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HAZARDS OF COMMON RADIOGRAPHIC TECHNIQUES TO STAFF AND PATIENTS

INTRODUCTION :

Diagnostic rediographic techniques constitute an extremely important tool in the hands of the physician today all over world. Exposure rates as high as 868 exposures per year per thousand population are prevalent in European countries(1). In developing countries the rate is quite less as compared to these. However it also constitutes major source of rediation to mankind only next to N weapons and Nuclear Energy processors. Precisely therefore it has to be used with a lot of discretion and economy since radiation has proved to be a major determinnat of cancers and genetic mutations.

The Xray Units in India are mainly operated at two levels. The first is the Xray Units in major hospitals and consultant Radiologists processing a good number of exposures even 100 a day-required for a range of diagnostic needs. Such installations normally use hish output low time exposure' machines with a reasonable saftey organisation. The Second level is that of the taluka level nursing homes/clinics, some urban 'Bazar' X ray clinics that operate' low output longer time exposure' machines with poor saftey organisation.

The general consensus among experts indicates that, properly used, the usual diagnostic X ray prosedures do not cause much harm to the patients/staff considering the contribution they offer in patient managment. But badly organised units can harm the population in the long run. This paper attempts to outline some issues in this context.

2. THE BIOLOGIC EFFECTS OF X RAYS :

The biologic effects of X ray can be summed up as follows :

i) There is no' tolerance level' for exposure since even small doses are biologically not' lost! As far as biological effects are concerned there is no 'adjustment dose' for radiation.

ii) The probability of occurrence of X ray hazards shows a linear relationship with exposure. More the dose proportionately, more shall be the occurrence of hazrdous effects.

iii) There is a sigmoid relationship between the exposure dose and the severity of the effects. Thus after an initial threshhold and then steady rise of dose-severity curve, there is a

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steep rise for subsequent dosages till there is a platau of steady rise again. The last segment of staedy rise is accounted for by selective elimination of affected persons due to deaths.

iv) There are some somatic 'certainty effects' like radiation erythema, bone marrow fibrosis, radiation ulcers, skin cancers etc. which almost certainly occur after a latency period, provided the dose is more than 10 and 100 rads for whole body and partial body irradiation respectively. These show a sigmoid dose-effect relationship. In the early days of radidiagnosis these were frequent occurences beacuse of poor protection measures. In almost all cases of such effects, the event can be traced back to some past exposure. These effects are more severe with time concentrated dose as a compared to a time spreaded exposure.

v) There are some somatic stochastic effects like organ cancers and leukemias that show a linear relation as for dose effect. These effects occur at their respective ageprofiles, only much more commonly in the exposed population.

vi) The genetic effects are always stochastic and there are two modalities. First, the effect is mostly lethal to gonadal cells so that there is a lower brith rate in the exposed population. Second-less frequently there are chromosome abnormalities and mutations. Mutations are recessive that show up in later generations if the other partner also carries recessive trait. Such chances increase with accumulation of abnormal genes in the total genetic pool of the child bearing (Prospective or current) age groups. Older parents carrying such abnormalities do not after the gene pool. The somatic expression of these abnormalities can be very severe and in this sense X rays are a major threat to genetic constitution of the population if effective gonad protection is not offered. Children/persons below 18 years are 10 times prone to such abnormalities as compared to the adults.(1)

vii) These biologic risks to patients have to be weighed against the possible benifits of radiodiagnosis and those on the staff compared to level of occupational hazards in other professions to get a balanced picture of the risk profile.

3. THE DOSE IN RADIODIAGNOSIS.

The dose of the exposure is a function of many factors. The output of the machine in Milliampere, the time duration of exposure, the distance of the subject from the Xray Tube all decide the dose of the exposure.

Maximum Permissible Dose(MPD) is defined as : The Permissible dose for an individual is that dose, accumulated over a long period of time or resulting from a single exposure, which, in the light of the present knowledge, carries a negligible probability of severe somatic or gentic injuries; furthermore it is such a dose that any effects that ensue more frequently are of a minor nature that would not be considered unacceptable by the exposed individual and by the competent medical authorities (1).

It is estimated that in the last two decades in most countries 75-96% of the exposed staff did not receive more than one tenth of the MPD. It is also estimated that in no country the genetically significant dose from this source is more than 1% of the natural nackground radiation. However the same MPD level can not be accepted for children since children are about 10 times susceptible as compared to adults.(1)

4. THE ESTIMATION OF CANCER RISK :

There can be no generalisation about cancer risk from X rays. Much depends upon the dose, the organs receiving Xrays, the age of the subject, positioning of subjects and some other factors. When a subject is exposed-whole body-all organs may get irradiation but the risk is not similar in all the organs. Generally extremeties are not sensitive and so also skin, bones and thyroid. As for dose every procedure involves different dosages. Chest radiographs, extremities and thinner parts/ need much less exposure than abdomen, Thickset individuals need more exposure than thin ones. AnAP chest view harms the bone marrow much more than a PA view. A 'repeat' doubles the dose and the risk thereof. Exposure of abdomen in an 18 year subject causes cancers with manyfold frequency as compared to the same procedure in a 60 year old subject- An elderly person can take much more dose without cancer risk since there is relatively shorter survival period for cancers to develop. Therefore multiple radiographs for diagnosis of gastric ulcers, renal stones, barioum shadows involve much less risk than a single exposure in a child.. Risk changes to more than 10,000 times from one situation to another situtions (2).

The variation in risk due to these factors is quite sizeable as will be evident from the risk tables(2) given in the appendix 1.

5. GONADAL DOSE :

Almost every exposure, save dental or similarly skin close exposures and well limited (collimated) exposures, result in

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some irradiation of the gonads. Appendix II shows the Gonadal dose grouping and also bone marrow dose grouping(1). This will underline the need to lead-shield the gonads whenever possible.

6. THE RISK FACTORS, THE X RAY MACHINE,DESIGN FACTORS,SHIELDING:

i) The useful beam size : The Xray beam directed towards the target/film is known as the useful (Primary) beam. The useful beamsize depends upon the design of the Xray Tube head outpet and the distance of the subject from the tube head. Most often unless optical devices are used to show the field of the beam,the useful beam irradiates regions that surround the target region. This can be avoided by optical devices and adjusting the distance factor.

ii) Back radiation/scattered radiation : Radiation other than the useful beam is known as the back/scattered radiation. This mainly affect the staff. Adquate distancing of the operators, control panel, lead apron are all necessary to avoid the exposure to this radiation. Back radiation can also affect the patient and suiatable position is necessary to minimise this dose(1).

iii) Fluroscopy : The machine output in fluroscopy operation is very low but time factor offsets this advantage. Moreover, staff doing fluroscopy is necessariely exposed to the useful beam in a routine manner. Proper darkroom facility, timer-indicators, apring switch,lead flaps,lead gloves,proper dark adaptation and good training are all necessary to minimise dose.

iv) Calculated Vs actual dose exposure : It is possible to calculate individual exposure doses as per the readings of MA,Kv, time in secs. But actual doses are found to vary to about 0.1 to 0.4 times the calculated dose due to equipment dactors. This is known to happen even in best of units(2). The real way of estimating actual exposure dose is to use special instruments like Gigar counters,crystal dosimeters,ionisation chambes etc. which is usually not done in India though BARC can help do this on request. It is estimated that much smaller doses than are actually delivered are really necessary for most of the procedures.

v) Leakages from Tube head : There is no other way to detect leakages from tube head(that will give substantially more radiation than the weak back radiation) than special detectors like the Geiger counters. Whenever new installations/changes are made it is mandatory to check for this with the help of special services. BARC can help in this.

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vi) Film and screens : Insensitive films/screens entail a longer exposure of the subject and staff and also reduce machine life. It is necessary to use suitably sensitive films/screen to minimise exposure.

vii) Design and shielding : X ray can penetrate and have to be stopped from affecting surrounding people by special design and devices. As dar as design is concerned,adquate spacing is the first important thing. Since radiation at a given point is inversely proportional to distance from the source. Thus a unit housed in a 10 x 10 feet room is more hazardous to outside people than the same unit housed in a 15 x 15 feet room. Unfortunately this is a restraint in many Xray clinics. Secondly the useful beam has to be primariely directed at exterior wall so that minimum exposure occurs to the surrounding life. Thus it should not be directed at the waiting room,wards,street,passages unless adequately shielded. The control panel should be outside the Xray room in units operating more than 50 kv machines.
As for shielding,lead and wall thickness are two principal considerations. For every 50 Kv rating of the machine a 0.5mm lead thickness is necessary to stop the useful beam(eg the fluroscopy procedures) Stray radiation can be taken care of by putting a 0.25mm lead barrier (the usual lead aprons) provided the staff is distanced at about 10 ft from the source. A 9 inch brick mortar wall is equivalent to 1mm lead thickness and so is a 6 inch concrete slab. All walls should be designed to stop the primary radiation of the useful beam. Since machine position, direction of beam, installation etc.can change subsequently and this should be kept in mind. Doors/windows should be sheilded with a 1mm lead thickness with adequate overlap so that radiation does not escape the gaps. It is always better to seek help of radiation engineers while designing the unit.

viii) Staff Monitoring for radiation : Xray unit staff and other staff routinely coming in contact of Xray units(Nurses/Ward-servants etc.) are exposed to radiation. Unless proper precautions are taken to restrict staff entry in 'switch-on' time, and adequately protect the operating staff a great risk awaits them by way of cancers, leukemias and gonadal irradiation. Standing behind the Xray tube,lead aprons,control panel,adequate distance are all necessary. The film badge monitoring is a routine method in upper strata Xray clinics. In the lower category of taluka level units,bazar clinics and minor units operating in small nursing homes no such monitoring is ever done; perhaps with the idea that the dose involved is low. In this context,the conditions in the latter category are quite bad

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since most of the operators have little knowledge of the potential risk of this invisible meance. At present there is no working mechanism of regulating the conditions at such clinics. Although the total work load is quite small in this category, the neglect of basic protective factors understandbly constitutes a very real threat to both patients and operators.

7. CONCLUSION :

Xray are a great help in patient management. Generally speaking MPD is not exceeded both in case of staff and patients since there is a relative paucity of facilities in developing countries. As for the well equipped clinics with adequate sheilding and care little harm is done to staff and the risk is acceptable. As for the lower rung units conditions are apalling, with potential risk for both the patients and staff and much needs be done to regulate these units. Gonadal irradiation must be avoided in early and middle age groups whenever not necessary. A longterm projection of gonadal irradiations to a fair portion of population (that is going to bear progeny) indicates accumulation of abnormal elements in the genetic pool and this can be real cause of concerns. Cancer risks in the exposed populations is going to increase but no generalisation can be possible in this regard. Early age of exposure, no. of exposures procedures involving high dose to susceptible organs are all risk factors to be watched.

8. REFERENCES :

(1) Mannual on Radiation Protection in hospitals and General Practice : Volume 1 By C B Braestrup & K.J. viktelof WHO Publication. Geneva 1974 PP 28,29,31,27

(2) X-RAYS, HEALTH EFFECTS OF COMMON EXAMS : By John W.Gofman & Egan O'Connor, Sierra Club books, San Fransisco 1985 PP 86,87,2,349

APPENDIX I

CANCER RISK ESTIMATION USING VARIOUS FACTORS FOR CHEST VIEW. (2)

Age yrs	Entry dose	Beam HVL	PA VIEW Male Cancer Risk	PA VIEW Female Cancer Risk	AP VIEW Male Cancer Risk	AP VIEW Female Cancer Risk
Newborn	0.010 R	2.5 mm AL	37*per million	49 per million	90 per million	260 per million
One year	0.012 R	2.5 mm AL	37 ----"--	49 ----"--	95 ----"----	283 ----"----
Ten Yrs.	0.016 R	2.5 mm AL	31	35	102	280
15 Yrs.	0.021 R	2.5 mm AL	16	16	86	242
20 Yrs.	0.026 R	2.5 mm AL	15	13	44	124

* A Value of male risk of 37 per million means one cancer case in about 27,000 exposures.