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**Rubrik:** Discussion = Diskussion = Discussion

## *H. R. Schinz*, Zürich, zum Vortrag *A. Hollaender:*

Bevor ich auf Einzelheiten des Vortrages von *A. Hollaender* (Oak Ridge) eingehe, möchte ich folgende Feststellungen machen:

1. Wir Europäer sind den Amerikanern für ihre großen und wichtigen Forschungen sehr zu Dank verpflichtet und gratulieren ihnen zu ihren Ergebnissen.
2. Anderseits bitten wir die amerikanischen Forscher, auch die Arbeiten von uns Europäern zu lesen.
3. Diese gegenseitige Kenntnisnahme der Forschungsergebnisse kann für beide Teile nur von großem Vorteil sein.

Als Beispiel führe ich die Ergebnisse der Hodenbestrahlungen an. Herr *Hollaender* hat von einem Typus A und Typus B der Spermiogonien gesprochen und hat erklärt, daß merkwürdigerweise diese Erkenntnis erst vor kurzem in Amerika gewonnen wurde. Es sind aber jetzt ungefähr 32 Jahre her, daß Herr *Regaud*, damals Direktor des Institut du Radium in Paris mit seinen Mitarbeitern *Blanc*, *Lacassagne* und anderen und unabhängig davon ein gewisser *Schinz* in Zürich mit seinem damaligen Mitarbeiter *Slotopolsky* auf die Unterschiede in der Strahlensensibilität von *Reservespermiogonien* (neuerdings Typus A genannt) und von *aktiven Spermiogonien* (Typus B) aufmerksam gemacht hat und eine Sensibilitätsskala der spermiogenetischen Reihe aufgestellt hat, wobei die aktiven Spermiogonien höchst sensibel und die Folgeprodukte (Spermiocyten, Präspermiden, Spermiden und Spermatozoen) abnehmend strahlenempfindlich sind. Neuerdings wissen wir, unter anderem durch meine Mitarbeiterin Frau *Fritz-Niggli*, daß die Sensibilitätskala der spermiogenetischen Reihe Keimschäden gegenüber ganz anders verläuft:

Spermiocyten und Spermiden sind sehr viel sensibler als Spermiogonien. Reife Spermien sind wieder etwas unempfindlicher als Spermiden. Auseinanderhalten müssen wir also streng die *somatischen Hodenschädigungen* gegenüber karyoklastischen Röntgendosen von den *genetischen Hodenschädigungen* mit kleineren mutagenen Röntgendosen. Wodurch diese Sensibilitätsdifferenzen im einen wie im anderen Falle bedingt sind, wissen wir nicht. Theoretisch können wir sie erklären durch den größeren oder geringeren Gehalt an Schutzstoffen in den betreffenden Zellen, oder durch den geringeren oder größeren Gehalt an empfindlichen Proteiden in den betreffenden Zellen.

## *H. R. Schinz*, Zürich, zum Vortrag *O. Hug:*

Beim Auftreten von Spätschäden durch chronische Strahlenbelastung mit schwachen Dosen scheint mir wichtig, daß die Einzeldosen erstens irreversible, morphologisch vorerst unsichtbare Schäden setzen, die sich ohne Verlust kumulieren zu einer schädlichen Gesamtdosis. Geheimnisvoll bleibt dabei die Länge der klinischen Latenzzeit. Die spontane Radioaktivität genügt offensichtlich nicht zur Entstehung solcher Spätschäden, weil die Lebenszeit und damit die Einwirkungsdauer der Spontanstrahlung zu kurz ist. Die Lösung des Krebsproblems – und dies gilt auch für den Strahlenkrebs – wird dadurch erschwert, daß es sich bei den Spontankrebsen nicht um eine einzige Noxe sondern um eine Polyätiologie handelt. Die Entstehung einer Präcancerose – ein klinischer und nicht ein morphologischer Begriff – ist nicht notwendig und nicht hinreichend zur Erklärung einer Krebsentstehung.

*A. Hollaender*, Oak Ridge, zu *H. R. Schinz:*

I would not like to discuss here the question of priority. I would only like to point out that I mentioned some of the important early investigations. Unfortunately I did not mention Dr. Schinz by name in this. However, the important thing is to point out the tremendous difference in resistance between the A and early B spermatogonia. Saying that they contain different proteins is not very useful if one does not have proof for it. A more striking case is the following: There are now bacteria available which can stand 3 to 5 million of r, whereas the bacteria we usually work with take about 10,000 r to kill at 99,9 per cent level. We urgently need work which could tell us what are the differences between these cells. They are similar in appearance and they are similar in growth requirements. The unravelling of this difference in resistence is one of the most challenging problems.

*G. M. Ardran*, Harwell and Oxford: **Radiation Dose to Staff in Diagnostic X-Ray Departments**

The problem of fallout following nuclear explosions has already been discussed by several speakers. It has been shown that the hazard at the present time from this source is small as far as the population as a whole is concerned: the fallout will only become a serious problem if nuclear explosions continue. However, little has been said about the radiation hazard which is with us at the present time, and has been with us for some years. I refer to the dose of radiation delivered to the population from medical procedures, principally from diagnostic radiology. The exact magnitude of the dose is not known but the estimates which have been made indicate that in the more developed countries it is probably of the order of between 100 and 200 times the dose received from background radiation (1, 14, 15, 16). Many of the methods which may be used to reduce the population dose have already been described (1, 2, 3, 5, 6, 7, 8, 9, 12), and Dr. *Kemp*, with whom I have been associated for many years, will be dealing with some aspects of this problem later. I shall deal with the problem of the dose to the staff of diagnostic X-ray departments.

The tolerance dose for radiation workers used to be given as 1 r per week and it was not specifically stated that this dose was only to be received by radiation workers; the impression was given that this dose could be received by all for virtually a whole life-time without significant ill effects. More recently this dose has been reduced and in the United Kingdom the present maximum permissible dose is as follows:

"Maximum permissible cumulative doses for whole-body exposure:

(a) In any period of 13 consecutive weeks:
Blood-forming organs, gonads and eyes 3.0 rem

(b) Up to age of 30 years:
Blood-forming organs, gonads and eyes 50 rem

(c) After age of 30 years:
Blood forming organs, gonads and eyes 50 rem per decade

(d) In a life-time:
Blood-forming organs, gonads and eyes 200 rem

It will be noted that the limits applicable for exposure up to 30 years and per decade thereafter are equivalent to an average weekly dose of 100 mrem. This is one third of the maximum permissible weekly dose. In the case of long-term exposure, the protection must be planned accordingly." (13)

For simplicity in practice this may be considered as 5 r per year or 100 mr per week. Any dose over 100 mr a week must be regarded as a temporary overdose to be cancelled by ensuring that the dose is lower than the maximum permissible in the immediate future. It must be borne in mind that the level of background radiation, though varying from place to place, may be considered as about 1 r per 10 years or 100 mr per

annum. Thus radiation workers may receive 50 times background radiation though it has been suggested that it is undesirable that the population as a whole should receive more than twice the background radiation, and it may be desirable that they should in fact receive much less than this (14). It must also be borne in mind that this maximum permissible level of radiation is not a level which is desirable and every reasonable step should be taken to see that the dose is in fact as small as possible.

In many centres the problem of staff dose has been dealt with by protecting the staff by the use of protective cubicles or protective garments, but in Oxford we have tackled the problem slightly differently. The principle which we have adopted has been to use the minimum quantity of radiation necessary for the adequate conduct of any particular examination; to reduce all unwanted radiation as close as possible to the source from which it arises. Thus we have endeavoured to reduce leaks and stray or off-focus radiation from the X-ray tubes and their fittings (2, 9, 12), and to limit the scatter and the radiation which has passed through the patient as close to the source as is practicable. Some of the details of how this is carried out have been already described and some results which show how effective these measures have been, have been published (2, 6, 10), but they may be summarized as follows: it has been found possible to reduce the average radiation to the staff to not more than 5 mr per week without the use of built-in or elaborate cubicles, and to something of the order of 1 mr or less if cubicles are used in addition (10). We have made it a rule that no diagnostic X-ray worker should work at a site where the dose is more than 5 mr per week without wearing protective clothing or using a cubicle, whichever is practicable under the circumstances. We have adopted this principle because it is desirable to reduce unwanted radiation at source for the protection of the patient, and because all unwanted radiation tends to reduce the quality of the film or fluoroscopic image, and because these measures are desirable should the use of a protective cubicle not be feasible for a particular examination. We have found it very useful to place cassettes containing intensifying screens and screen-type films on the wall or at other sites where the operator might work (4). The films on processing following a particular examination, at the end of the day, or at the end of the week may be compared with standards prepared by irradiating the cassettes with known quantities of similar-quality radiation. They enable any department to rapidly check whether desirable dose levels have been exceeded. Should the film show more than a dark grey we regard it as a warning that further investigations are required and that the area is unsafe for unprotected personnel.

As a result of this work which has now extended over several years it is our opinion that no diagnostical worker need receive a dose of more than 5 mr in a week in a busy general hospital, and we would suggest therefore a reduction in the maximum permissible dose level for this class of worker. We would suggest a reduction to at least a third of the present level and this should allow ample latitude. We believe that provisions may be made so that the majority of workers need receive not more than 1 mr per week, which is roughly equivalent to the background level of radiation. The hazard to the workers will thus be reduced to one of practically negligible proportions.

Manufacturers and workers should appreciate that only comparatively simple modifications in equipment and methods of working are required to conform to the suggested lower standard. In ensuring collaboration we have pointed out that it is possible to take a chest radiograph with a skin dose of the order of 6 mr (7) and that therefore any worker receiving this dose, or more per week, is in fact taking a picture of himself or herself weekly. We have found that when expressed in this manner most workers consider it quite undesirable that this should be the case, even if the picture is underpenetrated in places. The fact that diagnostic workers need only receive such low doses is an indication that the level of radiation in diagnostic X-ray rooms has been kept to small proportions, and indicates that the patient is also probably receiving as little a dose as possible.

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*H. Isliker*, *H. Keller* et *B. Wili*, Berne: **Les effets de doses sublétales de rayons X sur les facteurs de la résistance à l'infection**

L'irradiation totale chez l'animal provoque des altérations significatives des protéines sanguines. Des doses en dessous de 50 r stimulent la biosynthèse des anticorps ainsi que de la properdine, qui est une protéine sanguine responsable de l'immunité naturelle. Des doses sublétales, au contraire, provoquent une chute du taux des anticorps, de la properdine et des leucocytes. Ces effets ont été rendus responsables des bactériémies sévères qui surviennent après une irradiation totale.

Le mécanisme de la chute de la properdine a été étudié au moyen de méthodes de traceurs radio-isotopes. L'abaissement est-il dû à un blocage de la biosynthèse ou à une réduction par des produits provenant de l'irradiation? L'incorporation dans la properdine de leucine marquée au $C^{14}$ n'est pas diminuée sous l'effet d'une irradiation totale du lapin avec 800 r. Cette observation parle contre un effet sur la biosynthèse et en faveur d'une séquestration de la properdine. En effet, certaines substances qui inactivent la properdine se trouvent augmentées dans le sérum après l'irradiation ($\alpha_2$-glycoprotéines et héparine).