60-1

0237

AEROMEDICAL LIBRARY

AIR1.941130.011g

INITIAL CLINICAL REACTION TO THERAPEUTIC WHOLE BODY X-RADIATION SOME CIVIL DEFENSE CONSIDERATIONS

Volanti Subvenimus

60-1

SCHOOL OF AVIATION MEDICINE
USAF AEROSPACE MEDICAL CENTER (ATC)
BROOKS AIR FORCE BASE, TEXAS

AEROMEDICAL LIBRARY
SCHOOL OF AVIATION MEDICINE
UNITED STATES AIR FORCE
DOCUMENT

AD 231545

INITIAL CLINICAL REACTION TO THERAPEUTIC WHOLE-BODY X-RADIATION — SOME CIVIL DEFENSE CONSIDERATIONS

WILLIAM C. LEVIN, M. D.*
MARTIN SCHNEIDER, M. D.*
HERBERT B. GERSTNER, M. D.†

*University of Texas—Medical Branch
Galveston, Texas

†School of Aviation Medicine, USAF
Brooks Air Force Base, Texas

60-1

SCHOOL OF AVIATION MEDICINE
USAF AEROSPACE MEDICAL CENTER (ATC)
BROOKS AIR FORCE BASE, TEXAS
November 1959

7757-36

INITIAL CLINICAL REACTION TO THERAPEUTIC WHOLE-BODY X-RADIATION — SOME CIVIL DEFENSE CONSIDERATIONS

Early clinical events displayed, by 11 cancer patients after whole-body roentgen treatment in a single large dose are compared with previous reports on "radiation sickness" and with acute sequelae observed in nuclear accidents. From this comparison, the typical initial reaction to penetrating radiation in the several-hundred-roentgen range emerges as follows: signs and symptoms—essentially in form of fatigue, nausea, and vomiting—begin to develop within 2 to 4 hours after exposure; they reach a climax between 5 and 8 hours after exposure; and they subside on the second or third day. During the intense phase of the disturbance, extending from approximately 4 to 10 hours postexposure, about 60 percent of the irradiated persons experience disability of various degrees. Despite its transitory nature, the reaction may present a major medical problem in civil defense situations because of coincidence and, thereby, of interference with evacuation plans and first-aid procedures. Therefore, the early sequelae of exposure to penetrating radiation require the attention of all physicians who may have to manage such emergencies.

Medical application of Roentgen's discovery of the "x-rays" soon led to the observation that cancerocidal doses of the new agent frequently elicited an early systemic reaction characterized by dizziness, fatigue, anorexia, nausea, and vomiting. This clinical complex—termed *radiation sickness*—became an increasingly serious problem as greater intensity and penetration of therapeutic radiation became possible through the use of improved x-ray equipment (1-3). The radiotherapist then learned to minimize the irksome side effect by dividing the total dose into fractions delivered at intervals; size of each fraction and length of intervals between exposures were determined by the patient's disease and general condition. This procedure, together with closer restriction of radiation to the tissue volume intended for treatment, proved so effective that *radiation sickness* lost its significance for modern radiotherapy. Interest in the early clinical reaction, however, was revived with the advent of the atomic age. Ever-accelerating utilization of nuclear energy, for military and industrial purposes alike, created the hazard of deliberate or, to a much less degree, accidental disasters exposing large populations to significant amounts of penetrating radiation. Under these circumstances, the early clinical sequelae that constitute the initial reaction to such exposure no longer interest the radiotherapist exclusively, but concern all physicians who, in an emergency, may be confronted with radiation casualties. The atomic age also brought about the need for more precise terminology based on the time relationship between the various phases in the clinical response to penetrating radiation. To identify the early burst of signs and symptoms, the broad term *radiation sickness* should be replaced by the more explicit terms *initial reaction* or *prodromal reaction* (4-6).

Although seldom seen as a complication of modern routine therapy, the initial reaction still can be observed in the exceptional cases that require treatment with single high doses to the entire body (7). Observations on such patients merit particular interest because they represent the only human data for which type

Received for publication on 8 July 1959.

of radiation, dose distribution, and total dose are known with certainty; they are, therefore, indispensable for establishing correlations between physical parameters and clinical consequences of radiation. On the basis of 11 case histories, the present report describes the early radiation-induced response and evaluates its potential role in nuclear disasters.

METHOD

Previous studies (7, 8) had shown that whole-body irradiation might induce palliation, or even temporary remission, in cancer patients for whom more promising kinds of treatment are not available. Accordingly, the 11 patients selected for the present series suffered from malignant neoplasms that were so widely disseminated and so far advanced—predominantly stage-III lymphomas of various histologic types (table I)—that any other mode of management appeared hopeless. The antecedent clinical history varied; in most instances, records revealed futile attempts at controlling the disease either by local x-radiation, by steroid administration, or by chemotherapy.

Hospital admission preceded irradiation by at least one week; during this period, each patient was seen daily by the same resident physician who, in addition to the usual examinations, recorded activity, behavior, and mental attitude. Seven of the patients were in relatively good general condition; they had permission to walk freely about the ward and to participate in moderate physical activities. For the remaining 4, however, confinement to bed was necessary because of weakness, weight loss, and a tendency toward nausea and rising temperature. The 1-week adaptation phase was followed by the radiation treatment and then by a period of observation usually exceeding 10 days. At all times, even on the day of treatment, the initially established routine was maintained—examination by the same physician, normal meal schedule, and freedom of movement for ambulatory patients. Administration of radiation, as a rule, occurred during the interval between breakfast and lunch (table I); only occasionally, antiemetic treatment was indicated.

The radiation source was a conventional x-ray apparatus operated under the following conditions: 250 kvp; 30 ma.; filtration added to beryllium window of tube, 1 mm. aluminum and 0.5 mm. copper; half-value layer, 1.2 mm. copper; open portal; and distance from target

TABLE I

Survey of patients treated with whole-body x-radiation

Patient	Sex	Age (years)	Diagnosis	Nominal air dose (r)	Start of radiation; time of day
1	f	62	Hodgkin's disease	150	0915
2	m	57	Adenocarcinoma	150	1235
3	f	61	Hodgkin's disease	150	1115
4	m	39	Hodgkin's disease	150	0930
5	m	69	Giant follicle lymphoma	150	1200
6	f	15	Ewing's sarcoma	150	1310
7	m	5	Acute lymphocytic leukemia	150	0930
8	m	48	Carcinoma of kidney	200	1010
9	m	13	Malignant lymphoma	200	0900
10	m	25	Lymphosarcoma	200	0930
11	m	52	Malignant lymphoma	200	0900

f: Female.
m: Male.

to mid-coronal plane of the patient, 200 cm. At that distance, the dose rate in air averaged 9 r per minute. Multiplication of this value by exposure time yielded the *nominal air dose* (9) that was adopted for dosimetry throughout this analysis. As verified by radiographic check-films, the entire body remained well within the primary beam directed horizontally toward the patient who, with hips and knees flexed, lay on his side upon a treatment table; half of the prescribed dose was given with the patient facing the x-ray machine and the rest was directed toward the patient's back. In this manner, whole-body doses of either 150 r or 200 r (table I) were administered during a single session of approximately 20 minutes for 150 r, and 25 minutes for 200 r.

RESULTS

As its most striking feature, the initial reaction displays wide variability among persons exposed to similar, or even identical, doses. Corroborating previous findings (7), reactions observed in the present series ranged from complete absence of symptoms to severe prostration. This dramatic individual difference of unknown origin, together with the difficulty of assessing complications possibly caused by the preradiation disease, renders the 11 patients too small a group for establishing a typical clinical picture. Yet, when present findings are compared with previous reports on early consequences of both therapeutic (7) and accidental (5) whole-body exposure, the characteristic initial reaction emerges with reasonable accuracy (10).

Typical clinical picture

Throughout the time of exposure, radiation induces no sensations, and the patient remains completely asymptomatic. After treatment is completed, this freedom from symptoms continues for an hour or so — the "delay period" (10). Then, rather abruptly, the reaction starts with the onset of fatigue, listlessness, and apathy. Usual activities are discontinued; lying on his bed, the patient withdraws more and more from his environment and appears depressed. Not infrequently, he describes his condition as "washed-out" or "worn-out," and complains about dizziness, dullness, and headache. This "fatigue complex" (11), as a rule, is accompanied by concurrently developing signs and symptoms related to the gastrointestinal tract. Loss of appetite and complaints about an "upset stomach" suddenly appear about 2 hours postexposure. Nausea, frequently associated with spells of frank vomiting, soon supervenes and increases in intensity until it reaches a climax between 5 and 8 hours postirradiation. At that time, the combination of "fatigue complex" and "vomiting complex" occasionally lead to pronounced weakness or even prostration. After the climax is passed, the reaction steadily recedes; intervals between bouts of vomiting lengthen, and emeses decrease in number as well as in volume until they disappear completely. Nausea, anorexia, and fatigue then subside in that order. Owing to gradual ebbing of the succession of exacerbations and remissions, duration of the initial reaction cannot be defined accurately; yet, the usual course is as follows: on the second day, moderate nausea and occasional spells of vomiting persist but the general condition is markedly improved; on the third day, the patient becomes asymptomatic.

Special observations

To fathom its potential impact upon populations engulfed by nuclear disasters, the initial reaction demands special analysis from two aspects—length of delay time and extent of disability (12). Length of delay time is important because the interval between radiation exposure and onset of clinical symptoms represents the period during which an exposed group remains physically fit and mentally alert—as is necessary for individuals who must actively participate in the evacuation of disaster areas. Extent of disability is of significance when evacuation cannot be executed or completed within the delay time; the initial reaction, then unfolding among members of the afflicted population, will impair capability for active participation in escape, rescue, and other emergency efforts. Again, for a reasonably accurate assessment of these two

important factors, the present findings are insufficient and must be supplemented by previous data (7, 13).

The delay time is known most reliably for patients who experience reactions leading to vomiting. Since it occurs shortly after onset of symptoms, the first emesis strikingly and dependably marks the beginning of the initial reaction and, thereby, marks the end of the delay period. The characteristic duration of this period is revealed by comparing the following sets of evidence (see table II): first, the present findings; second, a part of the M. D. Anderson results (7)—out of 30 patients exposed to 200 r, observations are presented only for those who vomited during the first 24 hours after treatment; and third, data reported for the Y-12 accident (13). The table demonstrates three main points: (a) when vomiting develops at all during the day of exposure, the initial emesis consistently occurs from 1 to 5 hours postradiation; (b) in the several-hundred-roentgen range, length of the delay period is barely affected by dose; and (c) agreement between therapy and accident data suggests irrelevance of radiation type (roentgen, gamma, neutron, or any mixture of these penetrating rays). Validity of the three points has been established by a comprehensive analysis covering additional studies on treatment and all known nuclear accidents (10). Hence, it must be anticipated that a population exposed in the several-hundred-roentgen range will remain completely asymptomatic for 1 hour, and will experience a negligible incidence of initial reactions during the ensuing hour. Consequently, for all practical purposes, the 2-hour time limit represents the delay period applicable to a large group of persons because, after this period of time, prodromal reactions sharply increase in incidence and reach a maximum between the fourth and fifth hours postexposure. Occasionally, vomiting may start on the second or even the third day, as has been reported for all groups—radiotherapy patients, individuals involved in nuclear accidents, and Japanese bomb casualties. These rare atypically timed manifestations probably can be explained as reactions to psychogenic stresses or to other complications (10).

TABLE II

Delay time elapsing between start of total-body irradiation and onset of vomiting on the day of exposure; observations on cancer patients—present series and M. D. Anderson series (ref. 7)—are compared with findings on healthy persons involved in a typical nuclear accident (ref. 13)

Patient	Present series		M. D. Anderson series		Nuclear accident	
	First emesis (hours)	Air dose (r)	First emesis (hours)	Air dose (r)	First emesis (hours)	Body dose (rad)
1	Nausea only	150	2	200	2	365
2	4.5	150	2	200	4	270
3	Nausea only	150	2	200	Asymptomatic	339
4	Asymptomatic	150	3	200	2	327
5	3.3	150	3	200	Nausea only	236
6	1	150	3.5	200		
7	3.5	150	4.5	200		
8	1.8	200	5	200		
9	1.5	200				
10	2.5	200				
11	Asymptomatic	200				

Disability among members of the present series displayed an extraordinary variability both in extent and in duration. Two patients remained completely asymptomatic and, obviously, retained full possession of capabilities existing prior to exposure. In two other patients, the reaction assumed the form of a mild indisposition characterized by fatigue, anorexia, and episodes of nausea, headache, and dizziness. Even during the period of definite discomfort, generally commencing about 2 hours and subsiding about 8 hours postexposure, almost any degree of activity probably could have been performed if necessary. Quite a different appraisal of the initial reaction, however, was necessary for the 7 patients who developed vomiting. During the most intense phase, usually extending from the second through the tenth hour postradiation, prodromal effects distinctly impaired mental and physical capabilities. This impairment, caused by the combination of apathy and depressed mood with weakness and malaise, attained such a degree in 4 of the patients as to seriously hamper execution of any task demanding more than well-drilled actions. In these instances, clinical impression suggested that disability had progressed too far to be overcome, or alleviated decisively, by psychologic factors—probably, not even by the strong motivations inherent in disaster situations. Such a conclusion could be drawn beyond any doubt for one patient who, throughout 24 hours, experienced complete prostration and absolute inability to walk. Thus, extent of disability among the 11 patients covered the entire scale from unnoticeable impairment to absolute physical incapacitation; when occurring, disability predominantly prevailed during the interval starting about 2 hours and terminating about 10 hours postexposure. How do these findings compare with previous data?

Comparison of the present series (G) with both the M. D. Anderson group (MDA) and the Y-12 patients (Y) yields the following distribution of severity: completely asymptomatic—G, 18 percent; MDA, 21 percent; Y, 20 percent; mild reaction not exceeding nausea—G, 18 percent; MDA, 18 percent; Y, 20 percent; and marked reaction associated with vomiting—G, 64 percent; MDA, 61 percent; Y, 60 percent. This close conformity between therapy and accident data is unexpected because the Y-12 group received distinctly higher doses. An explanation probably must be sought in two factors: first, because of spontaneous tendency toward nausea, advanced cancer patients may react at lower doses somewhat more vehemently than healthy persons; and second, available data suggest that, within the several-hundred-roentgen range, severity of the initial reaction is not enhanced significantly as dose exceeds the 300 r level (10).

Despite similarity in distribution of severity, the persons of the present series and those of the Y-12 group apparently differed in degree of disability. In cancer patients, reactions accompanied by vomiting rather consistently induced such a marked reduction of physical and mental faculties as to seriously compromise performance of difficult or strenuous tasks. In sharp contrast, of the 3 individuals who vomited among the Y-12 group, 2 remained in relatively good general condition—even at the height of reaction—although "mild weakness and over-all ill feeling" existed. Only one man experienced disability comparable to that seen in cancer patients; in this instance, however, disability probably resulted from a reaction that was psychogenic rather than truly initial (14). Obviously, caution must be exercised before drawing definite conclusions about extent of disability incurred by healthy persons and by cancer patients because the sets of data are too small and the significance for civil defense is too critical. Nevertheless, the following points require consideration: As mentioned above, advanced cancer patients are likely to react somewhat more violently; furthermore, since the systemic disturbance represents an additional burden that must be borne by the organism already weakened by preradiation disease, a higher degree of disability is likely to ensue. Thus, with respect to civil defense applicability, observations on cancer patients probably are too pessimistic. Findings on the Y-12 group, on the other hand, certainly are too optimistic because these persons entered medical care immediately after the accident and, shortly after onset of nausea,

they received antiemetic medication—injections of prochlorperazine dimaleate (13). None of these individuals became markedly disabled; it is difficult to decide whether the therapy was responsible for this relatively favorable state or whether the persons involved were of unusually low susceptibility. These possibilities must be considered seriously because other accident data closely agree with findings on cancer patients. Hempelmann's case reports (5) contain several examples of the initial reaction which clearly demonstrate that some persons enter a phase of marked weakness, or even of complete prostration; disability is most conspicuous during the interval extending from 2 through 10 hours after the accident.

The preceding analysis may be summarized briefly as follows: in regard to all aspects—distribution of severity, time course, and extent of disability—the initial reaction shows no difference between cancer patients and healthy persons; however, induction of corresponding degrees of impairment requires lower doses for the first than for the second group.

Other findings were surprisingly inconspicuous and equivocal among the cancer patients of the present series. At the height of the reaction—between the fifth and the eighth hour postexposure—5 patients showed a slight elevation of temperature, a trivial acceleration in the rate of pulse and respiration, and a barely perceptible drop in blood pressure. Even though such changes did not occur in the other 6 patients, they might represent true components of the initial reaction because similar effects were observed in persons exposed to much higher doses during nuclear accidents (5).

Case reports

To illustrate the points discussed thus far and to demonstrate the various types and degrees of clinical picture, three case histories were selected according to a stepwise increase in severity of the initial reaction. No significance should be attached to the fact that the preradiation disease involved abdominal structures in the two representatives for the more pronounced forms of reaction because similar clinical pictures were displayed by other susceptible patients who did not have such an involvement.

1. Mild initial reaction, patient N.C., case 3 of present report. Throughout one year prior to admission this 61-year-old woman had suffered from recurrent pleural effusions of unknown origin necessitating two thoracenteses. During the last few months of that period, she experienced a 25-pound weight loss, shortness of breath with "fluttering" of heart, and enlargement of lymph nodes—particularly conspicuous in both supraclavicular and axillary regions. After patient was admitted to hospital, biopsy of a scalene lymph node revealed malignant lymphoma—Hodgkin's granuloma.

During the pre-exposure observation period, the patient was found to be in fair physical condition; throughout most of the daytime, she walked about the ward and performed light work. Her morale was good: she liked to converse with patients, nurses, and physicians alike, and she displayed a positive attitude toward both her disease and her new environment. On 29 August 1957, she had breakfast as usual about 8:00 a.m. Later that morning, total-body radiation (150 r) was administered as follows: first half-dose, 11:08 a.m. to 11:25; repositioning, 11:25 to 11:30; and second half-dose, 11:30 to 11:47 a.m. Completely unaffected by the radiation procedure, the patient resumed her usual activities soon after return to the ward; however, she did express some resentment at having to undergo close examination so frequently. Temperature, pulse, respiratory rate, and blood pressure showed normal values. At 12:30 p.m., she ate lunch with fair appetite. Around 1:30 p.m.—2½ hours after start of exposure—a spell of malaise erupted suddenly; fatigue, headache, and anorexia appeared as chief complaints over which were superimposed brief episodes of nausea associated with regurgitations causing "sour" taste but no frank emesis. After an hour, this wave of discomfort largely subsided, and the patient was able to resume her usual activities; however, listlessness and somewhat subdued behavior persisted. Although the examination at 3:30 p.m. revealed a small rise in temperature associated with trivial fall of both blood pressure and pulse rate, the patient expressed no complaints. This practically asymptomatic state was interrupted by a second wave of apathy, anorexia, and nausea arising around 5:30 p.m.—6½ hours after exposure. The period of discomfort lasted approximately 2 hours; thereafter, the patient returned to a completely asymptomatic state. During the following days, a few periods of poor appetite were the only complaints that could conceivably have been caused by the radiation treatment.

Comment. The initial reaction of this patient stands out as two waves of mild indisposition, with no appreciable impairment of mental and physical capabilities.

2. Moderate initial reaction, patient J.H., case 10 of present report. Several months prior to hospitalization, this 25-year-old man started to experience general weakness, exertional dyspnea, epigastric as well as substernal pain, and loss of body weight. On his admission to the hospital, the most prominent findings were generalized adenopathy and a marked reduction of both capacity and distensibility of the stomach displaying large rugae. Biopsy of the right lacrimal gland revealed infiltrations of small lymphocytes consistent with the diagnosis of lymphosarcoma.

During the pre-exposure observation period, the patient complained about weakness, nasal congestion, and night sweats; however, he was able to ambulate and to participate in some activities. On 5 November 1957, the patient had his usual breakfast about 8:00 a.m. and received total-body radiation (200 r) between 9:30 and 10:00 a.m. He, then, walked about the ward and conversed with other patients. This asymptomatic period suddenly terminated at noon—2½ hours after start of radiation—with the abrupt onset of marked anorexia and severe nausea followed by a bout of vomiting. Patient could not eat his lunch. Although vomiting failed to recur, anorexia and nausea unabatedly persisted until 4:00 p.m. and then gradually subsided. During the intense phase of discomfort—extending from 2½ through 6 hours post-exposure—the patient appeared apathetic, weak, and too listless for ambulation. At the height of the reaction, temperature rose to 100 degrees, while pulse rate, respiratory rate, and blood pressure remained practically unchanged. Late in the afternoon, the patient's condition improved; he ate supper at 5:00 p.m. and, although slightly listless, he resumed ambulation. The next morning the patient appeared asymptomatic and ate his entire breakfast with good appetite.

Comment. The initial reaction of this patient caused a moderate impairment of mental and physical fitness which was clearly evident throughout a 5-hour period starting at 2½ hours postirradiation. During that interval, execution of strenuous tasks would have been doubtful, at best.

3. Severe initial reaction, patient V.A., case 5 of present report. Approximately 3 months prior to admission, this 69-year-old man noticed development of a tumor in the epigastrium. Growth of the mass was paralleled by increasing polydipsia, polyphagia, polyuria, and weight loss. Examination on admission revealed lymphadenopathy, particularly prominent in the left parietal and left axillary regions. Exploratory laparotomy and biopsy disclosed that the large abdominal mass was a malignant giant-follicle lymphoma.

During the pre-exposure observation period, the patient's physical condition was fair; he liked to roam about the ward and to assist in little tasks. Displaying a bright and cheerful attitude, he established friendly relations with other patients as well as with hospital personnel. On 9 April 1957, he had his usual breakfast about 8:00 a.m. Total-body radiation (150 r) was started at noon and was completed by 12:40 p.m. After return to the ward, the patient displayed his normal cheerful attitude in explaining to others the irradiation procedure. After his 1 o'clock lunch, eaten with perfect appetite, he slept for an hour as was his custom. This completely asymptomatic period ended at 3:20 p.m. when vomiting suddenly started. Concomitant with the onset of repetitive emeses—producing large amounts of undigested food and watery fluid—the patient became increasingly lethargic. Muscle strength, particularly in the lower extremities, was distinctly reduced, and the gait appeared unsteady and ataxic. The distress reached a climax between 5 and 6 p.m. At that time, the patient became prostrated and mentally depressed; the temperature rose from 98° to 101.2° while pulse, respiratory rate, and blood pressure remained unchanged; attempts at eating supper were followed immediately by such severe bouts of vomiting as to necessitate peroral administration of 25 mg. of chlorpromazine hydrochloride. The period of intense disability lasted about 5 hours. Around 8:30 p.m. marked improvement was indicated by the patient's resuming ambulation, and eating a small meal consisting of corn chips and oranges, and drinking some water. The next morning, the patient appeared asymptomatic, muscle strength had completely returned, and breakfast was eaten with normal appetite. During the following days, no complaints related to the radiation treatment were expressed; however, some waves of anorexia, extending into the fourth postradiation day, perhaps must be regarded as last remnants of the initial reaction.

Comment. The initial reaction of this patient caused a transitory severe depression of both mental and physical capabilities; the period of disability began at 3¼ hours after start of irradiation and lasted for about 5 hours. During that interval, diligent execution of any task would have been impossible.

DISCUSSION

The subsequent discussion of the initial reaction will center around two aspects—namely, its potential significance in the atomic age and its therapeutic management.

Civil defense aspects

When medical assistance is readily available as in both radiotherapy and reactor accidents involving small numbers of persons, the initial reaction represents a bothersome but insignificant side effect that, owing to its short duration, rarely poses serious problems. Yet, this harmless disorder may assume quite a different role when certain civil defense situations are analyzed (12). In case of nuclear disaster, exposed persons might have to endure several hours of driving or walking through streets congested by vehicles and panic-stricken people in order to reach medical facilities. En route they could easily become so affected by the disturbance as to be physically unfit at a time when extreme physical and mental efforts are necessary for survival. A proportionately smaller group of hypersensitive persons would probably have reactions so severe as to imperil their escape from the disaster area without aid. Therefore the disturbance must be taken into account by authorities designing evacuation plans and other emergency measures which require active participation of exposed populations. The several-hour delay between exposure and arrival at medical facilities also has another implication demanding the physician's attention: on admission, casualties already may display initial reactions. Radiation-induced dizzines, nausea, and vomiting—when occurring in patients with mechanical or thermal lesions, particularly of head and abdomen—easily can be mistaken as sequelae of these other injuries. Thus, unrecognized, the initial reaction may jeopardize proper diagnosis, prognosis, and classification of casualties (12).

Therapy

Owing to its unsolved pathogenesis, the reaction can neither be prevented nor treated with specific remedies. Nevertheless, clinical experience has firmly established several principles of management which, when properly applied, can alleviate or even suppress overt manifestations in many instances. Among these principles, psychologic reassurance plays a leading role because (as with motion sickness) the initial reaction frequently is aggravated by apprehension or introspection. Such reassurance becomes especially important in civil defense situations where uncertainty and fear, triggered by onset of nausea and vomiting, may grow so powerful as to induce outbreak of mass hysteria in an uninformed exposed population. Education must center around two characteristic peculiarities of the initial reaction—namely, its brief transient course and its relative insignificance as indicator of dosage received; in a wide dose range, severity of clinical manifestations is determined much more by individual susceptibility than by amount of radiation (10). Experience in radiotherapy demonstrates that proper psychologic preparation frequently suffices for controlling the distress. When these measures prove insufficient, however, additional steps must be taken. Among the drugs, all sedatives are probably beneficial; by helping restore equanimity they support psychologic measures, and by depressing the excitability of autonomic centers they raise the threshold for nausea and vomiting. Selection of type and dose of medication is determined by the given situation; often, the drug of choice will be one that acts almost exclusively on the medullary autonomic centers but does not affect cortical functions. Since barbiturates possess certain deficiencies in this regard, they have largely been replaced by more effective chemicals developed during recent years—e.g., meclizine, prochlorperazine, and chlorpromazine. According to clinical experience, the combination of psychologic measures and drug medication satisfactorily alleviates the initial reaction in practically all cases. Only the occasional hypersensitive patient will develop disturbances of such a degree as to necessitate parenteral supply of fluid, glucose, and protein.

The authors are indebted to Airman First Class Frances A. Quinn and to Mrs. Rose Kellermann for technical and secretarial assistance.

REFERENCES

1. Beclere, A. The "penetrating irradiations sickness." Am. J. Roentgenol. 5:498-506 (1918).

2. Doub, H. P., A. Bolliger, and F. W. Hartman. Immediate metabolic disturbances following deep roentgen ray therapy. J. A. M. A. 85:1299-1303 (1925).

3. Ellinger, F. Medical radiation biology. Springfield, Ill.: Charles C Thomas, 1957.

4. Oughterson, A. W., and S. Warren. Medical effects of the atomic bomb in Japan. New York: McGraw-Hill, 1956.

5. Hempelmann, L. H., H. Lisco, and J. G. Hoffman. The acute radiation syndrome: A study of nine cases and a review of the problem. Ann. Int. M. 36:279-510 (1952).

6. Gerstner, H. B. Acute clinical effects of penetrating nuclear radiation. J. A. M. A. 168:381-388 (1958).

7. Miller, L. S., G. H. Fletcher, and H. B. Gerstner. Radiobiologic observations on cancer patients treated with whole-body x-irradiation. Radiation Res. 8:150-165 (1958).

8. Medinger, F. G., and L. F. Craver. Total body irradiation with review of cases. Am. J. Roentgenol. 48:651-671 (1942).

9. Sinclair, W. K., and A. Cole. Technic and dosimetry for whole-body x-irradiation of patients. School of Aviation Medicine, USAF, Report No. 57-70, Mar. 1957.

10. Gerstner, H. B. Reaction to short-term radiation in man. Annual Review of Medicine, vol. 11 (1960).

11. Court Brown, W. M., and R. F. Mahler. Discussion on the radiation syndrome. Proc. Roy. Soc. Med. 46:245-250 (1953).

12. Gerstner, H. B. Initial clinical reaction to penetrating nuclear radiation: Military and civil defense aspects. (In preparation)

13. Brucer, M. The acute radiation syndrome: A medical report on the Y-12 accident, June 16, 1958. U. S. Atomic Energy Commission Report ORINS-25, 1959.

14. Staff Medical Division ORINS. Personal communication.