

TABLE I.
Immediate and Late Effects of Repeated Subconcussive Trauma.

Procedure	15 blows	Unconscious (2" to 60') %	Persistent changes in behavior %	Death within 29 days %	No apparent effects %
Moving head against fixed object	1 min apart	73	13	17	27
	2-6 days apart	57	7	17	43
Moving object against fixed head	1 min apart	40	10	7	60
	2-6 days apart	40	10	0	60

findings. Obscuring of stratification, shrinkage and pyknosis of nerve cells of the cortex, and demyelinated areas were frequently found, and where demyelination and breaking down of axons were still in progress scavenger cells, loaded with fat droplets, were noticeable. Evidence of reaction of glia cells in the parts that were damaged was encountered at times, mostly without appreciable increase of glial fibers.

Summary. Rats submitted to repeated blunt impacts on the head, the strength of

each of which was insufficient to cause any immediate or late ill effects, frequently revealed cumulative effects as shown by unconsciousness, at times followed by death or by persisting changes in behavior. A certain correspondence was found between the response to the trauma during life and the amount and degree of cerebral damage at post mortem examination, which consisted mainly of degenerative changes in neurons detected by present histological methods.

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Microscopic Neuronal Injury in Rats Submitted to Concussive Head Trauma Under Different Mechanisms.

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Preliminary experiments in an investigation on the effects of repeated minimal impacts on the head led to the study of a number of brains of animals (68) recovering from a short period of unconsciousness after receiving a single concussive blow. Using a trauma of the same momentum (mass 567 g, velocity 345 cm/sec), half of the animals were made to strike the moving head against a stationary object and the other half were struck by a moving object on the stationary head. Although no differences were seen in the immediate effects in the two series (all animals being made unconscious by the blow for a period ranging from 10 seconds to 15 minutes), in view of the possibility of different morphological patterns resulting from the two

different mechanisms of trauma, a comparative study of this material seemed of value.

Observations. At postmortem examination, no evidence of skull fracture was found in any case, and in all but one, in which petechial hemorrhages were seen in both the pons and the bulbar region, the gross inspection of the brains and even the study of the hematoxylin-eosin stained sections failed to reveal any remarkable change, except for an occasional vascular engorgement and for some doubtful signs of edema of the brain matter. However, when the stains proper for the nervous system elements were applied, definite neuronal changes were seen. Regardless of the mechanism of trauma these changes had a wide distribution, involving the cerebral

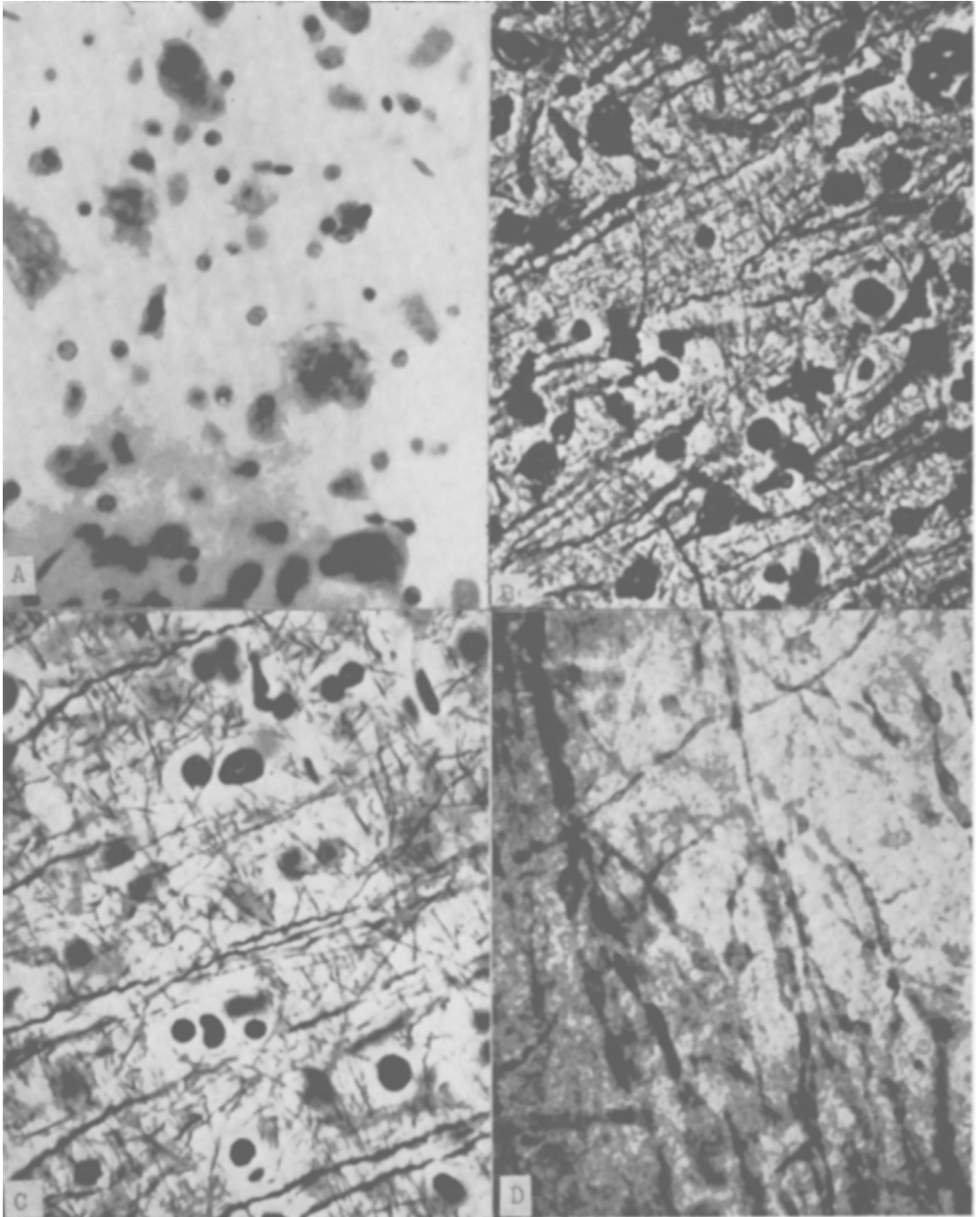


FIG. 1.

Microphotographs of the cerebrum of a rat recovering from a short period of unconsciousness induced by a blow on the head which had left skull and brain apparently intact.

A. Cortical nerve cells showing marked tigrolysis and peripheral vacuolization.

B. Thickening, spiroid course, and twisting of cortical axons.

C. Swelling, cork-screw appearance, and fragmentation of medullated nerve fibers.

D. Moniliform swelling and incipient disintegration of myelin sheaths.

hemispheres, mid-brain, pons, medulla oblongata, and occasionally even the upper cervical cord, the impacts being constantly delivered on the occipito-parietal region.

In the Cajal stained preparations, thickening, spiroid course, and at times definite twisting of the axons of the cortical cells were already apparent in the animals killed at the 1st hour. The corresponding nerve cells in the Nissl stain showed obscuring of the cell outlines, tigrolysis, and huge peripheral vacuoli. These changes were not diffuse, as groups of damaged neurons alternated with others displaying normal patterns. The same type of focal change was displayed by the medullated axons which appeared poorly impregnated and swollen, with a corresponding moniliform swelling of the myelin sheaths in the Spielmeyer preparations.

More advanced myelin disintegration and neurolysis were found in the animals killed from the 4th to the 72nd hour, as shown by fragmentation of axis cylinders, with incip-

ient neurolysis and myelin reabsorption and resolution into round, oval or irregularly shaped fat globules.

Of 16 animals killed after 2 months observation, only 4 revealed a definite pathology characterized by focal areas of demyelination, and rarefaction of nerve cells in the cerebral cortex with obliteration of axis cylinders and glial proliferation in the most damaged areas.

Summary. Rats recovering from a temporary period of unconsciousness, varying from 10 seconds to 15 minutes, following a blunt impact on the head which had left skull and brain apparently intact, frequently revealed microscopic evidence of neuronal injury affecting, in multiple areas, nerve cells, axis cylinders, and myelin sheaths. Using a trauma of the same strength, no differences were seen, either in the immediate effects or in the type and extent of cerebral changes, when the impact was delivered on the stationary head or on the head in rapidly accelerated motion.

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Gastric Mucosal Lesions in Rats Submitted to Head Trauma.

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A relationship between cerebral birth injury and hemorrhagic erosions in the mucosa of the alimentary tract (stomach, esophagus, first portion of the duodenum) has been known to exist for many years; yet it was not until 1932 when Cushing¹ reported additional instances of ulcers developing in individuals submitted to surgical intervention in the brain that the conception of the neurogenic origin of mucosal lesions in the intestinal tract gained widespread interest (Oppper and Zim-

merman,² Vanzant and Brown,³ Ivy,⁴ Keller⁵). Although some observations on the experimental animal have shown that these mucosal defects have a tendency to heal promptly, yet in the opinion of others this does not seem to be invariably the case, leaving unsettled the problem of the relationship between head trauma and peptic ulcer.

Rats submitted for other investigative purposes to blunt impacts on the head, single or repeated, of different intensity, revealed evidence of gastric damage in a number of cases, 14 out of 183, or 7% approximately. Some of the rats had been struck by a moving object on the stationary head and others had

¹ Cushing, H., *Surg., Gynec. and Obst.*, 1932, **55**, 1.

² Oppper, L., and Zimmerman, H. M., *Yale J. Biol. and Med.*, 1938, **11**, 49.

³ Vanzant, F. R., and Brown, J. A., *Am. J. Digest. Dis.*, 1938, **5**, 11.

⁴ Ivy, A. C., *Arch. Int. Med.*, 1920, **25**, 6.

⁵ Keller, A. D., *Arch. Path.*, 1936, **21**, 137, 165.