HDS/DRM

704471

Reprint from

"PERSONNEL DOSIMETRY
FOR RADIATION ACCIDENTS"

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 1965

REPOSITORY DOE - FORRESTAL
COLLECTION MARKEY FILES
BOX No. 3 of 6
FOLDER ACCIDENT FILE #1

1004265

THE IMPORTANCE OF DOSIMETRY TO THE MEDICAL MANAGEMENT OF PERSONS ACCIDENTALLY EXPOSED TO HIGH LEVELS OF RADIATION

G.A. ANDREWS, J.A. AUXIER* AND C.C. LUSHBAUGH
MEDICAL DIVISION, OAK RIDGE INSTITUTE OF NUCLEAR STUDIES
AND
*HEALTH PHYSICS DIVISION, OAK RIDGE NATIONAL LABORATORY,
OAK RIDGE, TENN., UNITED STATES OF AMERICA

Abstract — Résumé — Аннотация — Resumen

THE IMPORTANCE OF DOSIMETRY TO THE MEDICAL MANAGEMENT OF PERSONS ACCIDENTALLY EXPOSED TO HIGH LEVELS OF RADIATION. Radiation accidents continue to occur sporadically and it appears that there is no hope of eliminating them entirely. The management of patients exposed to large doses of radiation is constantly improving because of increasing ability to prevent and treat infection and to control haemorrhage. The possible effectiveness of temporary bone marrow grafts offers promise of a further reduction in mortality. The use of this growing biological information is closely related to, and to a large extent dependent upon, improvements in physical dosimetry for radiation accidents.

LE ROLE DE LA DOSIMÉTRIE DANS LES SOINS MÉDICAUX A DONNER AUX PERSONNES ACCIDENTELLEMENT EXPOSÉES A DE FORTES DOSES DE RAYONNEMENT. Des accidents provoqués par les rayonnements continuent à se produire de temps à autre et il ne semble guère que l'on puisse espérer les éliminer entièrement. Toutefois, le traitement des sujets exposés à de fortes doses de rayonnement ne cesse de s'améliorer; on parvient, en effet, dans une mesure croissante à empêcher et à traiter l'infection ainsi qu'à arrêter l'hémorragie. Comme la greffe temporaire de la moelle des os semble devoir donner des résultats, on peut s'attendre à une nouvelle réduction du taux de mortalité. L'application de ces connaissances biologiques sans cesse accrues est fonction, dans une large mesure, des améliorations apportées à la dosimétrie physique des accidents nucléaires.

ЗНАЧЕНИЕ ДОЗИМЕТРИИ ДЛЯ ОКАЗАНИЯ МЕДИЦИНСКОЙ ПОМОЩИ СЛУЧАЙНО ПОДВЕРГШИМСЯ ОБЛУЧЕНИЮ БОЛЬШИМИ ДОЗАМИ. Радиационные аварии все еще иногда происходят, и, кажется, нет надежды избавиться от них совсем. Методы оказания помощи лицам, подвергшимся облучению большими дозами, постоянно улучшаются благодаря все большим возможностям предотвращения и борьбы с инфекцией, а также предотвращения кровотечения. Возможная эффективность временной пересадки костного мозга открывает перспективы для снижения смертности. Использование этого возрастающего количества биологической информации тесно связано и зависит в большой степени от улучшения физической дозиметрии на случай радиационных аварий.

IMPORTANCIA DE LA DOSIMETRIA PARA EL TRATAMIENTO MEDICO DE LAS PERSONAS ACCIDENTALMENTE EXPUESTAS A DOSIS ELEVADAS DE RADIACIONES. De vez en cuando se siguen produciendo accidentes de irradiación y las perspectivas de evitarlos por completo parecen ser bastante remotas. El tratamiento de las víctimas expuestas a dosis elevadas de radiaciones mejora constantemente debido a la creciente posibilidad de prevenir y tratar las infecciones, y de controlar las hemorragias. También es posible que la eficacia de los injertos temporales de médula ósea se traduzca en una disminución de la mortalidad. El aprovechamiento de estos conocimientos biológicos cada vez más amplios guarda una estrecha relación con los perfeccionamientos en materia de dosimetría física en caso de accidentes de irradiación.

1004266

1. INTRODUCTION

In view of the many persons who have worked among the hazards of the atomic energy industry since 1940, surprisingly small numbers have been killed or seriously injured in radiation accidents. The accidents that have occurred have received a great deal of publicity and study. Perhaps this attention is partly due to general apprehensiveness about radiation effects and the widespread concern that has been expressed about low-dose occupational and environmental exposures. In the radiation accidents, the effects of exposure are clearly demonstrable and no statistician is needed to determine that injury has been sustained. Those of us who are greatly interested in radiation effects are pleased that there is this strong support of the study of radiation accidents. If the effort seems out of proportion to the seriousness of the problem, it can be justified on the basis of the increasing use of nuclear energy with attendant possibilities for accidents and on the basis of the wide usefulness of the biologic information derived, for radiation injury involves phenomena applicable to other biologic problems.

For the purposes of this discussion we shall concentrate on acute penetrating total-body irradiation received from an external source. The responses to this type of exposure can be taken as the prototype for most types of acute radiation effect, including those caused by internal radioisotopes of short effective half-life. External exposures to radiations of very low penetrating ability present special problems with skin effects out of proportion to haematopoietic or gastro-intestinal damage. Similarly, uneven exposures of various parts of the body to penetrating radiations may alter the response and make dosage determination difficult if not impossible. A certain amount of non-uniformity is the rule and the degree of non-uniformity at which the reliability of the dosimetry or specific biological response must be partially discounted will be a matter of subjective judgement for the clinician.

Accidental exposure to internal radioisotopes may be of several different types, involving inhalation, ingestion, injection, or wound contamination; here the dosimetry problems include identification of the radioisotope and determination of the amount and distribution in the body. For gamma-emitting isotopes, whole-body counters are extremely useful; for those without gamma emissions, determinations of body burdens may depend largely on levels in the urine or expired air, and their estimation may be extremely difficult and unsatisfactory. The problem of plutonium in wounds is an especially knotty one and will be discussed in a later paper in this programme. Other specific forms of radiation hazard present their own peculiar dosimetry problems and several of these will be discussed by later speakers.

2. EXPERIENCE AT THE 1958 OAK RIDGE ACCIDENT

In June 1958 there was a serious radiation accident in Oak Ridge. This accident may be informative to consider, particularly in the light of dosimetric considerations as they relate to clinical management. In 1958 there

1004267

TABLE I

PHYSICAL DOSIMETRY AVAILABLE AT VARIOUS TIMES AFTER THE OAK RIDGE ACCIDENT OF 1958

Time after accident	Dose estimates
13 h	320 to 706 rem "Probably not less than half these figures; possibly higher."
3 d*	163 to 276 rad 201 to 320 rem
Weeks later	236 to 365 rad

* Day-3 estimates were made by two separate groups of health physicists.

had not been recent serious accidents and our most vivid memory was of the fatal Los Alamos accident of 1946.

In the Oak Ridge accident, some enriched uranium was inadvertently allowed to flow into a large container and criticality occurred. Five men received high doses of gamma and neutron radiation, and three others received lower doses. The accident occurred at two p.m. There was no surface contamination. As a dosimeter, each man was wearing only a small piece of indium foil. All five of the men who received high doses experienced nausea and four vomited. Blood was obtained for Na^{24} assay and an attempt was made to assay the men in a whole-body counter, but there was so much induced radioactivity that the electronics were overloaded and the counts obtained were not satisfactory. The men were admitted to the ORINS Medical Division hospital at 11.00 p.m. The clinical staff had not been informed of the accident until shortly before the patients arrived at the hospital.

The information available on dosage measurements for the five most heavily exposed is summarized in Table I. This illustrates the early uncertainty about doses; however, it should be pointed out that, as compared with other accidents, the early estimates were much more accurate than are usually made.

The patients had a favourable clinical course after nausea and vomiting ceased. On June 19, the third day after the accident, we felt that a crucial decision had to be made about whether or not to use bone-marrow grafts. Table II shows the status of our information at that time. The two sets of doses given came from two separate groups of health physicists working on the problem; one chose to report in rads and one in rems, but the difference in units is not the only basis for the differences in the two sets of figures. We do not know the factor for relative biologic effectiveness of neutrons used

1004268

TABLE II

DATA ON ESTIMATED PHYSICAL DOSE, BLOOD CHANGES, AND CLINICAL FINDINGS USED FOR CLINICAL PLANNING 3 DAYS AFTER THE OAK RIDGE ACCIDENT OF 1958

Patient	Dose estimates				Haematologic changes (Rank order)*	Clinical course (Rank order)*
	Group 1		Group 2			
	(rad)	Rank order*	(rem)	Rank order*		
A	276	1	320	1	1	1
B	188	4	256	4	3	3
C	230	3	292	2	4	5
D	239	2	272	3	5	4
E	163	5	201	5	2	2

*Rank order: 1 - most severe; 5 - least severe

to derive the values in rems. In deciding about the use of bone-marrow grafts we also put considerable weight on the clinical and haematologic values. Our estimate then was that without marrow grafts patients B, C, and D had an excellent chance for survival, and patients A and E had at least a 50% chance. We considered giving grafts to all the patients, giving them only to patients A and E, or giving them to none. A decision was made to give no marrow. We had considerable confidence in the physical dose values available at that time and they were one basis for the decision. At that time we were under the impression – with which we would not now agree – that the marrow would have to be given very early to be of any possible value.

The patients were treated with very little medication. No blood transfusions were given. Two of them showed a rather alarming degree of haematologic depression in the fifth week after exposure, but all recovered spontaneously.

3. CLINICAL MANIFESTATIONS OF RADIATION INJURY

The effects depend very largely on dose. Although much emphasis has been placed on variations in sensitivity from person to person, there is no reason to believe that this individual variation is greater for radiation than it is for other types of injury, and, in fact, one is impressed by the relative uniformity of response.

Figure 1 illustrates the type of response expected at the different dose levels. This information is largely extrapolated from work on experimental

1004269

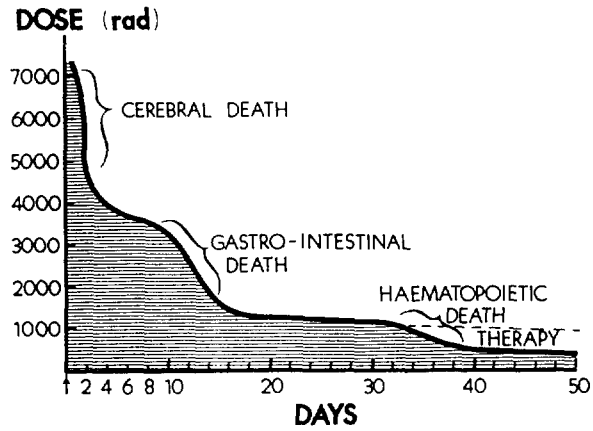

Fig. 1

Graph indicating length of survival and mode of death after various doses of total-body irradiation
The broken line suggests the improvement in survival that can be achieved with therapy.

animals and may not be entirely correct for the human being, but it is helpful in illustrating some very general facts. Depending on the radiation dose received, the exposed person may show the major injury expressed in the nervous system, the gastro-intestinal tract, or in the haematopoietic tissues.

Very high doses, manifested mainly by neurological damage, have not been experienced by human beings under conditions that would allow clear interpretation. The Los Alamos accident in 1958 and the recent Rhode Island accident in 1964 involved doses at these levels and there was believed to be clinical evidence of neurologic damage, but this was complicated by direct damage to the heart and by cardiovascular failure in both patients, and damage to nervous tissue was not confirmed at autopsy.

Similarly, a typical picture of gastro-intestinal damage has not been seen in the human being; one of the early Los Alamos patients approximated it. The picture is characterized by severe and persistent nausea and vomiting associated with death of the cells lining the intestinal tract, leading to severe loss of body fluids and infection along the intestinal tract. Experience in clinical total-body irradiation for purposes of marrow grafts suggests that the human being may have a high threshold for gastro-intestinal damage.

The clinical situation produced by dose levels that damage primarily the haematopoietic system is of much greater importance because experience has shown that many more persons are injured at these dose levels. Furthermore, effective treatment is available, while for neurological and gastro-intestinal damage no known treatment can prevent death. Figures 2, 3, 4 and 5 portray typical haematologic responses to different doses. That there is so long an interval between exposure and the occurrence of maximal haematopoietic depression is particularly interesting.

1004270

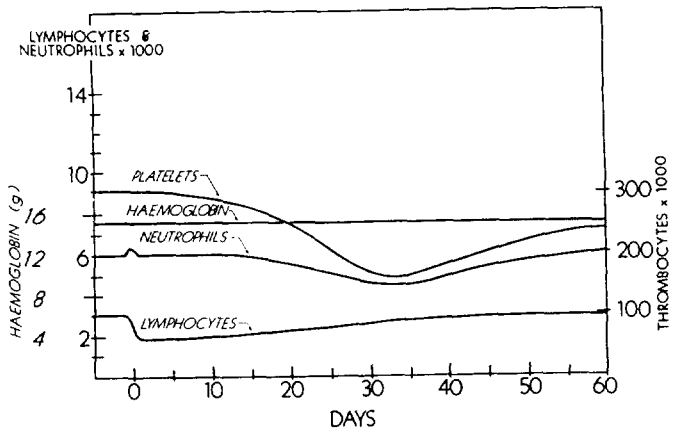

Fig. 2

Typical haematological response after 100 rad

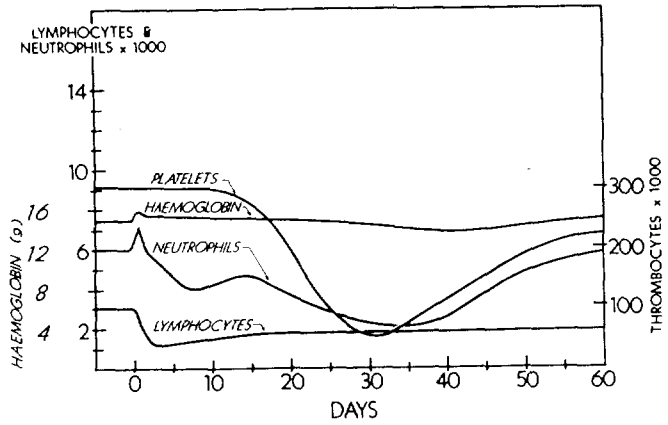

Fig. 3

Typical haematological response after 200 rad

4. TREATMENT

Effective therapy is available for management of patients exposed in the LD50 range, but little can be done for those who have received doses in the supralethal range. For neurologic manifestations there are only purely symptomatic measures – the use of drugs for sedation and the control of convulsions. For the severe gastro-intestinal syndrome, fluid and electrolytes lost should be replaced and efforts can be made to control invasion by enteric bacteria; but if the damage to the mucosa of the intestine is severe, these measures will be of no avail.

1004271

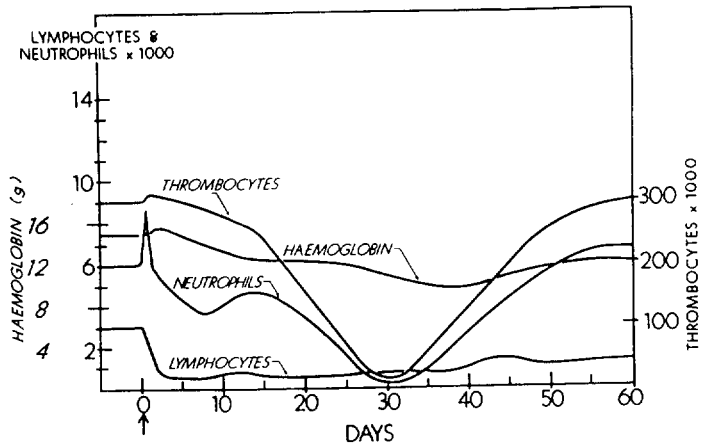

Fig. 4

Typical haematological response after 300 rad

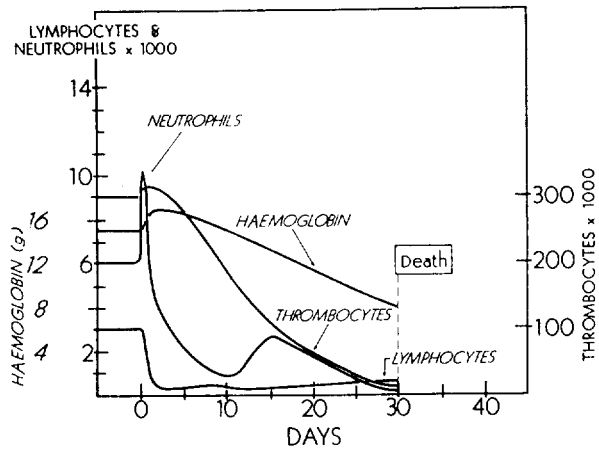

Fig. 5

Typical haematological response after 450 rad

It is at the lower doses, 200 to 1000 rad, that more is known of therapeutic management. Measures and the indications for them can be outlined as follows:

(1) Rest: Unusual exertion is believed to enhance the damaging effects of radiation.

(2) Sedation: This may be needed to control apprehension and vomiting. However, the early use of sedatives may suppress vomiting, and thus obscure a valuable biologic dosimeter.

(3) Maintenance of fluid and nutritional requirements: This is self-evident.

(4) Prevention of infection: An attempt should be made to place the patient

1004272

in an environment as near infection-free as possible. Base-line cultures of nose, throat, stool and urine for pathogenic organisms should be obtained. Judicious attempts are needed to clear up existing sites of infection before severe leukopenia is reached. Prophylactic use of antibacterial agents is probably not indicated simply on the basis of leukopenia. However, in the presence of severe leukopenia, prophylactic use of nystatin to prevent Candida infections is probably well worth while.

(5) Therapy of infection: Once the presence of infection is known or strongly suspected on the basis of fever, thorough efforts should be made to identify the organism. However, it may be necessary to start antibiotic therapy before cultures are reported if the clinical course is unfavourable; the choice of drugs can later be altered on the basis of cultured reports and sensitivity findings. Gamma globulin may be of value in combating infections.

(6) Whole blood and platelet transfusions: These are mainly needed for bleeding. Unless there is significant anaemia, requiring whole blood replacement, concentrated fresh platelets are the most often desirable, and using very large quantities may be necessary. The need for platelets is gauged on the presence of clinical haemorrhagic phenomena, and to some extent on the patient's platelet count.

(7) Bone-marrow grafts: These are advisable in situations in which recovery is unlikely without them. Probably some patients can be saved by a temporary marrow graft. The marrow should probably be given some time later than the first two or three days after exposure, but before two weeks have elapsed. The decision to give the graft is based on biologic and dosimetric evidence that the exposure has been so high that recovery without this therapy is unlikely. Perhaps in the future large volumes of normal donor white cells will be available, and these may be an adequate or preferable substitute for bone marrow.

5. EARLY MANAGEMENT OF AN ACCIDENT

Certain points appear important to clinicians who have had experience with radiation accidents. In retrospect it is obvious that in all accidents important information has been lost in the excitement of the situation. It is desirable for someone to keep a very careful record of all pertinent events and the exact time that they occur.

If the accident victim has sustained associated trauma or radiation contamination on the external surface of the body, these are probably more in need of immediate attention than are the effects of the absorbed radiation dose. Clothing should be saved and carefully labelled to be studied for contamination and induced radioactivity. If the patient's body has external contamination, prompt efforts should be made to remove it; this may require shaving off contaminated hair. A whole-body counter is a valuable instrument in this situation for showing neutron-induced or surface radioactivity, or both, and the spectrum may help to make the differentiation. However, in all accidents in which neutron exposures are significant or in which there is sufficient contamination to represent a hazard, the activity will be sufficient to overload the sensitive electronics of low-level whole-body counters.

1004273

Therefore, it is wise to plan simple alterations, generally the installation of small crystals, which will enable early post-exposure evaluations to be made.

There is need to obtain early and repeated blood samples for haematologic tests, for measurements of induced radioactivity and for special biochemical tests. To use Na^{24} as an index of induced radioactivity, a sample of serum or plasma should be counted in a calibrated instrument, and at the same time a sample of serum should be measured for stable sodium. All urine excreted by the patient should be refrigerated and saved for biochemical tests. Samples of hair and nails, carefully identified as to location on the body, are also of value for determinations of induced radioactivity; these measurements may serve as the basis for neutron dosimetry and may be especially helpful in showing uneven doses to different parts of the body.

6. BIOLOGIC DOSIMETRY

The history of radiation accidents has shown that the physician has been justified in putting great reliance on biologic manifestations as early indices of dose. The presence of nausea and vomiting during the first few hours after exposure suggests that the dose has probably been more than 200 rad. Incidental or emotionally induced vomiting is always mentioned as a possibility, but in most radiation accidents it has not been a major cause of confusion. The absence of vomiting is strong evidence that the dose of radiation is less than a lethal one and throws serious doubts on the validity of dose estimates placed in the lethal range. Early diahorrhea is an ominous sign and suggests a lethal dose, as does the persistence of vomiting after the first 48 or 72 hours. Figure 6 shows correlation between dose and incidence of anoxia, nausea and vomiting in a series of patients exposed accidentally and therapeutically in Oak Ridge. The results at high doses are influenced by the use of medications that undoubtedly reduced the incidence of vomiting. The presence of erythema of large portions of the skin is a very ominous sign, although perhaps less so if the radiation is known to include a large low-energy component. Early neurologic signs and hypotension are, of course, indicative of a very high dose. Among laboratory tests, the absolute lymphocyte count appears to be of greatest value. Figures 7 and 8 give data on this. Increased amounts of beta-aminoisobutyric acid, taurine, and possibly creatine in the urine appear to be related to the dose, but these biochemical assays are not yet widely accepted for purposes of clinical dosimetry.

7. THE ROLE OF DOSAGE MEASUREMENTS

At the same time that the clinician is trying to assess the degree of injury to his patient by watching the clinical responses and laboratory tests, he is anxiously awaiting the results of the measurements reported by the health physicist. If preplanned dosimetry systems are in operation, this information may be quickly available; if not, many hours or even several

1004274

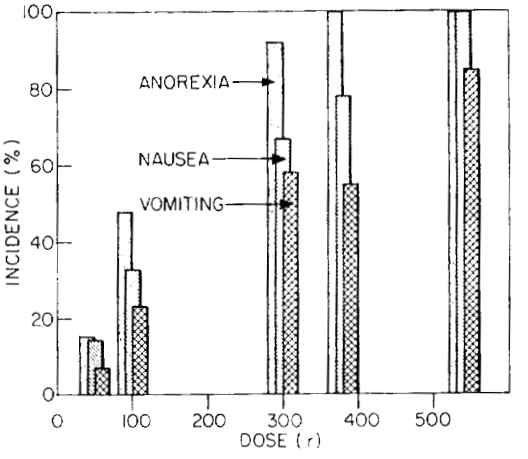

Fig. 6

Chart showing levels of radiation causing anorexia, nausea, and vomiting

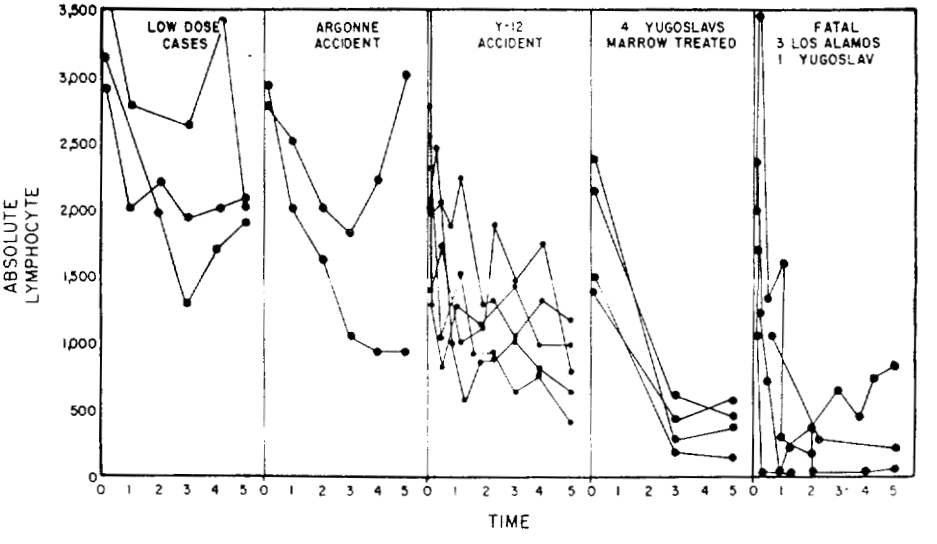

Fig. 7

Patterns in change of absolute lymphocyte count in radiation accidents

days may be needed to derive information by indirect means. In either situation it is now apparent that when neutron exposure is involved the most sensitive and reliable "detectors" are sodium and sulphur activation in the blood and hair respectively. Alone, these detectors serve largely as indicators of neutron exposure, rather than as dosimetric tools. However, in conjunction with other data, including the results of calculation of neutron and gamma-ray leakage spectra from similar assemblies, good approxi-

1004275

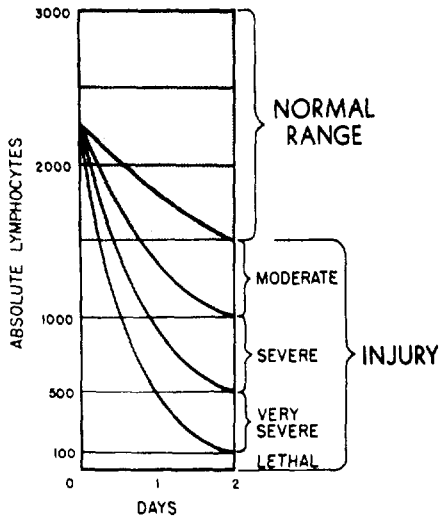

Fig. 8

Schematic relationships between lymphocyte levels and dose

mation of dose can be made quickly. Of course, where film badges and area monitoring systems are used, information on dose in radiation accidents can be derived from these along with the studies of induced radioactivity. It is reasonable to assume that at large nuclear installations, such as the Oak Ridge National Laboratory, at which both personnel and nuclear accident monitoring systems are utilized, estimates of the first-collision absorbed dose could be made with a precision of ± 25% within one to three hours post exposure, unless the exposure is grossly non-uniform. Sometimes a simulated repetition of the accident is required to establish certain facts needed for dose determination.

Although information on dose is needed as soon as it can possibly be obtained, an early grossly erroneous estimate (e.g. error greater than a factor of 2) is worse than none. Total dosage is not enough; such an estimate should include, as far as possible, information on the quality and depth-dose distribution of the radiation. Several papers to be presented here will deal with devices for measuring some characteristics of the radiation field from nuclear accidents. It is reasonable to assume that, if used, any or all would yield important data for computing "doses." However, we must keep in mind that the system used is no better than the capabilities of the men who use it and that having any system is no guarantee, a priori, that good estimates will be obtained from it. Consequently, all sources of information available at the time of an accident should be used.

There are three main clinical uses for information on dose:

(1) After the initial needs of the post-accident situation have been met, dosage figures give some help in appraising the magnitude of the clinical problem, what special hospital, consultant, and supportive facilities may be needed, and how the outlook can best be described to those concerned.

1004276

(2) During the later, most important period of clinical management of irradiated patients, while the clinician will wish to rely mainly on detectable biologic responses of patients to determine therapy, he will also be assisted by physical dose data, especially in atypical or borderline clinical situations.

The physical dosimetry projects the probabilities for future clinical developments; the scientific basis for physical dosimetry is constantly improving. The clinician can thus make prognoses with greater accuracy than he can on the basis of day-to-day clinical manifestations. For example, when the dosimetry for the Y-12 accident in Oak Ridge was established, the relatively reassuring values were a major factor in the decision not to give marrow infusions.

(3) More information on radiation effects in man is greatly needed. Clinical total-body irradiation therapy may have excellent dosimetry, but the results are biased by the underlying disease being treated. Radiation accidents, unfortunate as they are, are the best source of information on radiation responses of the normal person. If the patient recovers, extensive clinical and laboratory observations will be available. If the patient dies, autopsy will allow many observations on radiation effects that can be correlated with clinical and laboratory findings. However, none of this information derived from accidents will be of much value in improving our knowledge of the radiosensitivity of man without accurate radiation dosimetry.

DISCUSSION

H. P. JAMMET (Chairman): Mr. Andrews' introductory address seems to me of particular value in view of his experience with one of the first accidents to be extensively studied, and his subsequent close attention to all those which have occurred anywhere in the world. His review has made it clear that the object of dosimetry in the case of accidents must be the injured person himself, and that its purpose is to provide a basis for making as accurate as possible a diagnosis, selecting therapeutic methods, and forecasting the course of the illness.

He has also pointed out the uncertainties involved in dosimetry, and the disagreements which may be apparent between the results of physical dosimetry and those of clinical examination. Far from being a ground for pessimism, such discrepancies are, in my view, rather a source of comfort on the scientific level, justifying as they so fully do the need for this Symposium and indicating the direction of the further effort necessary to obtain the reliable information without which, it must be said, the medical profession is often hard put to it to make the decisions it is inevitably called upon to make.

A further interesting point about Mr. Andrews' review is that he has demonstrated that - at any rate insofar as external radiation is concerned, though this may not be so true of internal contamination - we have the time not only to carry out immediate emergency dosimetry, but also to supplement and perfect it in the days following the accident, and thus to influence, one way or the other, subsequent decisions.

1004277

J.P. LOUTIT: I should like to question Dr. Andrews on his statement, under the heading "Bone-marrow grafts", that "Perhaps in the future large volumes of normal donor white cells will be available and these may be a... preferable substitute for bone marrow". In the experimental animal the immunological activity of lymphocytes for graft-versus-host reactions is greatest for peripheral blood lymphocytes, considerably less for lymph node lymphocytes, and least for bone marrow. If the same applies in man, should we not exercise caution with large volumes of peripheral blood leukocytes in order to avoid the complications of secondary graft-versus-host reactions? What evidence can Dr. Andrews adduce for his suggestion?

G.A. ANDREWS: What I have in mind is that repeated injections of functioning mature neutrophile granulocytes from healthy donors may prove to be the best treatment for profound leukopenia, and it may be possible to use this therapy without producing even a temporary haematopoietic graft. Dr. Emil Freireich and his associates at the National Institutes of Health in the United States have performed some interesting studies in children with acute leukaemia who had uncontrolled infections associated with severe marrow depression due to anti-leukaemic drug therapy. These patients were given large numbers of cells obtained from the blood of donors who had chronic granulocytic leukaemia. Many of the recipients experienced prompt and dramatic control of infections previously resistant to anti-microbial drug therapy. In a few of the recipients there was, surprisingly, a temporary haematopoietic homograft; in some patients this persisted as long as several weeks. There was no evidence of any immunological complication.

Of course, this is quite different from using normal white cells for radiation accident victims and we can only conjecture on the possibilities. The lack of immunological complications in the patients given leukaemic white cells might be explained by the relatively small number of lymphocytes present in these abnormal donors. One would be hesitant to use such donors for radiation accident patients because of the remote possibility of producing persistent grafted leukaemia. Normal human leukocytes offer interesting possibilities, since new techniques may some day make them available in quantity. If so, they may be obtainable with less stress to the donor than bone marrow, and they will be easier to manipulate in vitro. Early, cautions trials in leukaemic patients should serve to delineate any possible hazards. Perhaps these cells will serve the desirable function of combatting infection without producing grafts. The experience with bone marrow has shown that grafts are not readily produced in human beings, in contrast with experimental animals. If normal leukocytes do produce grafts with immunological complications due to lymphocytes, these can perhaps be combatted by manipulating the donor to change the cell population, or by processing of the cells in vitro (centrifugal separation or selective cell damage by radiation).

H. SMITH: I have a comment on Dr. Andrews' paper. Even though the gastro-intestinal syndrome is not easily demonstrable in humans at a clinical level, sub-clinical changes can be detected. One of the primary reactions is that of a change in membrane permeability. We have observed in several patients that irradiation involving the abdomen at levels around 150 r can result in increased urinary excretion of indoxyl sulphate. This may therefore be of value in predicting the need for therapy, but I must emphasize that these are preliminary findings.

1004278

H.M. PARKER: In his oral presentation Dr. Andrews has spoken about the confusion to the physician of having more than one group of health physicists. Would he like to balance this by discussing the confusion to the patient of having more than one physician? Accidents of this type are so rare that experts descend on the patient from the entire country, and if unrestrained could leave very little patient after all the samples are taken. Could Dr. Andrews discuss how to control this?

G.A. ANDREWS: I agree. Each accident victim must have one physician, and not a group or committee of them. It is the duty of this physician to ensure control of testing, blood-letting and, in particular, the psychological environment of his patient.

G. COWPER: Dr. Andrews has drawn attention to cases of nausea following irradiation accidents when no significant exposure has occurred.

At the time of the NRX reactor accident in 1952, there was a building contractor on the site with a large number of employees. These workers were not involved in any way in the incident and received no exposure. They also had no training whatsoever in matters relating to irradiation and its effects. They could perhaps be considered typical of the population in general.

That evening a number of them appeared at the local hospital showing very impressive nausea. The relevance of this to us is that it throws light on the problem of dealing with an untrained population living in the vicinity of an installation which has an accident of such severity that a significant dispersal of radioactive substances occurs.

1004279