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is given as a function of the incident electron energy. Plotting the difference ΔD of the dose at the interface to the dose in the homogeneous phantom at the same depth against the electron energy (Fig. 2, bottom) the data points can be approximated by $\Delta D(E) = 37{\cdot}4 - 0{\cdot}58E$. So, in the energy interval investigated there is a nearly linear decrease of the relative back-scattering with energy, which amounts to about 0·6 per cent per MeV.

Yours, etc.,
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THE EDITOR—SIR,

EARLY EFFECTS OF X-IRRADIATION ON CENTRAL NERVE FIBRES

Although there have been a number of morphological studies of the late effects of radiation on the brain and spinal cord, early changes in central nerve fibres have not been adequately evaluated. The occurrence of delayed necrosis of the cord months or years after therapeutic doses of radiation is well-recognized (Boden, 1948; Jellinger and Sturm, 1971) and has been attributed to the induction of somatic mutations in interstitial cells (Zeman, 1966). Since transient neurological symptoms consisting of "electrical" paraesthesiae on neck flexion may occur soon after irradiation in man (Jones, 1964), we decided to look for morphological changes in the nerve fibres in the cord in the early stages after experimental irradiation using the particularly sensitive technique of isolation of single nerve fibres (McDonald and Ohlrich, 1971), together with light and electron microscopic examination of cord sections.

Female Wistar rats (200–270 g) were irradiated under pentobarbitone anaesthesia. Five groups of six animals received single doses of 400, 1,000, 2,000, 4,000 or 6,000 rads of X-irradiation (250 kV, 15 mA, HVL 2·4 mm Cu, 60 rad/min.) to the mid-cervical cord through 1·0 × 0·5 cm apertures in a 4 mm thick lead shield. Pairs of animals from each group were sacrificed two, four and eight weeks after irradiation. Five groups of three animals received similar doses to the lumbar cord through 1·0 cm circular apertures. Single animals were sacrificed four, eight and twelve weeks after irradiation. None of the irradiated animals showed neurological abnormalities when sacrificed. Non-irradiated controls were sacrificed at comparable intervals after irradiation. Animals were killed by glutaraldehyde perfusion through the aorta. Blocks from the centre of the irradiated area of the cord were post-fixed in osmium tetroxide and embedded in epon for light and electron microscopic examination. Longitudinal strips of cord were post-fixed in Dalton's fluid and teased in glycerine under a dissecting microscope (McDonald and Ohlrich, 1971).

A number of abnormalities were found in teased myelinated fibres. The most frequent consisted of myelin balls in the paranodal region of otherwise intact fibres (Fig. 1A and B). The nodal gap was widened in some fibres showing this change but was of normal width in others. Other fibres showed only nodal widening (Fig. 1C). These changes were found with relative ease in all irradiated animals as early as two weeks after irradiation and were more frequent at four and eight weeks. In some animals occasional fibres showed more extensive break-down of myelin segments.

Fibres undergoing a Wallerian-type of degeneration were found in all animals examined. These comprised small and large diameter fibres which were distributed randomly throughout the white matter particularly in the ventral half of the cord and in the superficial portions of the dorsal columns. The smallest degenerating fibres were only detected by electron microscopy. Counts of degenerating myelinated fibres were made in complete transverse sections of the cord under oil-immersion. The numbers of such fibres in the lumbar cord were clearly related to the X-ray dose (Fig. 2). A similar relationship was found for the cervical

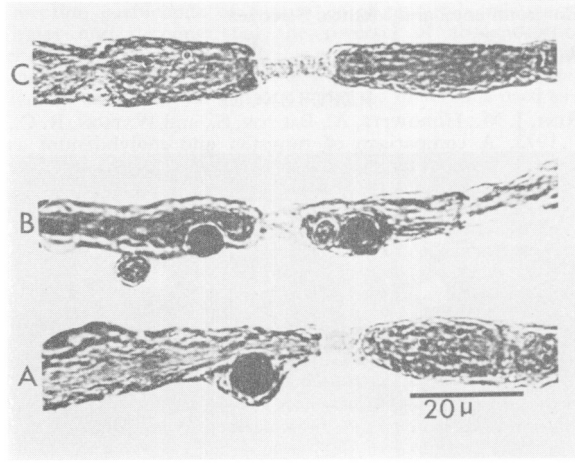

FIG. 1.

Single myelinated nerve fibres teased from the spinal white matter of an animal exposed to 1,000 rads and sacrificed eight weeks after irradiation, showing nodes and the paranodal regions of the myelin sheath. Densely-stained myelin balls are present within the myelin sheath in A and B and are also adherent to the sheath in B. The nodal gap is widened in each fibre (A = 5·5 μ; B = 6·2 μ; C = 12·5 μ; normal < 1 μ).

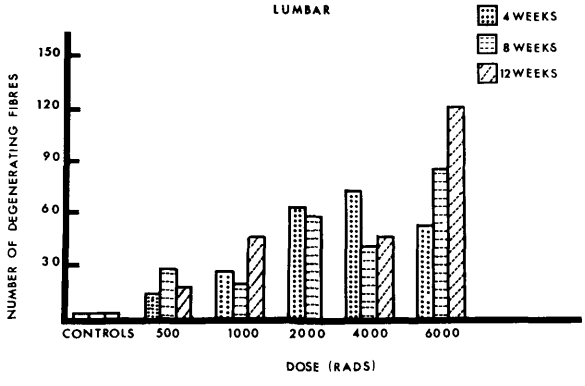

FIG. 2.

Histogram showing absolute numbers of fibres undergoing Wallerian-type degeneration at 4, 8 and 12 weeks in lumbar-irradiated animals and in controls. The numbers in each column represent counts from single animals.

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cord but was less clear than in the lumbar region. The number of degenerating fibres also appeared to be time-dependent but further data are required to establish the time course of these changes. No inflammatory or glial cellular reaction was found in the irradiated area. Blood vessels of all calibres were normal.

We were interested in the significance of the paranodal changes in otherwise intact nerve fibres and examined the possibility that they might represent early changes in fibres which had sustained axonal injury and were about to undergo Wallerian-type degeneration, as is thought to be the case in the peripheral nervous system (PNS) (Causey and Palmer, 1952; Ballin and Thomas, 1969). Since there has been no study of the early changes in Wallerian degeneration in central nerve fibres, we sectioned the dorsal columns in five further rats and studied fibres rostral to the lesion after 9–48 hours. Although nodal widening and paranodal myelin break-down were found in some fibres at 24 hours, the morphological appearances were quite different from those seen in irradiated animals. It thus seems likely that the paranodal changes represent a direct effect of radiation on the myelin itself or the oligodendrocytes, leading to paranodal demyelination, rather than merely the accompaniments of axonal degeneration. The ultimate fate of the fibres showing the paranodal changes is uncertain. There is no convincing evidence of repair by remyelination during the first three months and we do not know whether such fibres ultimately undergo Wallerian-type degeneration. The relationship of the early changes to the extensive delayed radionecrosis of the cord which occurs 4–12 months after irradiation in the rat (Innes and Carsten, 1961; van der Kogel and Barendsen, 1974) is still unclear. Further experiments with longer survival times after irradiation are in progress.

Two interesting points arise from this study. Firstly, the use of refined techniques has revealed hitherto unrecognised changes in myelinated central fibres as a result of exposure to doses of X-rays as low as 500 rads. The severity of damage is dose-dependent and may also be time-dependent. Secondly, the occurrence of the early myelin changes in the paranodal region accords with the similar distribution of abnormalities in central demyelinating lesions produced by diphtheria toxin (Harrison *et al.*, 1972) and compression (R. F. Gledhill, B. M. Harrison and W. I. McDonald, unpublished observations) and possibly by experimental allergic encephalomyelitis (Lampert, 1965) and multiple sclerosis (Suzuki *et al.*, 1969). It thus seems that paranodal demyelination is a fairly general mode of reaction in the CNS as in the PNS, despite the very different relationship between myelin sheath and myelin-forming cell in the two sites (Bunge, 1968).

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Yours, etc.,
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THE EDITOR—SIR,

RADIOLOGY AND THE COMMUNITY

Your leading article and the letter from Dr. Emrys-Roberts (July, 1975) are timely reminders that we should examine the role of radiology in community medicine. It is by no means a heresy to continually review the services supplied to patients by such an expanding and changing speciality as radiology.

It should be possible for qualified doctors to interpret films of the extremities following minor injuries, and with careful choice of equipment and firm instructions they could even take the films themselves—casualty officers are known to do this in accident departments! This may even reduce the number of unnecessary and "litigophobic" requests. It is, however, extremely important that those areas which are known to be difficult should have high-quality films and a radiological opinion. In many cases, it is this back-up facility which is not immediately available to the general practitioner. Rather than separating them further, I feel that a closer personal relationship between a consultant radiologist and his local practitioners is very much desirable.

In hospital radiology we pay a good deal of attention to clinico-radiological meetings, not only for our own benefit, but also for the patient. This principle should also be applied to general practice, via the community hospitals. A weekly radiological session with general practitioners, discussing patients whose films are too difficult for them to interpret, would give interest to both and benefit to the