30-50% of the initial value after shunting procedure and returned to the preoperative state after malfunctioning shunt. Therefore measurement of ventricular HIAA and HVA may be a useful method to test easily shunt function.

In four cases normal pressure hydrocephalus showed typical psychic symptom and P.E.G., RI cisternographic finding specific to this symptom and clinical improvement after shunting procedure. The HIAA level of which the mean value was  $139\pm32$  ng/ml was slightly higher than that of cases without CSF blockage. Comparing changes of ventricular HIAA level with psychic symptom in all cases mentioned above no correlation was observed, nevertheless the increasing HIAA level presumably caused by CSF circulatory disturbance was observed. Based on this finding it is reasonable to presume that changes of HIAA in NPH may reflect CSF circulatory disturbance rather than psychic symptom.

## **B-51.** Engineering Aspects of Skull Fracture and Brain Damage

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Clarification of the human tolerance limits against trauma would promote prevention of injury as well as application in clinical medicine.

Semi-free fall test to give impact on twenty dry human skulls at mid-frontal regions were performed using a strain-gauge load cell, an accelerometer, DC amplifiers and a cathoderay oscilloscope. Various buffer materials including a scalp simulator were used. At fracture notching and abrupt lowering of the load curves as well as high frequency vibration of the acceleration curves were noted. The rise time at fracture became shorter compared to those when fracture did not occur. The dynamic load level for frontal bone fracture ranged between 400 and 1300 kg., independent of acceleration, energy, buffer materials, as well as rise times. The peak loads at the moment of fracture were closely related to the weights of dry skulls. These results indicate that human skulls have the characteristics of brittle fracture dynamically. Postulating a head falling brow-down on a hard, flat surface without the effect of the body, the threshold for fracture in terms of peak acceleration and rise time is very close to the Wayne State Human Tolerance Curve.

Similar falling test on ten human skull dummies, made of plastic compounds and filled with water Inside the cavity were conducted, using the above-mentioned sensors as well as a strain-gauge pressure sensor set at the internal wall of the occipital extremity and the outputs were all recorded in magnetic tapes. The occipital pressures reached to minus one atmospheric or so-called cavitation pressure before the skull yielded. The occipital acceleration curves were transformed into the Effective Displacement Indexes of Brinn and others using an analog computor. These index curves showed definite diminishment of the peak value effected by the skull fracture.

From these experiments it is concluded that the skull fracture appears to lessen the acceleration (deceleration) to the head andthe socalled acceleration injury of the brain. However, skull fracture by itself can cause severe brain damage. Therefore, the Wayne State Human Tolerance Curve should be applied only to those closed head injury without skull fracture. Instead, skull deformation and possibly snap-back of the deformed skull should be considered as the mechanism of the brain damage with skull fracture.

## B-52. Medical and Dynamic Analysis on the Protective Effect of a Motorcycle Helmet (1st report)

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With the aid of the Japan Automobile Manufacturers Association, the Japan National Police Agency and the Japan Council of Traffic Science, 220 cases of victims of motorcycle accidents which took place in four local prefectures in Japan during the last win-

- 155 -