Radiation Injury: A Technical and Legal Survey

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Scope

Application of the law to technical subjects can often be criticized by one skilled in that particular technical field. The expert in the courtroom must be quite careful that he does not get so involved in the fine points of the technical subject that he fails to make his point as to the important legal facts. Whether the opposing attorneys are apt to help or hinder him depends largely upon which side the technical truth favors.

If a lawyer is to properly use qualified technical help in the preparation of his case he must have both an "everyman's" view and a technical view of the matter on trial. While the technical library will often help the lawyer to obtain the knowledge he needs, he usually will be handicapped in finding it unless he has a basic working knowledge of the subject in which he is interested. So basic a thing as scientific language may be the source of great difficulty in some fields.

In the field of radiation damage much has been written and many scientific opinions have been given. As to legal decisions, there is much to criticize from a technical point of view in the early X-ray cases, particularly in regard to the leeway allowed to physicians in treating their patients through use of a new tool. The following survey is intended to serve to give to the lawyer a basic working knowledge of the subject of radiation. With this, plus knowledge of general principles of law, common sense should enable him to get his client's point across to the judge and the jury.

A primary objective of this portion of this paper is to establish the relations between various types of radiation as to sources and effects.

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One identity that is often overlooked, for example, is that of X-rays and the gamma rays of atomic disintegration. Knowledge that they are the same should give us a less hysterical view of atomic radiation, since we have all come in contact with X-ray equipment and know that it can be properly controlled and used for human benefit.

Measurement of the effects of all types of radiation can be simplified by measuring in common terms. Work is the union of energy and time, and in the electrical scheme is usually measured in kilowatt-hours. It is upon this basis that we pay our power bills, and it is in a unit of the same dimension, though smaller size, that we attempt to measure radioactive energy and its effects. The use of work-energy units is basically a practical approach and is subject to relatively little error when calculations are made. To avoid confusion, many common radiation terms are entirely left out in this discussion, because they cannot be adequately defined on a non-technical basis without unduly lengthening this article.

Types of Radiation

The most common type of dangerous radiation is the X-ray. An X-ray is the same type of radiant energy as is light, except that it is more energetic. X-rays which are close to light in their energy levels are called soft X-rays; and the more energetic ones are called hard X-rays.

Still higher on the energy scale are the gamma rays. Gamma radiation can be produced by radioactive decay of certain unstable elements such as radium. Each radioactive disintegration usually produces one photon of radiation; and each electron striking the target of an X-ray tube may produce one photon of radiant energy. These photons travel with the speed of light, and are weightless, as also is light.

The energy level of a gamma ray or an X-ray is determined by its wavelength and frequency, just as is the energy of light. The visible effect of different wavelengths in light is color. Each wavelength is associated with the particular amount of energy needed to produce a photon of such wavelength, and this is commonly expressed in electron volts. An electron is the smallest charged particle in the atomic universe. If it is in motion, and that motion can be stopped by a retarding potential of one volt, it is said to have one electron volt of energy. If this energy is used to make a photon, then the photon has one electron volt of energy.
From the red end of the visible spectrum, at 1.8 electron volts, to the violet end of the spectrum, at 3.1 electron volts per photon, we can go on to radiation in the billion electron volt range. X-rays are generally considered to start at energies of 1000 electron volts per photon.

**Beta particles** are accelerated electrons. Their source, conventionally, is radioactive decay, but any accelerated electron will act in the same way that a beta particle will act. Since these particles are electrons, their energy level in electron volts is the retarding potential needed to stop them. If they strike, or pass close to an atom, they will either ionize it or will produce a photon of radiant energy. A stream of beta particles (electrons) directed to the target of an X-ray tube, will produce X-rays. When an atom is ionized, an electron is knocked from it and the atom is then in a more energetic state. The beta particle or photon passing by is reduced in energy by the amount that the ion is raised in energy above its original level. The beta particle is one of the chief products of any radioactive disintegration, and may appear alone or in conjunction with other types of radiation.

The **alpha particle** is also the product of atomic disintegration, and is a heavy, short range particle. It is one of the primary products of the decay of radium, and consists of a helium atom with two electrons removed. It is not generally found except as a product of decay of the very heavy radio-elements.

**Protons** are hydrogen atoms with the electron removed, leaving them as positive hydrogen ions. They are but rarely produced outside of particle accelerators, and will not be mentioned further.

**Neutrons** are uncharged particles of approximately the same mass as protons, but, due to their lack of charge, may penetrate into other materials for large distances. Virtually their only source is a working atomic pile.

**Measurement of Radiation**

The common unit of radiation mensuration is the Roentgen. This is commonly abbreviated as the r, and it consists of such radiation as will produce in one cubic centimeter of air 1 electrostatic unit of ionic charge. The energy necessary to do this is 83 to 85 ergs per gram of air, or $5.3 \times 10^{13}$ (5.3 times 10 raised to the 13th power) electron volt-photons per gram. Since the energy needed to ionize a gram of air is approximately the same
as is absorbed in a gram of tissue from the same radiation, the damage done to tissue can be calculated in terms of energy absorbed from the radiation. The number of r units a particular bit of tissue has absorbed thus is a direct measure of damage to that tissue.

To measure radiation, an ion chamber is commonly used. An ion chamber consists of a known volume of air or other gas at a known pressure and means to collect and measure all of the ions produced within the volume. Ion chambers are normally calibrated in r's per hour, and can be calibrated from a known radiation source. Ion chambers are insensitive to small amounts of radiation, and work best where there is a lot of radiation. They can often be used to compare radiation specimens by placing the sample inside the chamber.

When small amounts of radiant energy are to be measured, a Geiger counter can be used. This works on the principle that any particle or photon will trigger a gas discharge tube on the border of instability, and that the number of times the discharge is triggered is an indication of the number of photons or beta particles coming through. Geiger counters are accurate to within 5% to 20%, depending upon calibration. Knowledge of the type of radiation being measured is extremely important.

In using an X-ray machine, the amount of current to the target, expressed in milliamperes, is a good indication of the number of photons being produced, particularly if a calibration curve has been produced. It is important to know the accelerating voltage on the X-ray machine, so that efficiency can be computed from the calibration curve. Exposure of X-ray film in the use of the machine is also a good check upon the amount of radiation present.

It is common for persons using X-ray machines to carry a piece of dental film in the breast pocket, with a paper clip over it, to simulate shielding. The exposure during a period of time can thus be ascertained. Rings can be obtained with a film compartment in them to indicate the exposure of the hands. All of these measuring devices are customarily calibrated in cumulated damage or 'r' units. Dosimeters are charged condensers having a very high insulation value, the rate at which the charge leaks off being an indication of the number of charge carrying ions about as a result of passing radiation.

In a radioactive source of any natural or artificially produced radioactive element there will be a known amount present at a
particular time. From this time and amount, the radiation at any other time can be ascertained. This unit in which these amounts are expressed is the curie. Any material which undergoes $3.7 \times 10^{10}$ disintegrations per second contains a curie of radioactivity. A millicurie is one thousandth as many disintegrations, and a microcurie is one millionth as many. Artificial radioactive materials are normally furnished by the curie, usually at a certain price for a certain number of millicuries in a source. The word source indicates that the specimen is the source of the radiation. Depending upon the curies of material present, the energy of radiation from that material, and the shielding between the source and a particular spot, the radiation field in $\tau$ units per unit time can be calculated for this spot or any other spot near the source. In nearly any case the exposure in $\tau$ units can be pinpointed for the plaintiff's testimony and the defendant's testimony by an expert witness.

Absorption of Radiation

An X-ray photon going through air will ionize some of the air molecules, will excite others, and will occasionally transfer a large portion of its energy to a molecule with subsequent emission of a beta particle. Of all these processes, ionization is the most important. In one centimeter in air an X-ray or gamma ray will produce about 1.5 ion pairs. A beta particle will produce about 50 pairs and an alpha particle about 30,000 pairs. Since each pair formed will remove energy from the radiation by 20 to 30 electron volts, the range in air of an alpha particle of 4,000,000 electron volts energy will be about 6 centimeters.

Alpha particles are seldom dangerous if they are a few inches away, or if even a sheet of paper is placed between the source and the irradiated subject. A beta particle will have somewhat greater range than an alpha particle, but the betas most likely to be produced can be almost completely stopped with three-eighths of an inch of aluminum.

The ones most likely to be found are the common beta-emitting products of the atomic pile (fission byproducts) such as Strontium 90, having only beta emission of 600,000 electron volts maximum. Ruthenium 106 decays with formation of Rhenium 106 and maximum energy betas of 520,000 electron volts. The Rhenium 106 has a 30 second half life, hence it decays almost immediately to form Palladium 106, stable, and beta particles of maximum energy 4,500,000 electron volts plus some gamma rays.
An almost endless variety of active elements and their decay chains are known products of atomic fission. If these elements have an appreciable half life they can be commercially obtained. Strontium 90, with a 25 year half life, will radiate at one half its original rate in 25 years, and 25 years later, one-fourth, etc. For a given beta source the maximum energy of the beta particle is not the average energy, hence the exposure is not that of the maximum energy but that of the average, and can, in most cases, be precisely calculated from published data.

X-rays and gamma rays are less completely stopped by a given absorber than are alpha and beta particles. The absorption of very soft X-rays is quite complete and slightly more efficient than the 1.5 pairs per centimeter of air given for average X-rays or gamma rays. Television set X-rays are typical of this easily absorbed type. The accelerating voltage of the television tube runs between 12,000 and 25,000 volts. The glass screen is ample to absorb the majority of the X-rays, yet it is poor practice to look too closely for too long directly at the face of a television tube, since the eyes are exceptionally sensitive.

Higher voltage X-rays are absorbed on a proportional basis, and are absorbed better by materials of higher atomic weight than by materials of low atomic weight. It is for this reason that high atomic weight salts are used to fill certain cavities in the body in preparing them for X-ray pictures.

It is customary to use a small aluminum or plastic filter in front of low voltage X-ray machines (which may be between 35,000 and 100,000 volts), to absorb the soft X-rays produced. Absence of this shield may produce skin burns when otherwise the exposure is correct. X-ray pictures are taken by virtue of the difference in the amount of the original X-ray energy absorbed in the denser tissues compared with that absorbed in the lighter tissues. A particular thickness of material will ordinarily reduce X-rays to one half the original intensity, while addition of another equal thickness will bring the resulting rays down to one half again. By successive use of filters, the effect of X-ray or gamma radiation can be reduced. It is seldom completely eliminated, and gamma rays from radium behind several inches of lead can still be detected with a Geiger counter. Beta particles can be completely shielded out.

**Biological Effects**

Radiation damage to animals, including man, can be divided into total body exposure and localized exposure. Total body ex-
Exposure by gross amounts of radiation is unusual, since most sources of radiation are essentially point sources and radiation varies inversely as the square of the distance between the source and the irradiated body. Total body radiation can be tallied up to some degree and is a measure of the long term damage done.

At the present time no accurate chart has been prepared showing decrease in life span in man with particular cumulated radiation dosage, but such charts are available for mice, guinea pigs, rats and rabbits. Other animals also have been tested, and the substance of all the tests is the fact that there will be a definite reduction in life span when some threshold cumulated exposure level is reached.

With small doses of radiation this reduction in life span may vary from nothing to a few days or hours. As radiation exposure goes up there will probably be a sharp demarcation point, after which further exposure will have a greater effect on reduction of life span. There will also be a difference in whether the cumulated total body exposure is obtained uniformly throughout the tissues or if it is localized.

To date each one of us has a cumulated total of radiation exposure that can be divided out by the person’s weight, to give the average r's of exposure per gram of tissue. This exposure comes from cosmic rays, radiation from elements in the earth, ingested radioactive salts, and a cumulation of dental and medical radiation treatments. Some of us may also have been exposed to industrial X-ray, radium dial watches, thickness gauges with radioactive sources, and radiation from television sets. We may eat from plates glazed with uranium oxide glazes, and we may use a polonium static reducer on the brush with which we wipe the dust from our phonograph records.

Localized exposure may cause damage of the local tissues, and have little, if any, effect upon the rest of the body. Certain tissues are more resistant than others to radiation. In addition, there is a difference in sensitivity between individuals, partly related to coloring. Blonds are more sensitive than brunets.

By the very nature of the damage done, if the tissue is similar there can hardly be wide variations in different individuals. In my opinion a difference in the effect of a given treatment between two persons should be less than 2:1. By this I mean to say that the theory of hypersensitivity to X-rays is highly suspect. An entirely different effect might be present if there had been a previous experience with radiation on one of the subjects.
Local exposure of the skin will ordinarily result in a redness as a first result within a few days, possibly resulting in a tan. If greater exposure occurs, further redness will appear, possibly resulting in formation of lesions within a few weeks to several months.

X-ray burns heal very slowly, and may require surgical removal of the dead tissue. Beta ray burns are almost entirely limited to skin effects, and will generally not be as deep as X-ray burns. Exposure of certain organs may give the victim radiation sickness. Other organs are more or less sensitive, but due to being protected to some degree by intervening tissue, the effect of radiation upon the tissue is usually primary.

Sterility in women can be obtained through radiation exposure of the ovaries. Radiation of the testes in man will generally result in some degree of at least temporary sterility. The amount of radiation needed to cause sterility is somewhere between 200 and 600 r.

The genetic effect is somewhat different. Any radiation at all has a chance of modifying one of the chromosomes used to transmit hereditary qualities from one generation to another. If this modification occurs in a sperm which is subsequently used to fertilize an ovum, the product may be a mutation. While some mutations may be good, generally a damaged chromosome will result in a loss of some attribute.

An example of a good mutation might be purely conjectural. A bad mutation might be defective hearing or any other impairment. These mutations probably would be recessive, but would still become part of the hereditary equipment of the generations.

A second mechanism for permanent damage to the strain might be a defect in the portion of the testes in which sperm are produced. This would, in effect, be the changing of a model. Damage of this type would, after it occurred, become a statistic with reference to progeny produced at any time after the damage. This second means of damage has been more difficult to prove than the former type of genetic damage, but is still a possibility. A recent committee of the National Academy of Sciences recommends no more than 5 r per year for industrial workers, to minimize genetic effects.

An increased tendency towards cancer may also be a result of radiation, and probably will vary in accordance with the total body cumulative radiation. Radiation of certain parts of the
body appears to decrease resistance to cancer of these parts. The effect of radiation in producing maimed cells is quite obvious, and should these maimed cells not be killed by normal body processes, a cancer results.

There is perhaps more danger in X-raying the young than in treating the mature, for during the growth processes, enzymes tend to increase growth rather than to curb it, and it is therefore easier to get a defective cell to reproduce. X-ray of the fetus in utero has been shown to increase the incidence of cancer in children so treated.

Internal radiation exposure is very serious when certain chemical elements are involved. Radium is a particularly bad element to ingest, because it tends to migrate into the bone marrow, where it continuously destroys the red-blood-cell-producing tissues. Strontium 90, a beta producer having a 25 year half life, is also apt to migrate to the bones, replacing calcium, and producing the same effect. Certain types of radio-iodine are used to treat goiter and other diseases of the organs which concentrate iodine. With short lived isotopes, such as iodine 131 with an 8 day half life, very little long term effect is obtained with small amounts, while with radium having a 1590 year half life, damage done is essentially permanent.

The damage done (in roentgen units) from something internal can be easily calculated by determining the average energy given off per disintegration and multiplying this by the number of disintegrations, to get the total energy involved. Radium, with several daughter products with high energy particles emitted in each one, is one of the worst elements to ingest. For each disintegration of radium an alpha and gamma particle is produced, the two together having an energy of 4,800,000 electron volts. Radon, the daughter element, decays with production of 5,486,000 electron volt alphas, and then goes on to decay through eight more steps of approximately the same energy for each step, before it ends its career as lead.

Tolerance Levels

The subject of tolerance to radiation is an exceedingly difficult problem when all types of damage are considered. A lethal dose, when given to 1000 average humans, would kill all of them. A dose to kill half of them is believed to be between 500 and 600 r's total body radiation. The amount of radiation having no effect has been revised downward several times since 1940, and

[Not proved.]
is now a cumulated total of 10 \( r \)'s on the average, to prevent genetic damage. Probably 100 \( r \)'s could be tolerated with little effect other than an increased tendency towards cancer.

For industrial workers in atomic plants the tolerance varies between .1 \( r \) per month and .05 \( r \) per month, with occasional allowed exposures of greater duration. Since the exposure needed to kill a tumor is between 200 and 2000 \( r \)'s, it can be seen that there will be a considerable exposure above industrial tolerance when any X-ray work is done medically. To show just an erythema on skin, something between 200 and 400 \( r \)'s is needed. To take X-ray pictures, something between 2 and 20 \( r \)'s normally is needed.

From this rough outline some idea of exposure limits can be obtained. At a particular time, recent figures for that date should be obtained in order to take advantages of any lowered tolerance for which effects have been documented.

Radiation Bibliography


Legal Implications of Radiation

In 1954 the Atomic Energy Commission was directed by Congress\(^1\) to make available small amounts of radioactive materials under general license to the public. The stipulation was that the material was to be small enough in activity not to be dangerous, and that it would not be used in foods or drugs or for medical purposes. Congress evidently felt that more good than harm would come of this practice. This should be the principle upon which any radioactive material or mechanical means for obtaining radiation should be used.

Natural radioactive elements have been available to the general public at relatively high prices since the Curies first discovered radium. The variety and purity of radioactive isotopes produced by the atomic pile or by the cyclotron have opened new possibilities for use of these products and, due to the enormous amount of waste materials from operation of present day plutonium facilities, some of these products can be produced very cheaply. The practice of the Atomic Energy Commission with respect to letting active materials reach the hands of the public has been very conservative and very safe. A training period in handling radioisotopes has been a must, and documentation accounting for every curie distributed has been carefully worked out. As a result of this precaution, there have been virtually no cases where serious harm resulted from misuse of atomic radiation.

In the atomic energy plants themselves, a very fine safety record has been obtained through very careful health physics work, and through proper training of employees.\(^2\) The precautionary idea is so well followed through that employees at atomic plants wonder if the Russians may not be able to progress faster than we do in the field, because of their lower standard of care for human life. An occasional accident has occurred, but on the whole the safety record is very good. Where government money is available without the economic pressures of private business, the handling of radioactive materials can be safe. As

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\(^2\) See, Cable, Charles M., and Early, William N., Torts and the Atom: The problem of insurance, 45 Ky. L. J. 3 (1956): "The operating history of 25 reactors in the United States for the years 1943 to 1954 shows no accidents involving radiation injury sufficient to cause lost time of personnel during some 600,000 operating hours and 17 million man hours." Quoted from a speech by Clark C. Vogel, General Counsel of the AEC, before a seminar in Control and Use of Atomic Energy, on March 27, 1956.
more and more atomic material flows out to private industry this high standard of safety may well be reduced for economic reasons. With more knowledge of radiation hazard available to the public, misuse becomes a tort instead of an accident.

Legal Precedent, the X-ray

The X-ray was adopted in a very different way than was atomic energy. As the X-ray tube was discovered in 1895, the public was totally ignorant of its effects. Use of X-ray thus was presumed to be innocent until proved to be harmful. There were many cases of X-ray burns produced in the first medical use, and some of these cases came to the courts.

The X-ray was used for two things in medicine—diagnosis and treatment. Many of the early cases involved X-ray burns produced during diagnosis. In some of these cases the physicians actually won the judgments. By today's standards, however, there could only be one answer,—negligence—for an X-ray burn produced during a diagnosis.

The patient's body is almost a measuring device for radiation, certain amounts of radiation causing certain effects. Within the limit of accuracy of this measuring device there can be little argument on amount of dosage given. A patient is almost completely under a doctor's control in this respect, and since the effect of X-ray is a delayed one, there can be little question but that the agent doing the damage, the X-ray machine, was completely in the doctor's or operator's hands. In the case of diagnosis, the amount of the exposure is so far under the harmful dose that a burn clearly proves negligence. Res ipsa loquitur could almost be defined by an X-ray case. If for some reason the diagnostic exposure requires too much radiation, then obviously that type of diagnosis should not be used.

Typical of diagnostic X-ray burn cases was the 1928 case of Ballance v. Dunnington\(^3\) in which the plaintiff had to have a foot amputated eight inches above the ankle, because the defendant was negligent with his X-ray machine while looking for a needle embedded in the patient's foot. This case was decided for the defendant, with the statement that the patient assumes the risk of burns, though not of negligent burns. Had his lawyer known, he had the proof of negligence in the plaintiff's missing foot itself.

King v. Ditto\(^4\) was a very similar case, in which the plain-

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\(^4\) 142 Ore. 207, 19 P. 2d 1100 (1933).
RADIATION INJURY: A SURVEY

Tiff's hand was burned as her physician looked for an embedded needle with an X-ray machine. The jury found for the defendant, but was reversed on appeal. The appellate judge found, in this case, that the judgment of the physician must be more than merely his best judgment—it must be his best judgment based upon reasonable care.

An indication of the special sensitivity of the eye to X-ray is found in the 1932 case of Adams v. Boyce, in which the patient lost her eye while X-ray was being used in looking for a foreign body. The decision there, for the defendant, was based upon the argument that he had used reasonable care. The physician was doubtless unaware of any special sensitivity of the eye, and at that time it might have been reasonable that he should not have taken this factor into account.

In Routen v. McGehee, the plaintiff in another needle-in-the-foot case claimed, but did not prove, actual X-ray damage. The use of the foot injury as the measurement of radiation sustained will work both ways. Failure to show damage of typical radiation injury will bar recovery, as proof of such damage will sustain it.

In the case of Giles v. Tyson the plaintiff was burned during removal of a splinter from his arm. The judge in this case tried to get away from the idea that a doctor is only required to use such reasonable care as is customary in his own region. The new theory offered was that there should be no regional immunity with anything as dangerous as X-rays. Part of the opinion said:

"The science of X-rays has become certain and exact and its application and use is known and understood in all civilized and advanced communities by the administrators of the rays. Such being the status of the Roentgen, it is a fixed and exact science and the safe mode of its application and use is, or should be, as well known in one community as another, and in city, town, or village there can be but one proper way to apply the useful, but dangerous, agency. Such being the case, an expert in the use of X-rays can testify as to its proper use in village or city . . . It would be equally as culpable or negligent for a person to use the dangerous agency ignorantly or negligently in one community as in another."

A number of other diagnostic cases occurred in the 1920's. The first one found was in 1916. The earlier ones were hip

5 37 Calif. App. 2d 541, 9 P. 2d 1044 (1932).
6 206 Ark. 501, 186 S. W. 2d 779 (1945).
7 13 S. W. 2d 452 (Tex., 1929).

"attempted to ignore the principle that" etc.]
X-rays, back X-rays, and one case of X-ray for a fractured rib. The decisions were mixed, showing that courts even then were not accepting the burn as prima facie evidence of negligence.

Pure ignorance was the cause of death in the 1927 case of Lett v. Smith. The illness of the patient there was diagnosed with a new X-ray machine for 30 to 35 minutes, rather than for a proper 1½ to 2 minutes. The trial court found for the plaintiff, but the case was reversed on appeal, and finally was again decided for the plaintiff on review of evidence by the higher court. The final appellate court found that having the machine too close to the patient, and leaving it on too long, constituted negligence. The real negligence lay in use of the X-ray without sufficient knowledge.

In Evans v. Clapp the defendant illustrated to many of his friends, separately, how the X-ray machine would reveal the plaintiff's fallen stomach. The jury awarded $5000 to the plaintiff, and the court stressed the fact that the injury was incurred not for the plaintiff's benefit but for the benefit of the defendant.

In diagnostic cases the physician must use his best judgment to determine whether the benefit derived by the use of the X-ray is enough to outweigh the harm done. In diagnosis, harm done is so little, generally, that its use is routine.

In using X-ray for treatment there is a much harder problem to solve. Generally, treatment is intended to deliberately destroy unwanted tissues, while doing the least damage to the remainder of the patient's body. In this type of treatment it is difficult to set a line of demarcation beyond which undue harm has been done, and before which a normal or tolerable amount of harm has been done. If, in the removal of a small tumor, there were to be some healthy tissue in the immediate vicinity also destroyed, this would be quite normal. On the other hand, if the X-ray operator were negligent and allowed the tumor itself to be exposed to, say, three times the normal amount needed to kill it, and therefore burned a deep wound into the patient, it would be very difficult to prove that the physician was negligent.

Four important cases of X-ray burns resulting from removal of plantar warts from the foot have arisen since 1950. Facer v. Lewis was decided for the defendant, on the basis that the plaintiff did not prove that the standard of care used was too

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8 6 La. App. 248.
9 231 S. W. 79 (Mo. App., 1921).
10 40 N. W. 2d 457 (Mich., 1950).
low. The jury was swayed by the nature of the injury in this case, and its verdict was overruled by the judge. There seems to be a common tendency among juries to consider anything less than a complete cure by a physician as evidence of negligence.

In another case it was decided that the plaintiff was under a duty to prove negligence, and that res ipsa loquitur did not apply. In Merkle v. Kegereis\footnote{11} a single large wart was treated, with the resulting loss of portions of several toes. The only explanation by the defendant was the possibility that too high voltage might have been used. The decision here was for the plaintiff. In Nance v. Hitch\footnote{12} it was held that “when a doctor uses the degree of skill normally used, the type of treatment normally used, the amount of treatment normally used, he may not be said to be negligent if an occasional burn results.”

The great majority of the cases appealed on X-ray damage were tried in the 1920’s. Of the cases found, two were prior to 1920, 25 between 1920 and 1929, 14 between 1930 and 1939, eight between 1940 and 1949, and six since then. This would suggest either that physicians are becoming better acquainted with X-ray treatment, or that fewer cases are being appealed.

One of the later cases, Barnes v. Mitchell\footnote{13} was decided in favor of the plaintiff against a chiropractor whose agent gave treatments which burned the patient’s hands. It was decided in this case that, since the inexperienced person giving the treatments did so in her employer’s behalf, the employer (chiropractor) was liable. From this case it is evident that the use of X-ray is no longer strictly confined to the medical profession. In view of medical experience with X-ray treatments, it would seem that a chiropractor would be held to the same standard as a doctor if he were to use X-ray in healing. This is covered by statutes regulating the practice of healing in most states. In Pennsylvania, for example, chiropractors using X-ray are required to have certain training.

In Pearlman v. Massachusetts Bonding Company\footnote{14} the plaintiff could not collect on an accident policy specifying “solely through external, violent, and accidental means,” for an X-ray burn of the fingers incurred as a result of 30 years of work as a

\footnote{11} 350 Ill. App. 103, 112 N. E. 2d 175 (1953).
\footnote{12} 238 No. Car. 1, 76 S. E. 2d 461 (1953).
\footnote{13} 67 N. W. 2d 208 (Mich., 1954).
\footnote{14} 130 N. E. 2d 54 (Ind. App., 1955).
dentist. It was held that he was doing an intentional act when injured, even though the result was unforeseen.

Patients also come in for some damage in dental cases, as in Coover v. Painless Parker, Dentist. Painless Parker did not live up to his name in burning the cheek and jaw of a patient. The jury did not think so either, and awarded $10,250 to the plaintiff. The case was affirmed upon an appeal based on the ground that this amount of damages was excessive. This injury falls into the "inexcusable" class.

**Radium Cases**

Radiation from radium is much less able to be controlled in energy than is X-ray energy, since the spectrum of energy emitted is fixed, whereas in the X-ray tube it may be varied. Hence its use has been largely confined to large hospitals and special cases. In Hubach v. Cole the defendant physician had attempted to remove a birthmark from the plaintiff's forehead by use of radium treatment. The birthmark, and the underlying skin, flesh and bone, were injured. The decision was for the plaintiff, on almost a res ipsa loquitur basis.

Other radium cases stem from the beginning of the radium-dial watch and clock business. It was found that by including radium in a paint having phosphorescent material added, a luminous paint could be produced. Even today radium is the primary activant in this paint, radium being an emitter of alpha particles and the alphas being the most efficient in light production. When watch dials were painted it was customary to employ women to do the work. As one of the methods of making the small, intricate figures, paint brushes were pointed by pulling them between the lips. Although precautions were taken to prevent the gamma radiation from harming the employees, no one was able to foresee that radium ingestion would be very dangerous. This unforeseeability was the successful defense in both Vallat v. Radium Dial Co. and LaPorte v. U. S. Radium Corp. Nearly every one of the people employed in radium dial painting died within 3 to 20 years later from the internal effects of radiation. In effect their employment was a death sentence for each of them.

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16 133 Ohio St. 137, 12 N. E. 2d 283 (1938).
Two other industrial diseases have come to notice since then, of the same general nature—the berylliosis cases\(^\text{19}\) and the cases of radar cataracts. In the case of those working with the metal beryllium, during the early part of the Second World War, many died within a short time after their exposure. Radar, on the other hand, has been found to cause cataracts to form in the eye if one remains close enough to the radar antenna to absorb enough of the energy. Cataracts are also the result of exposure to radioactive materials and to radiation from cyclotrons. Several scientists have been victims of the latter through too zealous pursuit of their wartime duties.

Prognosis and Summary

It is now quite definite that radiation of any intensity will cause some injury. The injury may be minute in many cases, to be sure. Nevertheless it is always present. In the medical use of radiation, either for diagnosis or treatment, there is something to be gained, but it would appear that too frequent use of X-ray or radiation on the same patient may border upon malpractice even if properly done.

A recent study in England indicates that prenatal X-ray treatments predispose children to cancer. If the child develops cancer it is not definite that X-ray caused that result. But statistically, it is a cause. If the incidence of cancer is doubled by such an exposure, is it not at least arguable that the negligent physician may be held liable as contributorily responsible?

When one is exposed to radiation due to another's negligence, such as insufficiently shielding a source in the next room, should the negligent person pay for the days or months cut off from the life expectancy of the damaged person?

Or should there be a minimum exposure to which one may be negligently exposed without anyone being held liable?

In the case of a physician treating a disease, should he not be liable for a burn produced in healthy tissue, because from a general health standpoint he should give too little rather than too much?

All of these questions will have to be answered by the courts.

\(^{19}\) Repeated absorption of such poisons as beryllium (e.g., washing work clothes impregnated with it, for several years) was held to be an "accident" for insurance policy purposes, despite the serial nature of the causation, in Beryllium Corp. v. American Mut. Liab. Ins. Co., 223 F. 2d 71 (C. A. 3, Penna., 1956); and see Anno. 40 A. L. R. 2d 1256, 1263. Cumulative effect is characteristic in radiation cases.
within the next few years. Our knowledge of the subject is continually increasing. That which today is known only to only a few scientists will be common knowledge by tomorrow. The courts, if they are to equitably serve the public, must keep up with the technical aspects of subjects argued before them. The way to higher standards of care for the public is through insistence that physicians and others handling radioactive materials maintain a high standard of knowledge and care.

The background radiation which the public must absorb is constantly increasing through test explosions of atomic weapons. Wastes from production of atomic fuels occasionally get away, too. Some of these wastes are concentrated biologically, and eventually find their way into the foodstuffs of man.

Is this a risk against which there will be no action, or should the government be strictly liable? In Bulloch v. United States a partial answer is given, to the effect that the government will be responsible for radiation damage proven to result from its negligence. In the particular case the decision was for the government, on the basis that damage to sheep near an atomic explosion area was due to frost and inclement weather rather than to radioactive fallout. From this case it appears that actionable damage must be of a very positive type, rather than merely a reduced life span. This view is probably a sensible one in our complex civilization.

Perhaps medical science can increase the average life span faster than cumulated radiation can decrease it. A few people must suffer the incidental accidents from which we learn lessons that make things safer for the rest of us.


For late current legal and scientific summaries, see Negligence and Compensation Service (NCS), under headings of Atomics, Radiation, X-Rays, etc. therein; also, Atomic Industry Reporter. For late current medical references, see, Current List of Medical Literature (Armed Forces Med. Lib.), under headings of Atomic Energy, Atomic Warfare, Radiation, etc.

[Dr. Wise added, in his letter returning the proofs of this article, the following overall comments:

. . . He does not recognize the tremendous moral responsibility incumbent upon the physician in treating a malignancy. In the latter pages of the article he attempts to theorize that it would be better to undertreat all lesions in order to prevent "burns" as he refers to them. There is no question but that we, particularly in the field of radiology, see many examples of culpable negligence. However, in my experience it is always true that the damage done through negligent use of radiation has, in the majority of instances, been due to undertreatment rather than to overtreatment. This is a facet of the problem that I believe should be emphasized to the legal profession. Admitting that this is a tremendous problem, I still feel that a rational approach to the problem must be a consideration of the balance between the moral responsibility of the physician to give sufficient radiation to arrest a malignant disease and the potential negligence both from undertreatment and overtreatment.

. . . I appreciate his feeling for the patient in attempting to place responsibility for negligence in the use of radiation, but is it not also true that the judiciary of this country has a moral responsibility to the defendant also? . . .]