bed with a specially made quick-release mechanism.

(f) The positioning of the patient in the ward has been found to be of importance (Fig. 4). It is usually convenient for a patient confined to bed and likely to require special attention to be nursed near sister's desk or near the door, but either of these involves avoidable exposure to radiation. Further, exposure is received by the nursing staff if a radium patient is next to a patient undergoing other treatment requiring constant attention. Again, a patient in the next bed may receive a dose of 1 or 2 r during a treatment. Such a dose is probably of little consequence, but efforts are made to avoid administering even this to a young woman, especially if pregnant. With these points in mind, it is now usual to nurse a radium patient in either bed 5 or 6 (see Fig. 4), and where possible to nurse in adjacent beds patients who are ambulant. Two radium patients may be nursed simultaneously in beds 5 and 6, but it is then essential to use lead screens to shield nurses when they are between the two beds.

(g) When radium patients are allowed only restricted movement in bed, their food must be cut up for them, and this is now done at the serving trolley rather than at the

bedside. At one time it was usual to nurse a radium patient in bed 10, mainly because at that time urine was drained intermittently, and nursing a patient in this bed enabled this to be done at night with little disturbance of the other patients. Unfortunately, the electricity socket for the ward food trolley is situated close to bed 10, so that during the serving of lunch and supper the nurse in charge had to stand near the radium for about three-quarters of an hour, and the other nurses were passing close to it.

(h) So far as is possible, patients are encouraged to carry out their own toilet. Since a radium treatment rarely lasts longer than four days, it is now the practice to bath the patient shortly before insertion of radium, and again immediately after removal, rather than to give the usual one blanket bath a day. If necessary, a single blanket bath is given during the treatment.

(i) The ward sister is responsible for some teaching of the student nurses, and the provision of a separate office now enables this to be carried out outside the ward altogether.

(j) It is natural that a "lonely" patient is sometimes befriended by a particular nurse. One such patient was elderly and virtually friendless, never having visitors, but during four days of radium treatment a nurse who befriended her received a dose of over 1,000 mr. It is important for nurses to realize that during radium treatment only a limited time may be spent at the bed, and this should only be used for carrying out essential nursing procedures.

(k) As has been pointed out by Leetz *et al.* (1958), Zeitz and Zolg (1960), and Ellis (1961), radiation intensity is higher at the side of the patient's bed than at the ends, and is lower at the head than at the foot. If the bed is arranged so that the head is towards the centre of the ward and the feet to the wall the radiation in the middle of the ward is reduced. In addition, many of the visits of a nurse to a patient require her to approach the patient's head. In the usual position this involves passing the radium twice, but when the bed is reversed it is avoided altogether. Clearly, this is not always possible or desirable, but some such arrangement can be of great advantage.

Conclusion

The radiation hazards of a radium ward, which may well be appreciable, cannot be controlled as they would be in a laboratory or factory. The study reported here shows one approach which can reduce the hazard substantially by careful observation of detail.

The points indicated are of particular relevance to the ward studied, although it is hoped that they and the methods used can guide others faced with similar problems. The results obtained will also be of assistance in safeguarding from radiation during the nursing of patients undergoing radioisotope therapy, although we find the external gamma-ray hazard here is of much less importance.

The special equipment used was modest in cost—materials costing less than £50. To have made it commercially might well have cost between £250 and £300.

Summary

One of the most intractable difficulties arising in a hospital is the adequate protection of nursing staff in a radium ward, particularly a gynaecological radium ward.

The radiation received by such nurses has been reduced to 30% of its previous level without detriment to the quality of the nursing care following an elementary application of work-study techniques. The time which nurses spend close to the patient has been reduced—for example, by using anaesthetics with a short recovery time, by avoiding transport of the patient

FIG. 4.—Layout of ward.

to the x-ray department, and by careful positioning of the bed in the ward. In addition, mobile lead screens have been designed which can give adequate protection to the nurses even while close to the patient during such nursing procedures as bed-making.

It is concluded that similar careful observation of detail could be used with advantage in other radiation protection work.

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made some hundreds of film-badge measurements; and Messrs. R. G. Burrows, D. T. Goodchild, and B. P. Danbury constructed many items of special equipment.

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ADRENAL HAEMORRHAGE AFTER OPEN HEART SURGERY

A REPORT OF TWO CASES

BY

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Acute post-operative adrenal insufficiency is a recognized hazard in patients suffering from Addison's disease or having corticosteroid therapy. Very rarely it follows adrenal haemorrhage, but a search of the literature has failed to reveal a report of this condition after open heart surgery. This paper describes two cases.

Case 1

An 11-year-old boy was admitted to hospital for repair of a ventricular septal defect. He had no symptoms apart from mild breathlessness on exertion since birth.

The defect was repaired with a free pericardial graft. Combined cardiopulmonary bypass with hypothermia, using the Melrose machine, lasted 90 minutes, including 64 minutes of complete bypass. The nasopharyngeal temperature fell to 30° C. The heart was further cooled to 18° C. by surrounding it with ice-slush. The systemic blood-pressure never fell below 80 mm. Hg. Heparin (2 mg./kg. body weight) was neutralized by hexadimethrine bromide ("polybrene") (4 mg./kg. body weight).

At the end of the operation he was conscious and rational, and his circulatory and respiratory state was satisfactory. On return to the ward he was nursed in an oxygen tent. Sixteen hours later he suddenly complained of feeling cold and started shivering. His oral temperature had been about 100.5° F. (38.1° C.), and, since a slight pyrexia is not uncommon after cardiopulmonary bypass, no special significance was attached to its presence on this occasion. It now rose rapidly to 105.5° F. (40.8° C.) and remained at this level despite attempts to cool him. Simultaneously his pulse rate steadily increased from 120 to 160 a minute, and his respiratory rate from 25 to 30 a minute.

Two hours later his blood-pressure fell abruptly from 140/100 to 110/70 and progressively declined over the next four hours to a systolic level of 60 mm. Hg. An intravenous infusion of metaraminol bitartrate ("aramine") was started at this point, but the systolic blood-pressure rose to only 70 mm. Hg. Mephentermine sulphate ("mephine") had no effect. Hydrocortisone hemisuccinate, 100 mg., was given intravenously as an empirical measure, also without effect. The total post-operative blood loss was 350 ml., and this had been replaced. There was no evidence of internal

haemorrhage. Intravenous chloramphenicol was given after blood had been taken for bacteriological culture. This subsequently proved negative. The remainder of the transfusion blood was not cultured, but none had been given for four hours before the onset of symptoms.

Marked generalized cyanosis appeared. His limbs became very cold despite his high temperature. An arterial blood sample showed normal oxygen saturation with a marked metabolic acidosis and compensatory respiratory alkalosis (oxygen saturation 93%; pH 7.35; pCO₂ 29 mm. Hg; bicarbonate 15 mEq/litre). The acidosis was probably due to his low cardiac output. A blood count taken before the administration of hydrocortisone showed: haemoglobin, 93%; total white cells, 1,700 (neutrophils 50%, eosinophils 1%, lymphocytes 47%, monocytes 2%).

His condition steadily deteriorated and he became comatose. There was increasing respiratory distress, with a waxing and waning pattern of respiration. Artificial ventilation was started when he suddenly stopped breathing. He died 24 hours after the end of the operation, eight hours after the first onset of symptoms.

At necropsy there was intense congestion of the zona fasciculata of both adrenal glands, with areas of haemorrhagic destruction in the left one. The pituitary and other endocrine glands were normal. There were no other significant findings.

Case 2

A 45-year-old woman was admitted to hospital for correction of an atrial septal defect and total anomalous pulmonary venous drainage. She had steadily deteriorated for the previous four years, and required pre-operative treatment for heart failure.

The lesion was corrected under combined cardiopulmonary bypass and hypothermia, using the Melrose machine. This lasted 132 minutes, including 105 minutes of complete bypass. The nasopharyngeal temperature fell to 20° C. The flow rate was reduced to a minimum during the hypothermia. Heparin and hexadimethrine bromide were used in the same dosage as in Case 1.

Her circulatory and respiratory state at the end of the operation was satisfactory and she regained consciousness in the operating-theatre. Twelve hours after her return to