ATTACHMENT 2

REVIEW OF DOSIMETRY
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The Public Health Response to Nasopharyngeal Radium Irradiation:
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REVIEW OF DOSIMETRY

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1. Radium

Radium is a naturally occurring radioactive isotope, with a half-life of 1600 years. For medical purposes it is in the form of a salt, radium sulfate, which is sealed in metal tubes. Figure 1 is a diagram of a radium tube. The wall, sometimes called the filter, of the tube may be brass, monel (a nickel alloy), or a platinum-iridium alloy. For most nasopharyngeal treatments, the overall length of the sources varied from 17 to 22 mm, with active lengths from 12 to 17 mm.

Radium emits three types of radiation: alpha particles, beta particles, and gamma rays. The alpha particles have a very short range and are completely removed by any filter. The beta particles have a relatively short range in tissue; the wall of a radium source removes all or most of the beta particles, depending upon the material and thickness. For example, 1.0 mm of brass removes 90% and 0.5 mm of platinum removes 100% of the beta particles. If beta particles do penetrate the wall of a source, they are completely absorbed within 10 mm of tissue. Gamma rays are the most penetrating radiation and the only contribution to absorbed dose at distances greater than 10 mm.

2. Typical Nasopharyngeal Treatments

Most treatments of benign conditions of the nasopharynx utilized a single radium tube. Figure 2 shows the placement of a radium tube during treatment. Although treatments varied, typical treatments were as follows: the activity, or strength, of the radium tube was 25 to 50 milligrams (mg), with a treatment time of seven to twelve minutes to each side of the nasopharynx. Each patient received from one to six treatments; multiple treatments were given at intervals of three to four weeks.

Treatments also were expressed as the product of source strength and duration in terms of "milligram-hours" (mgh). For example, 50 mg in place for 8 minutes to each side would result in a total of 13.33 mgh. (Milligram-hour is not a unit of dose; a calculation of dose requires a knowledge of the distance between the source and the location of the anatomical site of dose estimation.)

3. Gamma-ray Dose for a Typical Patient

For purposes of illustration, absorbed doses for a typical patient are presented here. The patient received three treatments of 13.33 mgh each (50 mg source in place for 8 minutes on each side) for a total of 40 mgh. Figure 3 is a graph of the absorbed dose in units of centigray (cGy) in tissue from a radium source left in place for a total of 40 mgh. Superimposed on the graph in Figure 3 are the locations of the brain, pituitary, salivary glands, and thyroid of an adult. The large dose gradient across the brain illustrates the difficulty of estimating dose to a large organ near the source. Although one can calculate an average dose to the brain, estimation of dose to more specific anatomical points or partitions is desirable.

Table I shows the organ doses for the typical patient described above. Doses for the adult are taken from the graph in Figure 3; the doses for the child are larger because the organs of interest are closer to the radium source. For this example, the same number of milligram-hours were used for the adult and child; in fact, many pediatric treatments utilized a smaller number of milligram-hours.

The data in Figure 3 and Table I are based on measurements in tissue-equivalent material, with verification by calculation. Radium has been used for medical purposes more than any other radioactive material and methods of deriving absorbed dose in tissue are well-established; essentially the same methods have been used since the 1920's and early 1930's, with refinements due to the advent of computers.

4. Information Required to Estimate Absorbed Dose in a Patient

To estimate the dose at any point in tissue, three things are needed: (1) description of the source, including activity and construction (active length, filter material, and filter thickness); (2) treatment time, and (3) distance between the source and point of dose specification.

In any epidemiologic study, the collection of information regarding exposure is crucial. For the patients considered here, exposure is the absorbed dose to the organ or anatomical site appropriate for a particular study. Information required to assess exposure should be derived for each individual in a study, based on that person's treatment record. Usually, data concerning the source activity and time of treatment will come from the patient's record. Additional information may be available in institutional

records, such as certificates of source calibration from the manufacturer or the National Bureau of Standards (now the National Institute of Standards and Technology). Institutional records also may include log books or card files which state when sources were removed from and returned to the radium safe. Where possible, redundant records should be linked in order to ascertain whether there are missing or incomplete records.

Age-specific distances from the source to the organ of interest are taken from published data, usually anatomy textbooks.

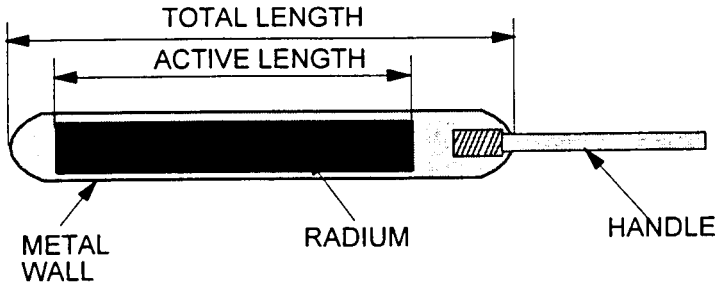
5. Other Types of Treatment

Although most nasopharyngeal treatments utilized radium, some publications indicate that treatments were given with radon sources. Radon, a gas, is a daughter product of radium; like radium, it is sealed in metal tubes and emits the same types of radiation. The principal difference is that radon has a half-life of 3.8 days; the short half-life means that it is necessary to know precisely when the strength of a radon source was measured in order to calculate accurately the absorbed dose in the patient. The activities of radon sources may be expressed in millicuries or milligram-radium-equivalent. For the same total milligram-hours, organ doses from radon will be the same as those from radium.

External beams of x-rays also were used to treat benign conditions of the nasopharynx. These were typically orthovoltage x-rays of approximately 200 to 280 kVp. The beams were lateral parallel-opposed, directed to the nasopharynx. The dose to organs in the head and neck depends highly upon the sizes and the radiation energy of the beams.

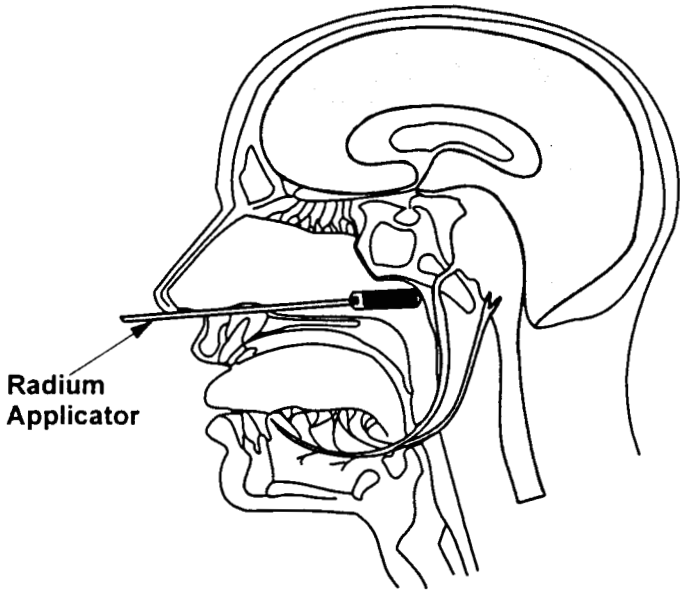
For both radon and external beam treatments, calculation and measurement methods are available to estimate absorbed dose at any anatomical site of interest if information concerning the treatments is available.

FIGURE 1



NASOPHARYNX RADIUM APPLICATOR

FIGURE 2



Section of Nasopharynx Showing Radium Applicator

FIGURE 3. DOSE FROM 40 MGH OF RADIUM

50 mg active length of Radium, 8 minutes each side, 3 treatments

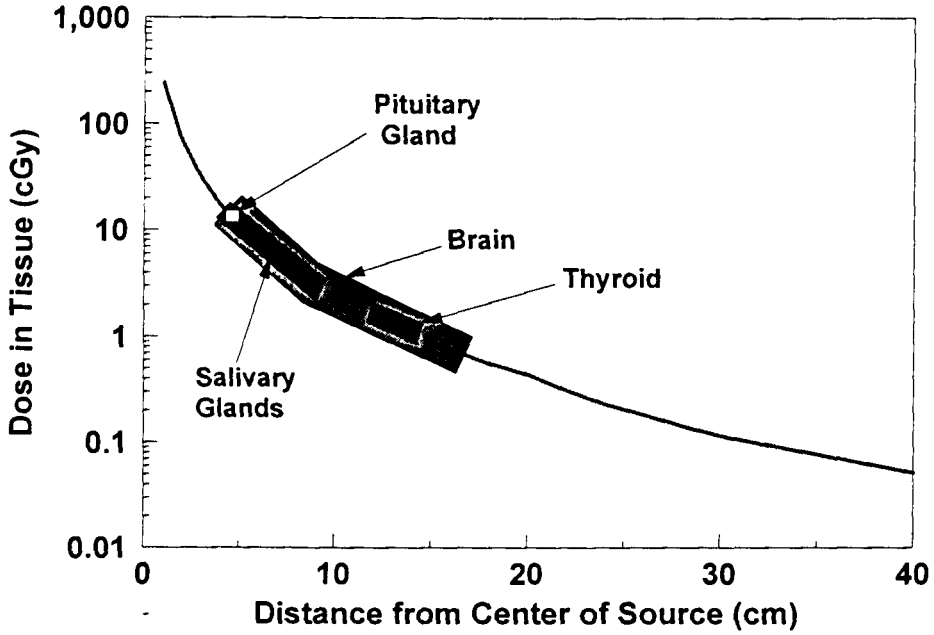


TABLE I
TYPICAL ORGAN DOSES (cGy) FROM A NASOPHARYNGEAL TREATMENT

Series of 3 treatments:
Source: 50 mg radium, 0.5 mm Pt filter, 15 mm active length
Time: 8 minutes to each side of Nasopharynx
Mgh: 40

	Adult	Child (6 year old)
Brain	3 (0.7 - 16)	4 (1 - 19)
Pituitary	16	27
Salivary Glands	8.5 (3 - 17)	11.1 (5 - 27)
Thyroid	1.4	3.1

Note: The above doses are intended as guidelines only and should not be used in an analysis of epidemiologic data.