FACTS, FABLES AND FOLLIES IN MEDICAL RADIOLOGY

Richard H. Chamberlain, M.D.
Chairman and Professor
Department of Radiology
Hospital of the University of Pennsylvania
3400 Spruce Street
Philadelphia, Pennsylvania 19104

It is repeatedly said that medical radiology is the largest single man-made source of radiation exposure of human beings. Not only is this true, justifying a considerable emphasis on medical radiology by all members of the International Radiation Protection Association, but it would be surprising if it were not true. Medical radiology is the only legitimate situation in which radiation exposure is purposefully given to human beings for their own benefit. It would be more remarkable, if not alarming, if any other man-made source exceeded it in human exposure.

As radiation protection experts, all of us should be well informed and have an accurate perspective of many of the aspects of medical radiology. We should also be able clearly to distinguish between facts, on the one hand, and the frequent fables and follies circulated and committed in the name of medical radiology, on the other. Radiation protection experts should have reasonably complete and accurate answers to such questions as: How much good is diagnostic radiology in medical practice? What is it particularly good for? How available is it? How well is it provided in different circumstances? What does it cost? How safe is its use and what can reasonably be done to make it even safer? Finally, how can radiation protection experts help to improve medical radiology in truly important ways?

I prepared this paper before the Congress began. It seems even more relevant after what you heard at the opening session and what was reported and emphasized in the news media from Mr. Lapp's presentation. You were told a large number of facts and subjected to much clever reasoning on radiation perspective in the United States of America.

Less in anger than in sadness, I must also say that you were subjected to some unfortunate fables, based on a series of "assumptions," and some dangerous follies were proposed, when Mr. Lapp strayed from his area of competence into pronouncements on medical radiation and what to do about it.

My viewpoint and attitudes are those of a physician-radiologist who has devoted a major part of his professional energies for over 35 years to the use of radiation in medicine. I have had three special interests: first, personal involvement in the medical care of individual patients, particularly in radiological diagnosis; secondly, appreciation of what is known of human radiobiological reactions, both somatic and genetic; thirdly, the constantly increasing applications of developments in physics, electronics and engineering to the production and control of x-ray beams, and to the improvement of methods of obtaining images of human structures. These interests have led

me to major involvement and commitment in two action programs. One is promotion of the principles and methods of expert and efficient use of radiation, commonly called radiation protection, which I prefer to call the thrifty use of radiation for medical diagnosis. It seems to me that the word thrifty more nearly expresses the concept of a proper balance between risk and benefit than does the word protection. No doubt my preference for the old fashioned term is influenced by the tradition of Benjamin Franklin and my Philadelphia environment. The second action program has been a dedication to the delivery of fine and appropriate radiological care to population groups large and small, both in the United States and abroad, and especially in disadvantaged and developing countries and areas.

What are some of the facts about the value of diagnostic radiology in medical management? In ecomonically advantaged situations, where sophisiticated medical radiology has been fully developed, experienced clinicians largely agree that from one-third to one-half of all the truly important decisions that they make for individual patients are based on radiological studies. These decisions are not only for the original discovery or diagnosis of disease and abnormality but also for intelligent and effective follow-up of the disease process and its treatment.

Three general levels of use can be related to a division of the types of diagnostic radiology into basic, advanced, and special examinations. As illustrated in Table I, basic examinations include reasonably simple studies of the chest, extremities, abdomen, head and spine. Advanced examinations frequently require the introduction of radio-opaque contrast materials and include studies of the stomach, small intestine, gallbladder, colon and kidneys. Special studies include the more elaborate examinations of the vascular system generally referred to as angiography, air studies such as pneumoencephalograms, etc.

Table I

Types of Diagnostic Radiology

1.	BASIC:	Chest, Extremities, Abdomen Head, Spine.
2.	ADVANCED:	Stomach, Small Intestine, Gallbladder, Colon, Kidneys.
3.	SPECIAL:	Angiography, Air Studies, etc.

Even though the full spectrum of examinations is available in fully advanced medical installations, it is interesting that the simpler basic studies are not only more easily made available but also have higher yield of benefit for most patients. The true value of a major tool in medical care, such as diagnostic radiology, is not to be measured only in mortality statistics or any other oversimplified criterion. The quality of life and the sense of well-being and health of the individual is of primary concern, although we all hope also for longevity. Medical statistics are not a group commodity but are made up of the contributions of each personal unit. In economically disadvantaged areas, the well-being of the individual patient reflects on the family and national welfare to an even more critical extent than in advanced countries, concerned as we are with such things as the rising cost of medical care in all nations. The patient with a broken bone, or active tuberculosis, or a hemoglobin of 7 or 8 grams due to multiple intestinal

parasites or malaria is not only sick himself but may be a critical detriment to his family and to the national productivity. The restoration of such an individual to productive life can be triply effective by converting him from being a burden, through neutrality, to making a positive contribution to the family and national economy.

Many fables are in circulation concerning the use of medical radiological diagnosis. Some persons seem to believe that the present use is excessive, that it ought to be limited to extreme urgency and that rigid rules are justifiable in prohibiting the small doses needed for diagnostic purposes, especially in potentially pregnant women and in the case of the fetus. I would not wish to give the impression of condoning promiscuous and random waste of radiation exposures. As a physician, however, I would like to emphasize that rigid rules are almost never sensible in clinical practice, that in a high proportion of radiological examinations one cannot anticipate the beneficial yield until the examination has been performed, and that the omission of a vital examination can lead to a disaster far more important than a possible or statistical risk from the radiation exposure. I wholeheartedly urge that considered judgment be used in each individual decision for radiation use. I view as follies the emphasis on expensive, elaborate and essentially useless programs of national recordkeeping of medical exposures, simplistic rules as to the justification of abortion on a radiation basis and undue emphasis on radiation protection programs in areas which should be using those same energies to furnish more medical radiological diagnosis for their people within their extremely limited national economy.

The availability of medical radiology in advantaged countries is documented by such surveys as the XES 1964 and the XES 1970 studies in the United States of America. These studies show that diagnostic examinations average to half of the population per year and are available essentially equally to different economic groups. Less reliable is a precise documentation of the availability of diagnostic radiology and, indeed, of medical care generally to developing areas. It seems likely, however, that of the approximately 3.5 billion of the world's population, as many as 2 to 2 1/2 billion have essentially no modern medical care, including medical radiology. It is a fable to imagine that the full spectrum of highly developed radiological diagnostic equipment and service can be transplanted directly to developing countries. With gross national product figures of the order of $200 to $300 per capita per annum, with no facilities for maintenance, totally inadequate educational systems and with far more pressing needs for basic medical control of infectious diseases, sanitation, and nutrition, they face stark reality in choice of emphases. Well meaning though the intent may be, it is also folly to imagine that the furnishing of yearly monetary aid for immediate consumption, or the sending out of small groups of physicians from advantaged countries for service can solve these problems. Aid in the form of money and people can, however, be helpful and effective if applied to assistance of developing nations to help themselves. I quote, from an unknown source:

> "If you give a man food
> You feed him for a day,
> But if you teach him how to grow his own,
> He can feed himself for life."

We also have some facts as to the current levels of the safety of the use of diagnostic radiology and of the costs. The full spectrum of modern diagnostic radiology can be enormously expensive; the increasing sophistication of the application of modern developments in electronics and physics, as well as the

general inflationary trends, are constantly raising those costs. Most of them, however, apply to the advanced and special studies which, desirable though they are for the individual patient, are generally less crucial in medical conditions which have a highly favorable prognosis. An impartial view would lead me also to propose that the associated radiation exposure, in even the most advanced nations, is acceptable both in terms of the actual radiobiological probabilities of somatic and genetic damage and in relation to the stark and unfulfilled health care needs and the variations within natural background. Fables are also in circulation concerning the safety of medical diagnostic radiation and, largely through misunderstanding or misquotation, have resulted in headlines attributing tens of thousands of deaths to diagnostic medical radiology. I simply do not believe, nor is there real scientific proof, that we are "killing" people with diagnostic radiology, even in those nations where it is being most widely used. I hasten to add, however, that I do not condone truly wasted radiation and believe that careful study and major attention should constantly be paid to both confining it to the area being examined and striving for higher efficiency. This brings us, however, to the difficulties and even the dilemmas of establishing cost effectiveness. It is always possible to use somewhat less radiation, no matter how low the exposure may be in any particular situation. This can be done either by much more elaborate pre-studies and identification of what is thought to be the precise problem or by the use of much more elaborate apparatus. In practice, however, there comes a point at which a very low dose simply does not justify the expenditure of excessive effort and cost to reduce it a tiny fraction further. A loss of perspective in this regard has led to what I consider to be a folly in our own nation, the proposal of regulations with undue emphasis on the percentage variation allowable in x-ray generator tolerances, and on elaborate feed-back control of collimation, most likely highly prone to greatly increased service problems. I believe that my opinion is supported by the XES 1970 study, which shows that the greater portion of the improvement likely to be achieved in collimation has already occurred between 1964 and 1970, without governmental regulation, but rather by education and voluntary cooperation.

I would like to make a plea that we refrain from playing the "numbers game" of extrapolated pseudo-statistics, which seems so popular these days, especially when human health and life are at stake as in clinical medicine. Fables are <u>not</u> converted to established facts by assumptions! We can sometimes excuse fables if they are harmless exercises of the imagination. We cannot excuse resultant follies if they stem from ignorance of elementary understanding of medicine, health, and the nature of diagnostic decisions for individual patients. Then they truly endanger the welfare of almost everyone--for <u>all</u> of us will eventually encounter illness and come to death.

Let me try to illustrate the cruelty of such folly. Mr. Lapp "calculated" 50,000 iatrogenic cancer deaths from diagnostic medical radiation in a little over 25 years. I reiterate that this was based on many "assumptions" and is <u>not</u> scientific fact. It divides into approximately 2,000 cases per year, however.

In the three hospitals for which I am the Director of Radiology, my staff and I perform a little over one thousandth of all the diagnostic radiological examinations per year in the United States. Even though we try to use as superb techniques as are available and practical within our financial limitations (and I think this may be better than the national average), we also have a high proportion of difficult, elaborate, and comprehensive examinations, with associated radiation doses that are higher than average.

If what Mr. Lapp contended were true, we could be producing 2 or more iatrogenic deaths per year. But let us now look at the real perspective in medical radiology. For this supposed risk, my staff and I are doing nearly 200,000 diagnostic radiological examinations per year. We not only interpret the films and do the associated procedures and fluoroscopies, but also know why the patients are being studied. In a large proportion of the cases, we personally consult with the other physicians involved regarding the original problem and its follow-up.

Beyond any shadow of doubt, our examinations are either the vital factor, or a major one, in saving tens of thousands of lives per year. I extend to Mr. Lapp, and to any of you, an invitation to come and see what really goes on in medical radiology -- and I am sure that great numbers of my radiologist colleagues would do the same.

To propose, as Mr. Lapp is reported to have said, that these examinations or their exposures could and should be reduced by 50% is not only folly and arrant nonsense, but would literally be condemning tens of thousands of patients to misery and untimely death, and for a highly dubious hypothesis of exaggerated emphasis. There are much higher priorities for intense attention.

I have dedicated a major part of my life to the cause of what I have referred to as "thrift" in the use of radiation. I can tell you that it is not easy or cheap to cut procedures or exposures in half. It may well cost triple or more for the same diagnostic information. This may well deny its accessibility to thousands of patients. Furthermore, if you had the choice of applying the same effort and cost to other directions which might save hundreds or thousands of lives, which would you have us choose?

The greatest cruelty is when, through the way in which it is reported, credulous people may be so confused or fearful that they forego needed radiological examination for their health and life.

For many years I have been seeking solutions to the need for simplified systems of equipment, associated with simplified education of technologists and physicians, and simplified service and supplies. In recent years this has resulted in a concept that I have called the "Technamatic System" of Radiology. It has been developed on principles of systems engineering to satisfy not only these aims, but also to bypass the difficulties of deficient and unstable electrical power supplies, to produce superb and reproducible quality of films, to have optimum characteristics of radiation safety, and to perform all of the basic category of examinations as well as the radiographic portions of some advanced studies. Hopefully, at least in large volume production, such apparatus is within economic feasibility and the education requirements are attainable. In four years of practical field trials with the units, in conjunction with the University of Saigon School of Medicine, my staff agree that it "performs as hoped for." I have also gained some other experience with its use in an Emergency Clinic and, as applicable, to various examinations in a large teaching hospital.

Figure 1 shows an overall view of the stand design which features fixed distance from tube to film plane, fixed axial centering, a high quality, fine-line stationary grid, an adequate range of vertical movement of the tube-film carrier C-arm, and a wheeled litter which acts as a poor-man's floating top. Without the litter it can be used for extremities. Rotated to a horizontal beam, it is applicable to erect chest examinations, as in Figure 2, or erect skull studies. Only 2 sizes of films, in appropriate cassettes, are used, 14" x 17" filling the film slot and 10" x 12" centered with a spacer-tray. A simple two-position rotating-box double collimator ensures precise collimation to the two film formats (Figure 3). The x-ray beam is furnished by a

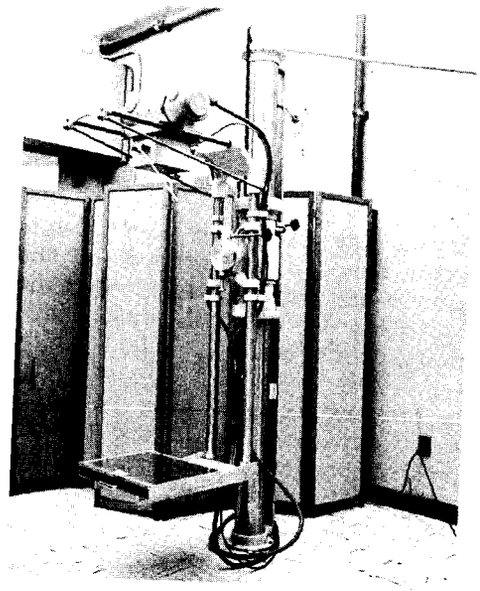

Figure 1.

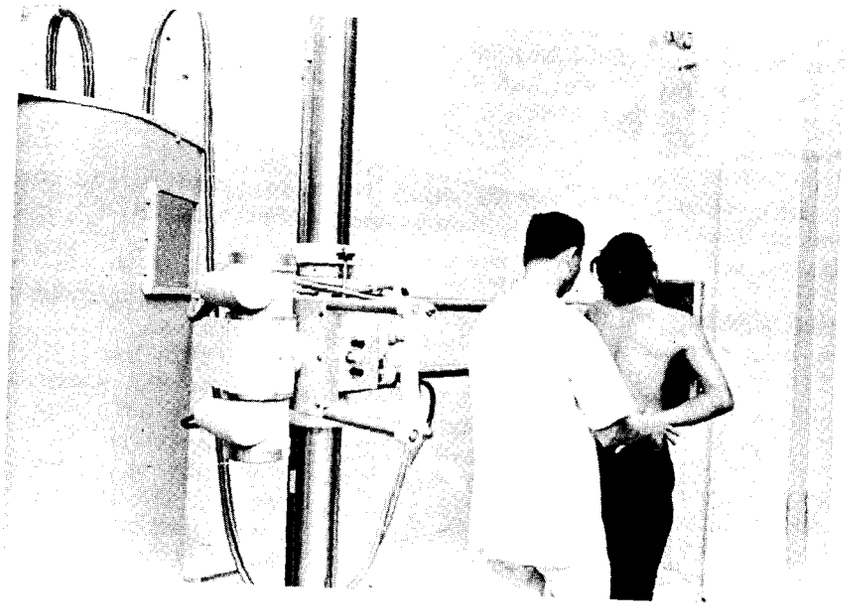

Figure 2.

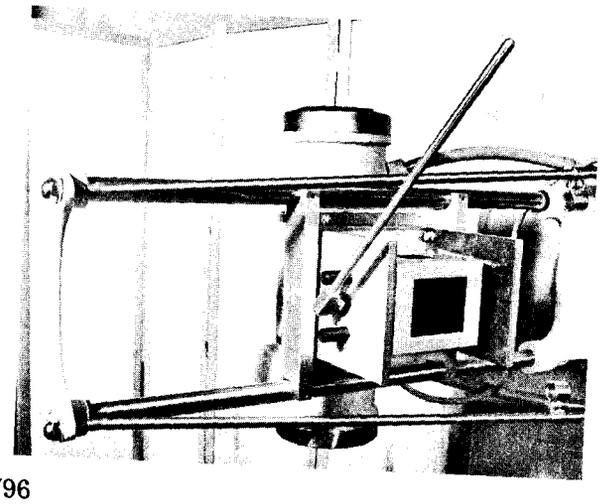

Figure 3.

500 Hz inverter at 100 milliamperes and 110 kV maximum, energized by high capacity nickel-cadmium batteries which also furnish filament and anode-rotor power. The controls are quite simple. High temperature hand-tank film developing has also been provided. The scope of examinations attainable is surprisingly complete and is shown in Table II. Simplified manuals for education of technologists and for daily use, applied specifically to this system, allow excellent performance after as little as 6 to 8 weeks training. They are easily translated into local languages. Tens of thousands of superb films so made are of such high quality that accurate diagnoses of fractures, pulmonary tuberculosis, and regionally prevalent disease are possible by physicians with only a few months radiological education. The good films also are suitable for referral to radiological specialists for consultative opinions. Service and supply problems are minimal compared to those posed by more complex apparatus, of various designs, and with less direct simplicity.

Obviously, many of these features have been dictated by the special needs and limitations of developing countries, but comparable advantages are also apparent when these concepts have been applied to small towns, inner city health centers, and special areas such as emergency clinics in hospitals in "developed" countries.

This example hopefully illustrates how practical, balanced, efficient, and deliverable solutions may be found to satisfy the multiple demands imposed by medical needs, poor financial and educational resources, and yet with due attention to high film quality and good radiation protection practice.

In conclusion, may I re-emphasize five points as follows:

1. There is a great need, for much of the world an unaccessible need, for the benefits of medical radiology for the good of mankind.

2. These needs can be met with due regard to acceptable radiation safety.

3. Emphasis on regulatory methods to ensure radiation safety is likely to be largely futile and much less desirable than emphasis on education and improved engineering.

4. Great future advances in the service of mankind are attainable through sound concepts of systems engineering which fits solutions to needs.

5. Radiation protection experts can exert great influence for good by discouraging narrow viewpoints and distorted emphases, and promoting balanced programs based on larger perspectives.

Mr. Lapp closed with a plea for you, in the International Radiation Protection Association, to assume individual responsibility to persuade the medical profession to reduce the diagnostic dose. I have also closed with a plea for you to work for dose reduction, but to work for it in areas where you have knowledge, experience, and understanding. May I also suggest that you be sure that you know the facts before leaping into areas beyond your expertise.

My favorite motto to post on the wall of scientific laboratories and workshops as well as in clinical areas is: "Are you working on the Answer; or are you part of the Problem."

TABLE II

DIAGNOSTIC RADIOLOGY PROCEDURES WITH THE TECHNAMATIC SYSTEM

HEST
PA & Lateral

INGERS
PA & Lateral

AND
PA & Oblique

RIST
PA & Lateral
Ulnar Deviation

)REARM
PA & Lateral

LBOW
AP + Prone/Supine
Lateral + Prone/Supine

JMERUS
AP & Lateral

HOULDER
AP
Internal & external rotation

)OT
AP & Oblique
Calcaneus lateral

IKLE
AP & Lateral

:G
AP & Lateral

IEE
AP & Lateral

IMUR
AP & Lateral

P
AP Regular & Frogleg
Lateral

ULL
AP & PA
Lateral right and left
Special - Waters, Towne

MANDIBLE
AP & Oblique

SINUSES
Waters
PA & Lateral

CERVICAL SPINE
AP & Lateral
Lateral flexion/extension

RIBS
AP & Oblique

THORACIC SPINE
AP & Oblique

LUMBAR SPINE
AP & Lateral
Lateral L/S junction

CLAVICLE
AP

ABDOMEN
AP Supine and Erect
Lateral
Right and Left Decubitus

UROGRAM
AP Supine and Erect
AP Pelvis

GB
AP & Oblique
Decubitus

PELVIS
AP

PREGNANCY
PA
Erect Lateral