terms of each of the 27 diseases. In each instance the weighted average—that is, the ratio of the weight of the hospital data to the sum of weights of all data of the disease—was determined. The actual diseases present scored highest in terms of weighted averages, and the correct diagnoses could be confirmed by referral to the definitive diagnostic criteria. In addition, it was possible to identify diseases which closely resembled the diseases in the hospital case and to note similarities and differences. In one instance the set of diagnoses in the hospital record was incomplete, but mechanical correlation of data by the afore-described procedure resulted in presentation of a complete set of correct hematologic diagnoses.

Study of the methods of correlation of data described in this report revealed that these operations can be performed by electronic computing procedures available at the present time (*5*). Tabulation of the findings can also be made automatically. It is believed that further evaluation of the efficiency of these methods in correlating data of this type is indicated.

MARTIN LIPKIN*
JAMES D. HARDY
U.S. Naval Air Development Center, Johnsville, Pennsylvania, and *School of Medicine, University of Pennsylvania, Philadelphia, Pennsylvania*

References and Notes

1. I. Bowman, in *Report to the President on a Program for Postwar Scientific Research* (Government Printing Office, Washington, D.C., 1945).
2. V. Bush, *Med. Ann. Dist. Columbia* **22**, 11 (1953).
3. M. Lipkin and J. D. Hardy, *U.S. Naval Air Development Center* (*Report NADC-MA-5505,* Johnsville, Pa., 1955).
4. M. Wintrobe, *Clinical Hematology* (Lea and Febiger, Philadelphia, 1951).
5. V. K. Zworykin, personal communication.

* Present address: Department of Medicine, New York Hospital–Cornell Medical Center, New York, N.Y.

22 January 1957

Radon Solubility in Rat Tissues

An estimation of the tissue radiation dose that arises from the inhalation of air containing radon can be made if, among other factors, the solubility of radon in various tissues is known. In the absence of such information, it has been customary to base estimates of the quantity of radon dissolved in the body on the following assumptions: (i) that radon solubility per gram of aqueous tissue is approximately equal to radon solubility per gram of water or physiological saline at body temperature; (ii) that radon solubility in the fatty tissues is comparable to the solubility of radon in some reference fatty substance such as olive oil.

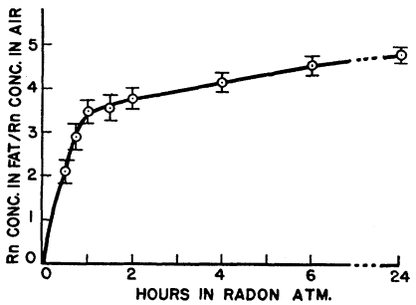

Fig. 1. Radon uptake by fat as a function of time of exposure. The vertical lines represent 95-percent confidence limits.

The values reported for the mean solubility of the entire soft tissue mass in man, based on such assumptions, range from 0.27 to 3.3 times that of the radon concentration in the inspired air (*1*).

The experiment reported here was undertaken to determine the solubility of radon in selected tissues of the rat and to study the rate at which radon is taken up by the fatty tissues that constitute the body's major reservoir of radon.

Adult Rochester Wistar rats were placed in a 14-lit Lucite inhalation chamber having separate cubicles for six rats. Expired carbon dioxide was absorbed on soda lime, and oxygen was continually supplied to maintain its initial concentration in the chamber air. A 30-minute trial period, to insure that the apparatus functioned properly, preceded the addition of radon to the chamber atmosphere. Except for radioactive decay and losses owing to inhalation, the radon concentration remained constant throughout a given experiment at levels ranging from about 0.5 to 5 μc/lit of air, as was determined from air samples withdrawn periodically from the chamber.

Exposure periods in the inhalation chamber ranged from 30 minutes to 48 hours, after which the rats were killed by the introduction of 1 lit of carbon monoxide into the chamber. Death occurred within 2 to 3 minutes. Rats were removed from the chamber, and specified tissues were dissected. Tissue samples (0.8 to 1.5 g) were rapidly placed in tared test tubes (50 by 12 mm) (control experiments in which tissue transfer was intentionally delayed indicated that the radon loss in the routine tissue transfer was equal to or less than 5 percent.) Close-fitting glass plungers were inserted into the test tubes until they came in contact with the tissue and were sealed to the test-tube walls with wax.

The relative gamma activity of the air and tissue samples was determined by counting in a well-type sodium iodide scintillation counter after allowing 4 hours for the build-up of radium C. Later recounts of the same samples showed no radon loss except that resulting from decay.

The distribution coefficient (radon concentration per milliliter of tissue/radon concentration per milliliter of air) at equilibrium was found to have the following mean values and standard errors: omental fat, 4.83 ± 0.07; venous blood, 0.405 ± 0.016; brain, 0.309 ± 0.008; liver, 0.306 ± 0.004; kidney, 0.285 ± 0.012; heart, 0.221 ± 0.013; testis, 0.184 ± 0.007; muscle, 0.154 ± 0.005. Experimental results indicate that the maximum, or equilibrium, value of radon concentration is attained much more slowly in fatty tissue than in any other tissue investigated. Tissues other than fat were essentially in equilibrium after 1 hour, and no consistent increase in radon concentration could be detected in any one of the other types of tissue by continuing the exposures for more than 1 hour.

The distribution coefficient shown for omental fat was determined by exposing rats to the radon atmosphere for 24 to 48 hours. The rate of build-up of the radon concentration in the fatty tissue can be observed in Fig. 1, which shows the increase of the distribution coefficient for omental fat with increasing periods of exposure. A half-equilibrium value is attained in about 30 minutes, and after 6 hours the value is at 95 percent of equilibrium. The curve presents data obtained from 90 rats, and the 95-percent confidence intervals are indicated for each value.

The information in Fig. 1 can be further evaluated by plotting it on semilogarithmic paper as follows: the value of the distribution coefficient at any time t is subtracted from the equilibrium value of the distribution coefficient, and this difference is plotted as a linear function of exposure time. If the curve shown in Fig. 1 represented a single exponential function, then the semilogarithmic plot would yield a straight line. On the contrary, the plot shows a sharp break in the semilogarithmic curve at an exposure period of about 1 hour. Such a plot appears to represent a process having two components with different time constants. The half-time for the fast component is 21 minutes; that for the slow component is 138 minutes. Such bimodality in gas uptake by adipose tissue has been suggested by H. B. Jones (*2*) on the basis of nonuniformity of blood perfusion within a tissue. Very few studies have been conducted on the uptake and loss of inert gases in single tissues.

By applying to man the values for the solubility of radon in various tissues of the rat, Black (*3*) has calculated that the mean solubility of the entire soft tissue mass in man is 0.89 as compared with earlier estimates ranging from 0.27 to 3.3 (*4*).

E. NUSSBAUM
J. B. HURSH
School of Medicine and Dentistry, University of Rochester, Rochester, New York

References and Notes

1. F. W. Spiers, *Brit. J. Radiol.* **29**, 409 (1956); J. B. Hursh, *Univ. of Rochester Atomic Energy Project Rept. UR-258* (1953).
2. H. B. Jones, *Advances in Biol. and Med. Phys.* **2**, 53 (1951).
3. S. Black, *Univ. of Rochester Atomic Energy Project Rept. UR-463* (1956).

4. This report is based on work performed under contract with the U.S. Atomic Energy Commission at the University of Rochester Atomic Energy Project.

11 October 1956

Instrumentation of Fetal Electrocardiography

During the past two decades maternal mortality has been progressively reduced. With the same standard of pediatric care, the reduction in stillbirths and neonatal mortality has been only a small fraction of the gain made in maternal mortality. In addition to the 160,000 infant deaths associated with the birth process each year, there are a large number of infants afflicted with cerebral palsy and mental retardation. It is possible that these problems find a common basis in fetal anoxia.

If significant gains are to be made in this area, a reliable means of accurately determining reversible "fetal distress" must be found. The present "normal" parameters of the fetal heart rate during labor have been charted from periodic auscultatory sampling and are therefore open to some question. If "fetal distress" is to be defined in terms of fetal cardiac rate and rhythm, the limits of "normal" must be defined accurately.

Because only minute amounts of fetal energy are available for study on the anterior abdominal wall of the mother, the basic problem is one of instrumentation. The types of fetal energy which can be detected with present instrumentation are as follows: (i) electric energy—electrocardiogram and electroencephalogram—and (ii) mechanical—phonocardiogram and infrasonic (less than 15 cy/sec).

Since Cremer's (*1*) success in recording the fetal electrocardiogram in 1906, there have been a number of reports of fetal electrocardiographic studies. By and large, the instrumentation has been limited to some type of preamplifying apparatus used with a standard electrocardiographic machine or an electroencephalograph. In many instances fetal *QRS* complexes were identified, but there are few records that show consistently recognizable *P* and *T* waves.

This preliminary report (*2*) outlines an instrumental approach to fetal distress using fetal electrocardiography for determination of the normal fetal heart rate throughout the course of labor and the notation of any changes of rate and rhythm which may be related to uterine contractions or abnormal obstetrical conditions.

In order to record accurately the fetal heart rate throughout labor, some means of removing the maternal electrocardiogram must be employed, since both electrocardiograms are present as vectors in a volume conductor. In principle, this is done by in-phase canceling of the maternal complex in a differential amplifier (Fig. 1). One input channel is connected to electrodes from the lower abdomen of the pregnant patient, where both maternal and fetal electrocardiograms are present. The other input channel is connected to two electrodes on the upper abdomen, where the maternal electrocardiogram alone is present. This maternal complex should be of the same configuration and amplitude as the lower one, for it is used for cancellation. Discrimination against outside electric interference is achieved by using differential amplifiers ahead of the canceling amplifier.

The tracings shown in Fig. 2 demonstrate experimental results that can be duplicated in the majority of patients throughout the course of labor. However, the necessity for matching and balancing one complex against another is a disadvantage, and current exploration of a system for rectification, integration, differentiation, and gating appears to offer a simpler solution.

In order to provide the most accurate definition of the normal fetal heart rate during labor, it is desirable to record it continuously and relate it graphically to the amplitude of the uterine contractions. Experimentally, this is a laborious task. In a 10- to 15-hour labor there are about 100,000 to 150,000 pulse intervals to be measured and plotted against about 150 uterine contractions. Currently it takes about 150 hours of technician's time to process one complete labor. If any reasonable number of labors are to be studied, some type of semiautomatic data-reduction system must be used.

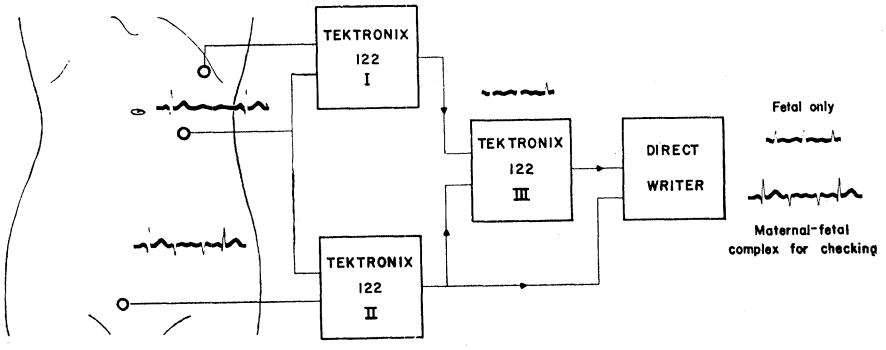

Fig. 1. Apparatus for cancellation of the maternal electrocardiogram. The Tektronix model 122 preamplifiers were connected as shown; the two-channel, direct-writing electrocardiograph is manufactured by the Elema Instrument Co., Stockholm, Sweden.

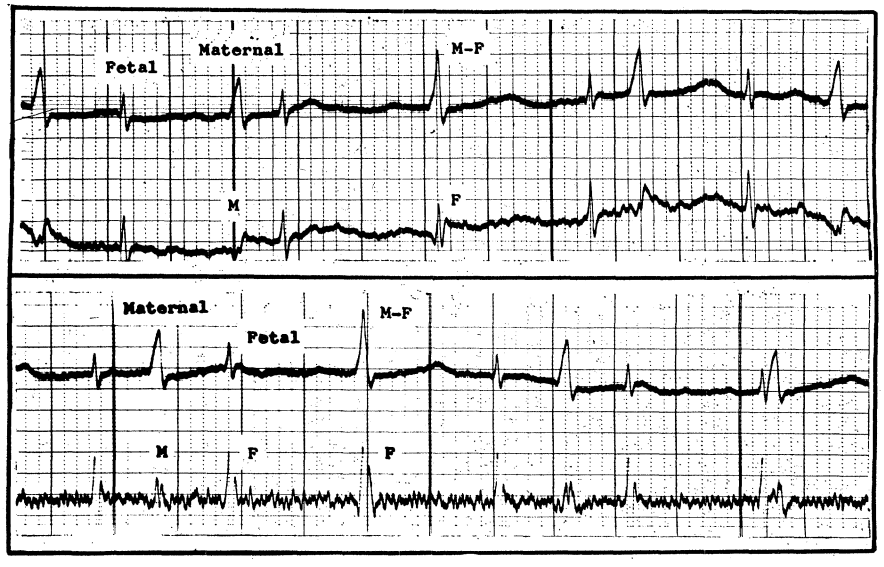

Fig. 2. Cancellation of maternal electrocardiogram: two records obtained with the two-channel electrocardiograph. The upper channels of both tracings show maternal and fetal electrocardiograms. The lower channels show only the fetal electrocardiogram, with cancellation of the maternal electrocardiogram. The lower channel of the bottom tracing shows differentiation for electronic counting.