POTENTIAL EXPOSURES IN RADIATION MEDICINE

César F. Arias

Comisión Nacional de Energía Atómica - Argentina

ABSTRACT

Accidental exposures have progressively caused greater concern along last years and the concept of potential exposures has been deeply explored in the new ICRP recommendations. Severe accidents have been produced by radiation sources employed in medicine. The particular way in wich these sources are used enhances the probability of undesirable exposures of workers, members of the public and patients. Nevertheless safety of medical sources have frequently not deserved the same degree of attention as other radiation sources. The tools of probabilistic safety assesment can be applied to evaluate and improve the safety of these sources.

THE CONCEPT AND SIGNIFICANCE OF POTENTIAL EXPOSURES

Any practice with radiation sources implies the irradiation of persons in conditions that can be regarded as normal, what means that radiation doses will be received by people according to predictable patterns, and in any case below certain limits. This objective can be achieved through an appropiate design of equipment and facilities and imposing restrictions to people's behavior.

Nevertheless since devices and people may fail the possibility of accidents can never be ignored. When an accident occurs radiation doses becomes distributed in an unexpected way. The exposures that results from events which are not certain but that can not be disregarded are called potential exposures.

Normal exposures usually contributes more than accidental exposure to collective doses through different places and along the time. However accidental exposures may cause a concentration of effects in place and time that are not justifiable and are not accepted by public opinion.

In the new recommendations of the International Commission of Radiation Protection (1), potential exposures deserves the same consideration as planned exposures what implies a significant evolution from the previous recommendations (2).

Concern about a potential exposure refers to its posible severity and to the probability of occurrence. The severity of an accident depends on the distribution of doses it produces and the number of exposed individuals.

The probability of accidental events with radiation sources depends directly or indirectly on human factors. Sources where safety relies strongly on human behavior have greater probabilities for potential exposures; that is the case of movable sources and unsealed sources, for instance. Since radiation emmisions of radioactive sources can not be controlled any radioisotopic source which is not longer used and has not been adequately disposed has a high potentiality for accidents.

POTENTIAL EXPOSURES RELATED TO MEDICAL RADIATION SOURCES

Medical sources are by far the most numerous and spread radiation sources any community has. According to UNSCEAR (3) in the world exist: 18.000 Radiation Therapy machines (4.300.000 procedures per year); 23.500 Nuclear Medicine machines (23.500.000 procedures per year); 440.000 X Rays machines (1.380 millones procedures per year).

These are sources are located at buildings usually frequented by many people totally ignorant about radiation risks and radiation protection (members of public).

Some sources are fixed and have large activities. (teletherapy sources). Some others have lower activities and are movable (brachytherapy sources, nuclear medicine sources). The first ones can cause infrequent and severe accidents. The second ones can cause more frequent and less severe accidents.

Radiation safety of medical sources depends on the behavior of many people: phisicians, technicians, nurses, physicists, maintenance workers, and sometimes responsibilities for the sources control are not well defined. In some countries radiation risks and protection have been poorly known by personnel involved in medical aplication of radiation for a long time. Consequently, safety routines may have been very weak in thoses countries. Additionally, in some countries regulatory procedures related to medical sources are less stringent than for other sources. Such circunstances contributes significantly to raise the potentiality for accidents, in particular when radioactive sources are not longer in use.

Radiation accidents may cause the abnormal exposure of workers and members of the public. Medical sources are used within facilities normally open to general public. Potentiality for public implications is then significant for these sources. However the number of exposed people involved may be much higher if the accident extends outside the facility.

Patient potential risks must also be considered (particularly in radiation therapy). Accidental situation may occur when a patient receives wrong doses, (greater or smaller than expected); or wrongly localized; or when a rigth dose is received by a wrong patient. Doses greater than prescribed involves over exposure risks while lower doses may be cause of treatment failure.

REVIEW OF SOME SIGNIFICANT ACCIDENTS PRODUCED BY MEDICAL RADIATION SOURCES

According to C. Lushbaugh (9) 101 fatalities attributable to radiological accidents have occurred between 1944 and 1989; 28 of them have been caused by medical sources. Non fatal accidents or incidents have involved many people; in U.S. during 1988; 470 patients were subjected to medical missadministrations; 438 in diagnostic procedures and 32 in radiation treatments. (2)

Medical radiation sources have caused overexposures to workers and members of the public as consequence of accidents. Patients have been subjected to missadministration of doses.

I) SOME SIGNIFICANT ACCIDENTS THAT HAVE PRODUCED DOSE MISSADMINISTRATION TO PATIENTS

1) 1986 - U.S. Texas - Linear accelerator unit (4)
Consequences: Two patients died after receiving doses of 200 Gy
Main cause: Wrong interaction between operator and computer.

2) 1988 - U.S. California - Tc^{99n} source employed in nuclear medicine (5)
Consequences: a patient received a dose 1000 times greater than prescribed.
Main cause: Failure in following protocol for radiopharmaceutical injections.

3) 1987 - 1988 U.S. Maryland - Co^{60} therapy unit (5)
Consequences: 33 patients received doses exceding up to 75% prescribed values.
Main cause: Computer programme was not upgraded after source was changed.

4) 1990 - Spain - Zaragoza - Linear Accelarator unit (6)
Consequences: 27 patients were overexposed 14 died
Main cause: Wrong functioning of energy selector after maintenance procedure.

II) SOME SIGNIFICANT ACCIDENTS THAT HAVE PRODUCED OVEREXPOSURE IN WORKERS AND MEMBERS OF THE PUBLIC

1) 1965 - U.S. X Ray fluoroscopic equipment (7)
Consequences: Two workers suffer burns in hands
Main cause: Interlock failure during maintenance operations.

2) 1984 - México - Ciudad Juarez - Co^{60} Therapy unit (8)
Consequences: 5 persons receives doses between 3 and 7 Gy - 80 persons received doses greated than 0,25 Gy; 814 building had to be demolished.
Main cause: A therapy equipment was disassembled without removing the source and 6000 cobalt pellets were dispersed into building materials.

3) 1987 - Brazil - Goiania - Cs^{137} Therapy unit (8)
Consequences: 4 persons (members of the public) died - 14 persons received doses greater than 1 Gy - 54 persons received doses greater than 0.25 Gy - 42 residences were contaminated and 4 had to be demolished.
Main cause: A no longer used source was abandoned without any safety meassure.

PREVENTION OF ACCIDENTS WITH MEDICAL SOURCES

Accidents are part of the unpredictable future. But unpredictability refers to the time at what the event may occur, not to the characteristics of the event itself. Any possible accidental event can be described as a potential event before it may occur and the possible sequences of causes that lead to it can be identified. By assigning probability figures to equipment failures and to human failures the probabilities for undesirable accident can be calculated (Probabilistic safety assesment). By increasing redundancy in the safety systems, assuring their independency and minimizing the influence of human failures the probabily of accidents can be reduced below acceptable limits.

By adopting these and other complementary means uncertainty about the future can not be completed avoided but prevention of accidents can be achieved on statistical basis.

This is the philosophy proposed by the ICRP for potential exposures and their application can be fully adopted for the safe employment of radiation sources in medicine.

REFERENCES

1)ICRP Publication N° 26 (1977)
2)ICRP Publication N° 60 (1990)
3)UNSCEAR 1988
4)C. Borras - Accidents with Medical Sources (1990)
5)NUREG Vol 3 N° 2 - Medical administration Report (1988)
6)Spain Society of Medical Physics (1991)
7)UNSCEAR (1982)
8)C.C. Lushbaugh Radiological Accidents (1989)
9)C.C. Lushbaugh An Historical Perspective of Human Involvement in Radiation Accidents (1990)