SAFE HANDLING OF CADAVERS CONTAINING RADIOACTIVE ISOTOPES

Handbook 56

U. S. Department of Commerce

National Bureau of Standards

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Preface

The Advisory Committee on X-ray and Radium Protection was formed in 1929 upon the recommendation of the International Commission on Radiological Protection, under the sponsorship of the National Bureau of Standards and with the cooperation of the leading radiological organizations. The small committee functioned effectively until the advent of atomic energy, which introduced a large number of new and serious problems in the field of radiation protection.

At a meeting of this committee in December 1946, the representatives of the various participating organizations agreed that the problems in radiation protection had become so manifold that the committee should enlarge its scope and membership and should appropriately change its title to be more inclusive. Accordingly, at that time the name of the committee was changed to the National Committee on Radiation Protection. At the same time, the number of participating organizations was increased and the total membership considerably enlarged. In order to distribute the work load, nine working subcommittees have been established, as listed below. Each of these subcommittees is charged with the responsibility of preparing protection recommendations in its particular field. The reports of the subcommittees are approved by the main committee before publication.

The following parent organizations and individuals comprise the main committee:

American College of Radiology: R. H. Chamberlain and G. C. Henny.
American Medical Association: P. C. Hodges.
American Radium Society: E. H. Quimby and T. P. Eberhard.
American Roetgen Ray Society: R. R. Newell and J. L. Weatherwax.
National Bureau of Standards: L. S. Taylor, Chairman, and M. S. Norloff, Secretary.
National Electrical Manufacturers Association: E. D. Trout.
Radiological Society of North America: G. Failla and R. S. Stone.
U. S. Air Force: S. E. Lifton, Maj.
U. S. Army: J. P. Cooney, Brig. Gen.
U. S. Atomic Energy Commission: K. Z. Morgan and J. C. Bugher.
U. S. Navy: C. F. Behrens, Rear Adm.
U. S. Public Health Service: H. L. Andrews and E. G. Williams.
Representatives-at-large: Shields Warren and H. B. Williams.

The following are the subcommittees and their chairmen:

Subcommittee 1.	Permissible Dose from External Sources, G. Failla.
Subcommittee 2.	Permissible Internal Dose, K. Z. Morgan.
Subcommittee 3.	X-rays up to Two Million Volts, H. O. Wyckoff.
Subcommittee 4.	Heavy Particles (Neutrons, Protons, and Heavier), D. Cowie.
Subcommittee 5.	Electrons, Gamma Rays, and X-rays above Two Million Volts, H. W. Koch.
Subcommittee 6.	Handling of Radioactive Isotopes and Fission Products, H. M. Parker.
Subcommittee 7.	Monitoring Methods and Instruments, H. L. Andrews.
Subcommittee 8.	Waste Disposal and Decontamination, J. H. Jensen.
Subcommittee 9.	Protection against Radiations from Radium, Cobalt-60, and Cesium-137 Encapsulated Sources, C. B. Braestrup.

With the increasing use of radioactive isotopes by industry, the medical profession, and research laboratories, it is essential that certain minimal precautions be taken to protect the user and the public. The recommendations contained in this Handbook represent what is believed to be the best available opinions on the subject as of this date. As our experience with radioisotopes broadens, we will undoubtedly be able to improve and strengthen the recommendations given in this report. In the meantime, comments and suggestions will be welcomed by the committee.

The present Handbook was prepared in order to provide pertinent information for the guidance of mortuary and medical personnel involved in the handling and autopsy of cadavers containing radioactive materials. More general information on radiation protection is available in other NBS Handbooks by the NCRP.

This Handbook was prepared by an ad-hoc subcommittee on Safe Handling of Cadavers Containing Radioactive Isotopes, the chairman of which was E. H. Quimby. Other members were E. R. King, Cmdr., M. C., U. S. N.; L. R. Peet, funeral director, New York City; and S. Spitz, M. D., pathologist, Memorial Hospital, New York City.

A. V. Astin, *Director*

Contents

Safe Handling of Cadavers Containing Radioactive Isotopes

1. Introduction

In the present state of our knowledge, it is considered wise to avoid all unnecessary radiation. The human race has developed in a field of natural radiation from cosmic rays and radioactive material in the earth; this level may be considered normal. A much higher level is known to be definitely harmful. Between these two extremes it is assumed that there is a level of exposure that can be tolerated by human beings without expectation of ill effects. When such a level is accepted, methods can be devised for making sure that this is not exceeded, for anyone going about his regular occupation.

The International Commission on Radiological Protection, after study of the great mass of available data on radiation effects, has established permissible levels for occupational exposure to radiation. These specify maximum permissible weekly doses for adults whose work entails possible irradiation. (See NBS Handbook 47.) The matter is discussed in detail in a report on Permissible Dose from External Sources [1].[1] No official levels are set for occasional or incidental exposures, but it is evident that they can be somewhat higher than those permitted every week. For occupational exposure, the maximum permissible weekly dose is 0.3 r to the whole body, and five times as much to the hands and forearms.[2]

If a patient dies shortly after having received a large internal therapeutic dose of a radioactive isotope, the handling of the body may pose problems of radiation exposure

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[1] Figures in brackets indicate the literature references at the end of this report.

[2] The *roentgen*, r, is the accepted unit of X- or gamma radiation; it is a very small fraction of the amount that is necessary to produce any visible effect on the skin. The maximum permissible weekly dose is of the same order of magnitude as that received in the course of certain standard types of X-ray examination. The *rep* (roentgen equivalent physical), the unit of beta radiation, represents essentially the same energy absorption per gram of tissue as the roentgen. (For exact definitions, see NBS Handbook 51 [2].)

for the pathologist and for the embalmer.[3] It is important for members of these groups to realize the existence of this problem, and to know how to meet it. It is equally important that they should not exaggerate the hazard nor be unreasonably fearful when it is minimial or nonexistent.

2. General Considerations

It should be accepted that at the present time, and in the next few years, at least, the probability that such bodies will be encountered frequently is very low. In principle, such therapy is not given to moribund patients, and it will be seen below that if a few days elapse between treatment and death, the possibility of radiation hazard is considerably reduced. In any hospital the number of patients receiving large internal doses of radioisotopes in any one week is small; it would be seldom that one institution would have as many as five highly radioactive patients at one time. The death of one of these would not be usual. In case of deaths in a particular hospital, the same pathologist might perform autopsies on all, but it is unlikely that the same embalmer would prepare all the bodies for burial. The problem should be approached, therefore, as one of relatively rare occurrence, not as something to be expected every week or month. Although calculations and recommendations in the present report are based on the maximum permissible doses for occupational exposure, it should be understood that doses occasionally exceeding these will not be expected to lead to any harm, if interim doses are lower than this level.

It can readily be shown that the permissible exposure will never be reached in handling the body of an individual who has received only a *tracer* dose of any isotope, such as is likely to be used for diagnostic purposes. The only possibility of danger would be concerned with therapeutic doses of these substances. The Advisory Committee on Isotope Distribution of the Atomic Energy Commission advises that all patients receiving large doses of radioisotopes be hospitalized until the isotope content is not more than 30 mC.[4] Accordingly, in cases that die outside the hospital

[3] There is, of course, no danger from any patient who has been treated by *external* irradiation with X-rays, radium, or any radioactive substance. No *radiation* remains in the patient after the treatment is over. It is only when actual *radioactive material* is present that there can be any problem.

[4] The millicurie (mC) is that amount of radioactive material in which 37 million atoms disintegrate each second. Therapeutic doses of isotopes are generally in millicurie amounts; tracer doses in microcuries (μC). One $\mu C = 0.001$ mC.

the funeral director should not encounter bodies containing more than 30 mC of radioactive isotope. It will be shown that if such a body is embalmed without opening, using standard aspiration and injection methods, the hazard is minimal. Furthermore, if the body is to be interred or cremated without embalming, there will be no radiation hazard from the necessary external handling.

On the other hand, if a patient containing this material dies in the hospital, it is highly probable that an autopsy will be performed. In this case the radiation hazard may be significant. However, in such a case, the examination will be carried out in an institution equipped for treatment with large doses of the isotope in question. The institution will have an official radiation safety officer, as required by the Isotopes Division of the Atomic Energy Commission, who carries the responsibility for safety throughout his institution; and his advice and cooperation are to be counted upon. No autopsy should be commenced on a body that is likely to contain more than 5 mC of radioactive iodine, I^{131}, or of radioactive gold, Au^{198}, without the consultation and advice of the radiation safety officer.[5]

The identification of a particular patient as radioactive is the responsibility of the doctor in charge of the case. While the patient is in the hospital, it is recommended that there be attached to his chart a tag stating the amount and kind of isotope administered and the time of its administration. Such a tag may also be attached to the patient's bed, unless this is psychologically undesirable. Many hospitals have this system already in operation for radium; it can easily be extended to isotopes.

If one of these patients dies in the hospital, the doctor who pronounces him dead should attach blank copies of the radioactivity form (see appendix, page 15) to the death certificate and to the patient's chart. These forms should be filled in before the body is surrendered to the funeral director. The physician in charge of the case should also be notified at once, in order that he may make arrangements for consultation with the radiation safety officer, if he considers it advisable.

Meantime, if the body is taken to the autopsy room the statement of dose and date of its administration on the radio-

[5] At the present time these are the only isotopes likely to be encountered in quantities large enough to be significant. Therapeutic does of radioactive phosphorus, P^{32}, are too small to constitute a problem, and other isotopes are used mainly for diagnostic purposes, in even smaller doses. If others come into therapeutic use, in large doses, an extension of this report may be desirable; at present there appears no immediate likelihood of this.

activity tag enable the pathologist, by reference to table 1 or its equivalent, to decide whether he can commence his examination without waiting for the safety officer. The alternative to the use of such a table is to summon the safety officer for any death occurring within 2 weeks following the administration of a therapeutic dose of a radioactive isotope.

TABLE 1. *Probable radioactive content of body at various times after various doses*

A guide for autopsy consideration. For values *in italics*, no precautions are necessary except wearing surgical rubber gloves. For values *not* in italics, consultation with radiological safety officer is indicated.

Dose of isotope	Days elapsed since treatment—							
	1	2	3	4	6	8	10	15
Au 198	Gold remaining in injected cavity							
mC	*mC*	*mC*	*mC*	*mC*	*mC*	*mC*	*mC*	*mC*
150	115	90	69	52	32	20	12	*3*
125	96	75	58	44	27	16	10	*3*
100	77	60	46	35	21	13	8	*2*
75	58	45	35	26	16	10	6	*2*
50	38	30	23	18	11	7	*4*	*1*
40	31	24	18	14	9	5	*3*	*1*
30	23	18	14	10	6	*4*	*2*	*1*
I^{131}	Iodine remaining in thyroid gland following dose for ablation of normal thyroid tissue							
60	18	16	14	12	10	8	6	*4*
50	15	13	12	11	9	7	5	*3*
40	12	10	9	8	7	5	*4*	*2*
30	9	8	7	6	5	*4*	*3*	*2*
20	6	5	5	*4*	*4*	*3*	*2*	*1*
10	*3*	*3*	*2*	*2*	*2*	*1*	*1*	*1*
I^{131}	Iodine remaining in functioning metastases following therapeutic dose post-thyroidectomy. (These are maximal; usually much smaller)							
100	20	18	16	14	12	9	7	*4*
75	15	13	12	11	9	7	5	*3*
50	10	9	8	7	6	5	*4*	*2*
35	7	6	5	5	*4*	*3*	*2*	*1*
20	*4*	*4*	*3*	*3*	*2*	*2*	*1*	*1*

3. Analysis of Extreme Cases

The largest therapeutic dose likely to be administered at the present time is instillation of about 150 mC of radioactive gold-198 in the treatment of metastatic cancer in the abdominal cavity,[6] or oral administration of 150 mC of radioactive iodine-131 in the treatment of thyroid cancer. An analysis of these extreme cases will indicate the limits of the problem.

3.1. No Autopsy

Consider first the cases in which no autopsy is to be performed, and the body need not be opened. Embalming will be by the injection method, and the likelihood of contamination is small. Nevertheless, even in these cases, rubber gloves should be worn by all who are involved in the procedures, in order to avoid the possibility of contamination by radioactive fluids from the body.

a. Radioactive Gold, Au^{198}; No Autopsy

A few hours after a patient has received 150 mC of Au^{198} in the abdominal cavity, an ionization-chamber-type survey meter placed close to the overlying surface shows a dose rate of about 1.5 r/hr; it is very much less at the shoulders and extremities. At 50 cm from the abdomen, which is the distance of much of the body of the operator, the observed rate is approximately one-tenth that found at the close position. The distribution of activity does not change appreciably with time, but its intensity decreases by about 25 percent in every 24 hr, because of radioactive decay.

If the embalming procedure can be carried out in 1 hr, without opening the body, anyone standing very close to it for the entire time would receive only about half the permissible weekly dose. It may be noted that a man standing close to the abdominal region of the body would receive a dose to his gonads somewhat higher than the average to his entire person; under the extreme conditions here discussed the dose rate might be as much as 0.5 r/hr at the start of the procedure. At this level, the permissible dose of 0.3 r would be received in 36 min. However, before this much time had elapsed the ascitic fluid would have been removed (see

[6] Intracavitary gold is also employed in treatment of pleural effusion due to cancer, but the dose is never as large as this.

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below) and the dose rates close to the body correspondingly lowered.[7]

Thus it appears that under these conditions, two bodies could be embalmed each week without exceeding the permissible dose for occupational exposure. Of course for smaller initial doses, or additional days after administration of the isotope, the exposure is even less.

If ascitic or pleural fluid is to be removed in the embalming process, it must be noted that this may contain from one-fourth to one-half of the radioactive material. Unless other instructions are given by the radiation safety officer, fluid should be removed from the body by means of a trocar and tubing, into a closed system, with suction if necessary. The trocar should be fixed to the body in such a manner that it is not necessary for anyone to hold the trocar or the tube, while the fluid is being withdrawn. At the completion of the drainage, the fluid can be disposed of directly into the sewer, with a large volume of diluting water [3]. If an aliquot of the fluid is to be saved for measurement of radioactivity, or study of cells, the sample should be taken by means of a remote control pipettor or other device, and placed in such a shielded container as may be recommended by the safety officer. There will be no appreciable activity in the blood or urine; therefore, blood and clots may be disposed of without special precautions.

b. Radioactive Iodine, I^{131}; No Autopsy

Within an hour after a patient has received 150 mC of I^{131}, measurements with an ionization-chamber type of survey meter indicate a surface dose rate over the abdomen of the order of 0.4 r/hr. The isotope is circulating freely throughout the body, and no part will be more active than the abdomen; but shoulders and legs will be more active than in the case of the body with the same amount of radioactive gold. Again at a distance of 50 cm the exposure is reduced to about one-tenth of that close to the surface. With these cases, as far as external irradiation is concerned, the permissible dose would not be exceeded if four or more were embalmed each week for an indefinite period.

During the first 24 hr after administration of this isotope, the blood and urine contain a good deal of radioactivity. These fluids should accordingly be removed into closed sys-

[7] The suggestion is sometimes made that a fluoroscopic lead-rubber apron would give considerable protection during these procedures. Actually the standard apron, with a lead equivalent of 0.5 mm, would only reduce the gamma-ray dose rate by about 10 percent. Two and one-half millimeters are required to reduce it to half. These are much more penetrating rays than the diagnostic X-rays for which the aprons are designed. There is no appreciable beta-ray exposure from the unopened body.

tems, as recommended for the ascitic fluid in the preceding section, and later flushed directly into the sewer. If clots are formed that cannot be disposed of in this manner, the radiation safety officer or his deputy should provide a shielded jar, and an instrument for scooping them into it. He will then undertake storage or disposal of this material.

After the day of administration, this general distribution of radiation is greatly reduced, both by urinary excretion of a large part of the isotope, and by concentration of the remaining part in functioning thyroid tissue. At this time only radiation from these regions of iodine storage need be considered. If as much as 50 mC is concentrated in a thyroid gland or metastasis (which is more than the amount usually to be expected even with very large initial doses), the dose rate directly over this site may be as much as 25 r/hr; at 10 cm this would be reduced to about 1 r/hr, and at 50 cm to 0.04 r/hr. Thus there would be no radiation hazard from general handling of the body, with an average distance of the order of 50 cm from most parts of the body of the operator. The region of high activity should be marked by the safety officer, so that it can be avoided.

From the above sections, it is evident that a body containing as large an amount of Au^{198} or I^{131} as is currently administered, presents no radiation hazard if the body is embalmed by injection procedures alone, and fluids are handled as indicated. In other words, the permissible dose to the entire person of the embalmer will not be exceeded under conditions likely to be encountered when the body is not opened, even if two or three such cases were handled every week.

3.2 Body To Be Opened for Autopsy

As long as the body remains unopened, the radiation received by anyone near it is almost entirely gamma, and the intensity remains low. Information concerning radiation to the whole body and to the gonads, presented in the previous section, is also applicable here. The change in emphasis when autopsy is to be performed, is the exposure of the hands to relatively intense beta radiation. When the organs and serous surfaces are exposed, the beta radiations previously absorbed by the superficial tissues can reach the hands of the pathologist as he dissects out the organs. This radiation is much more intense, but it is readily absorbed by material interposed between its source and the hands.

Published data indicate that even rubber gloves should be useful in this regard. To test their efficacy, 100 μC of Au^{198} were injected into the peritoneal cavity of a rat; the animal was sacrificed 36 hr later, and tissue taken from the cavity. The absorption of radiation from this exposed surface by surgical rubber gloves (31 mg/cm^2) and heavier rubber utility gloves (42.5 mg/cm^2) was measured with a geiger counter. Double thickness of the surgical gloves reduced the radiation to about one-third and double thicknesses of the heavier rubber gloves to about one-fifth of the unshielded value. Of course this reduction is essentially all in the beta radiation; the gamma rays are not affected appreciably by this amount of material. It appears from this that *double* heavy rubber autopsy gloves, with suitable gauntlet tops, would afford a considerable degree of protection from this radiation. Surgical gloves would give less protection, especially if stretched tightly.

Consider now extreme cases in which autopsies are to be performed on patients who have recently received large doses of Au^{198} or I^{131}. Because it is not possible to have prior accurate information regarding dosage rate levels within the body, in every hospital where there is a possibility of this situation arising, the radiological safety officer should be responsible for the safety of operators during the entire autopsy and the subsequent embalming. If the body is assumed to contain 5 mC or more of radioactive gold or iodine, it should not be opened until the safety officer or his deputy is present. Following the making of the incision, he can take suitable measurements and inform the pathologist of the length of time he may keep his hands in the cavity. If the radiation level is very high, the use of a team to complete removal of the organs may be necessary.

It should be pointed out that any delay that can be imposed between death and autopsy reduces the radiation levels by the natural decay of the radioactive material. In the case of I^{131} this is only about 9 percent per day; but for Au^{198}, it is about 25 percent per day.

In the following sections no attempt is made to give directions as to the methods of performing autopsies. It is probable that precautions ordinarily observed to prevent the spread of infectious material will aid greatly in preventing radioactive contamination. However, it seems desirable here to put all the emphasis on the radiation, without regard to concomitant problems.

a. Radioactive Gold, Au^{198}; With Autopsy

If a patient dies 8 hr after receiving a dose of 150 mC of Au^{198}, probably about 100 mC will have deposited out onto the serous surfaces, the remainder being in the cavity fluid.

Earlier than this a larger part will be in the fluid; later the proportion will not change much. Before the body is opened, as much as possible of this fluid should be removed. This is best done by means of a suction apparatus; the fluid is collected in the jar or trap, and can either be saved or washed down the drain in accordance with the instructions of the radiation safety officer. When the cavity is opened, the remaining fluid should be soaked up in sponges held in long forceps. These can be deposited in a waste container for the attention of the safety officer. It will then be unlikely that dangerous contamination of the exterior of the body, or of those handling it, will occur.

The remaining radioactive material is widely distributed over the surfaces of the cavity and of the organs within it. It is difficult to make any estimate of radiation rates. Even assuming uniform distribution over all serous surfaces, the folds and convolutions of these surfaces distort the picture. A very rough approximation may be arrived at by considering the abdominal cavity as a sphere 15 cm in diameter, with the radioactive material distributed uniformly throughout it. For 100 mC of Au^{198} as residual, the beta-ray intensity at any point inside will be of the order of 20 rep/hr, and the gamma about 4 r/hr.[8] Double heavy gloves would reduce the beta dose rate to about 5 rep/hr and the gamma would be unaffected, so that the total dose rate would be of the order of 9 r/hr. The permissible weekly dose to the hands being 1.5 r, the heavily gloved hands could work in this cavity one-sixth of an hour and remain within the level of weekly permissible dose.

The use of these gloves may reduce digital sensitivity and dexterity; the removal of organs may take longer than with surgical gloves alone, and manipulation depending on delicate sense of touch may not be possible. If time of hands in the cavity can be reduced to 5 min, double surgical gloves may be sufficient. *Bare hands should never be tolerated,* because of contamination of skin and nails; complete removal of such contamination may be difficult. When a staff of well-trained pathologists is available, it may be preferable to set up a team to work in relays on such a procedure as the one just outlined. If each of three men could work for 5 min, obviously a more careful job could be done than if only one man could work for this period. In any case, autopsies on radioactive bodies should be performed by a senior pathologist or one having experience with isotopes. If such an autopsy

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[8] Formulas have been developed for calculation of dose rate from radioactive isotopes under various conditions [4]. A review of these is outside the scope of this report.

must be performed during the night, it should be possible to call in the appropriate staff member.

Monitoring the body after removal of the viscera may indicate a radiation level low enough so that subsequent procedures can be carried out safely without further regard to radiation. Locations of regions of high activity, if present, can be indicated and avoided or approached with precautions.

If the removed organs are to be dissected immediately, each one should be monitored, and treated in accordance with the findings. It will be expected that everything in the abdominal cavity will be radioactive (since the Au^{198} was put into this cavity). Other tissues should not be active, unless they have become contaminated during the procedure. Dissection of active material should be carried out with long forceps (8 in.) and with long-handled scissors. Rubber gloves should *always* be worn. When possible, separate organs should be promptly removed from the main mass, and detailed dissection carried out a few feet away. As soon as possible after desired small samples have been taken, the active tissues should be placed in heavy crocks or glass jars for storage or for disposal according to procedures approved by the radiation safety officer. Some general suggestions are given in subsequent sections.

In the modern hospital with adequate cold storage facilities, organs may be stored for several days without gross pathologic alterations, or the viscera may be fixed. The usual order of the autopsy may be altered to permit finer dissections after a period of such cold storage or fixation to permit radioactive decay. Blocks of tissue for microscopic work may be taken immediately for prompt fixation, with handling precautions as noted in the following sections.

b. Radioactive Iodine, I^{131}; With Autopsy

For the patient who received 150 mC of this isotope less than 24 hr antemortem, activity is general throughout the body, all fluids carrying their proportional share. Procedure should be on a basis of step-by-step monitoring as in the case of the Au^{198}. Urine should be drained away and blood disposed of if possible, in the same manner as in the unautopsied case discussed above.

After the first day, when excretion has greatly reduced the total activity, and what remains is localized in certain organs and tissues, these regions of high activity can be identified, and either avoided or removed with suitable precautions. Maximum exposure would result from close contact with the thyroid gland or with a metastasis containing essentially all of the isotope. In the extreme case already mentioned, of 50 mC in a relatively small volume of tissue, the beta-ray dose rate at the surface of this tissue would be of the order of 10 rep/min; the gamma-ray dose rate would be unimportant. *Contact* with such a piece of tissue for one-sixth of a minute would deliver to the hand the permissible dose for habitual weekly exposure. (However, it should be noted that the gland could actually be held in the hand for half an hour without any visible reaction being produced. That is, as stated previously, the permissible level for chronic exposure is a very small part of the amount that would be expected to produce an observable effect.) Rubber gloves as recommended for Au^{198} will reduce the beta-ray dose rate considerably. Holding the active tissue with 10-cm forceps will further reduce it to about 1 percent of the contact value.

After these very active tissues have been removed from the body, further dissection for specimens for study should be carried out rapidly, with the same precautions as described in the case of Au^{198} above. The residue should be deposited in heavy jars or crocks for storage. (See below.)

When small specimens have been taken from the removed portions and put into specimen bottles, those bottles can probably be handled without special precautions. However, actual contact with even the small specimens should be avoided if the concentration of the isotope is more than 100 μC per gram of the tissue. Wearing gloves and using forceps and knives that keep the fingers 5 cm or more from the tissue should give adequate protection in any situation likely to be encountered with such small specimens. If the monitor shows less than 30 mr/hr in close proximity to the specimen, its radioactivity may be ignored in further work with it. The rest of the tissue should be put in containers to be retained for decay of radioactivity, covered with preservative, and stored as directed by the radiation safety officer. Each jar should carry a label giving the following information:

Date.
Name and hospital number of patient.
Isotope and radiation level at stated date.
Date when radiation level will be below permissible level for disposal.
Disposal of contents at that date.

After 3 weeks, the residue from any gold-198 patient can be considered inactive (8 half-lives; reduction to less than 0.4 percent). For I^{131} the corresponding period is 2 months.

Following removal of active foci, the general body level of radiation should be very low. When this has been reduced below 30 mr/hr (0.03 r/hr)[9] no extra precautions are necessary except the wearing of rubber gloves.

When the body is released to the funeral director, it should be accompanied by a radioactivity form stating the activity level and pointing out any necessary precautions. An acceptable form is given in the appendix (page 15). A copy of this form should also be attached to the deceased patient's chart. It is recommended that, if the radioactivity is above the level of 30 mr/hr, the funeral director embalm the body in the hospital morgue, with the advice of the hospital radiation safety officer.

4. Accident or Injury During Autopsy

In case of an injury occurring during embalming or autopsy, so that the rubber gloves are cut or torn and radioactive material may be introduced into the wound; the procedure should be stopped immediately, the gloves removed, and the wound washed with large quantities of running water, the edges being spread to facilitate flushing action [5]. The radiation safety officer should be notified at once, and should check to see whether there is residual contamination sufficient to warrant special decontamination measures, for which he will give instructions. If the injury was relatively minor, and contamination successfully removed, fresh gloves may be put on and work resumed. In case of more serious damage, necessitating dressings or other special care, someone else should complete the procedure.

5. Contaminated Clothing or Instruments

Clothing and instruments that become contaminated during an autopsy or embalming procedure require special handling. If practicable, they should be turned over directly to the radiation safety officer, to be returned after decontamination. However, with attention to pertinent sections of National Bureau of Standards Handbook 48 [5],[10] personnel themselves can remove low-level contamination. The instruments can usually be brought to a safe level by

[9] The frequently quoted level of 6 mr/hr is that allowed for occupational exposure of 48 hr/week. It is presumed that autopsy or embalming procedures at a level of 30 mr/hr will not take more than 10 hr/week (a very liberal estimate), and that the rest of the time there is no radiation exposure.

[10] This Handbook should be in the hands of every isotope user. It is not necessary to quote large sections of it here.

soaking them with soap or a detergent, rinsing them well in running water, and repeating these steps if necessary. Gloves should be thoroughly washed *before being removed from the hands.* If contamination persists, the gloves may be soaked and rinsed again, and if necessary, they may be stored when dry for the requisite period for decay of radioactivity, in a location approved by the radiation safety officer.

Gowns, towels, etc., should be monitored, and if activity is above the permissible levels cited in NBS Handbook 48, they should be stored for suitable decay before being sent to the laundry. With these articles, as with gloves, soaking with soap or detergent will frequently bring the activity to a low level. In this procedure, of course, the hands should not be used either to agitate the articles or to wring them out. A simple hand wringer will be serviceable if such a procedure is decided upon. Disposable waste (rags, wipes, etc.) should be collected in approved garbage bags and disposed of in accordance with instructions of the radiation safety officer.

Special care should be taken to prevent the floor of the autopsy room from being contaminated. Such contamination is inevitably transferred to the shoes, and from these all over the institution. In addition, the floors are often of rough concrete or other material that is difficult to decontaminate, and flushing or scrubbing them with water may only spread the contamination. Therefore, great care should be taken that all body fluids are properly discharged down the drain. In case of accidental overflow, the fluid should *immediately* be taken up as completely as possible with dry disposable waste, held in tongs or forceps, and put promptly into a suitable receptacle.

6. Cremation

In case the body is to be cremated without autopsy or embalming, there will be no preliminary preparation, and no handling precautions are necessary. If previous embalming is to be carried out, the procedures are the same as those discussed earlier; the same applies to cremation after autopsy.

In modern crematories, by a combination of high temperature and forced draft, all soft parts of the body are completely disposed of as smoke or very finely divided ash. At the end of the process only the bones remain on the tray. Since either I^{198} or Au^{198} would be entirely in the soft tissues, it appears that neither would leave any active residue. A small part of the isotope might be deposited on the inner surface of the stack, but most of it would pass out into the air. There it is widely dispersed; there is little data on which to base estimates as to possible concentrations that might be carried back to the foot of the stack. These will depend on stack height, wind velocity, and other conditions. One estimate [6] suggests that with a stack height of 10 m, for the largest doses likely to be administered, and under the worst possible atmospheric conditions, concentration in the air at the base of the stack might be a few times the permissible level for constant inhalation. As such an episode would be a rare one, this transient excess would probably not be serious. However, it is recommended that no body containing more than 30 mC of Au^{198} or I^{131} be cremated without special advice from a competent health and safety consultant. This is not an impracticable recommendation. Treatments at dose levels above 30 mC will have been given in a hospital, and it is quite probable that an autopsy will have been done. For either of the isotopes under consideration, following an autopsy there will probably be very little radioactive material left in the body; thus there will be no contraindication to immediate cremation.

If no autopsy is to be done, somewhat different conditions exist with the two isotopes. With Au^{198} there is no excretion, but radioactive decay is quite rapid; reduction to half occurs in 2.7 days. Accordingly, it is suggested that the body that contains more than 30 mC of this isotope be retained in the hospital morgue until this level is attained. For the maximum dose of 150 mC, this would be 6 days after administration; if death occurred on the third day, it would require 3 days more (see table 1). Withdrawal of as much as possible of the ascitic or pleural fluid, with precautions as indicated in section 3.1 (a), will hasten reduction of the isotope content of the body.

I^{131} decays much more slowly, the half period being 8 days, so that storage of this sort would be less practicable. However, with this isotope at least half is likely to have been excreted in the first 12 hr, and two-thirds in the first 24. Accordingly if death does not occur until the day after administration, the amount of radioactive material present has been greatly reduced by physiologic processes. If death occurs within the first 24 hr, emptying the bladder and withdrawing as much blood as possible may afford a considerable reduction of the I^{131} content. Beyond this, little can be accomplished by a few days delay in cremation. Since, however, the cremation of a body containing anything like the maximum amount of I^{131} will be a very rare occurrence, the possibility of resulting atmospheric contamination as a radiation hazard can be neglected.

7. References

[1] Forthcoming report of the National Committee on Radiation Protection Subcommittee on Permissible Dose from External Sources.
[2] National Bureau of Standards Handbook 51, Radiological monitoring methods and instruments (1952).
[3] National Bureau of Standards Handbook 49, Recommendations for waste disposal of phosphorus-32 and iodine-131 for medical users (1951).
[4] L. D. Marinelli, E. H. Quimby, and G. J. Hine, Dosage determination with radioactive isotopes. II. Practical considerations in therapy and protection. Am. J. Roentgenol. and Radium Therapy **59,** 260 (1948).
[5] National Bureau of Standards Handbook 48, Control and removal of radioactive contamination in laboratories (1951).
[6] J. C. Geyer, personal communication.

Appendix. An Acceptable Form for Radioactivity Report Accompanying Body

NAME OF HOSPITAL

REPORT OF RADIOACTIVITY TO FUNERAL DIRECTOR

This certifies that the remains of ______________________________
have been examined this date by the Radiation Safety Officer or his deputy. Radioactivity close to the surface of the body, as determined by ______________________________________ (is) (is not) below
(state instrument or method)
the rate of 30 mr/hr that is acceptable for embalmers during their work. The maximum permissible dose rate will not be exceeded, *provided* rubber gloves are worn, *and* further precautions are observed as listed below.

Further precautions:_____________________________________

____

____

Signed:_______________________________________
Radiation Safety Officer

Submitted for the National Committee on Radiation Protection.

LAURISTON S. TAYLOR,
Chairman.

WASHINGTON, July 1953.

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