MEASURES OF SEVERITY OF INJURY.

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This Conference aims to develop understanding of mechanisms of injury so that injuries can be prevented or mitigated in future. Laboratory experiments and even field studies which concentrate only on specific injuries may overlook the total injuring effects of real accidents. As a check on this, and as a means of assessing the overall protection provided by new mechanical or highway engineering changes, numerical estimates of severity of injury are required. The same estimates might be used in the assessment of the social cost of accidents and to compare different regimes of treatment.

The most promising approach dates from the early work of DeHaven on aircraft accidents. He had been the sole survivor of a mid-air crash in World War 1 and he was interested to study why some should die and some escape injury. To provide comparative assessment of injuries in such accidents DeHaven and the Cornell group developed the first practical method for ranking severity [1]. The present Abreviated Injury Scale (AIS) is a refinement of this and provides a 5 point scale of injury with further points for fatal cases [2]. The orinal basic criterion was "threat to life" but comparison with rankings by the other clinical measures - treatment time and impairment - showed them to be roughly comparable. As might be expected there is some relation also to energy of impact if only one body site is considered. A slight impact on a leg may give a sprain, more severe an undisplaced fracture, more severe an open fracture, more severe multiple fractures. A similar sequence could be cited for head injuries ranging from minor dizziness to severe intra-cranial damage, but the implication for threat to life and of severe impairment begins at much lower energies. Another obvious variable affecting the injuring effect of a given amount of energy is the size of the area of impact. With a boxing glove one needs to be an expert to cause much damage. With a dagger the same amount of energy can easily kill.

In practice many severe injuries in road traffic accidents are multiple. A scale such as the AIS is best suited to single injuries. The Cornell team did, however, provide weighting values for their rankings which might be added in multiple injuries. An improvement on these has been devised by Baker et al, 1974 [3]. This simply squares the values (1-5) of the AIS and for multiple injuries sums these squares for up to 3 injuries of different body regions. The Baltimore team showed that this total, which they name the Injury Severity Score (I.S.S.) gave a promising relation to mortality in a series of traffic accident cases.

Our own interest in relating severity of injury to mortality came from a different angle. We wished to assess the success of treatment of burns patients and for this we took percentage surface area of burns as the index of severity and found that Probit analysis could be used to establish 50% "lethal doses" of burning for given ages of patients [4]. We have used this method to monitor improvements in treatment both as a running check by comparing observed mortality with expected mortality for given ages and areas of burn, and by recalculating the Probit fit from time to time [5].

The finding by the Baltimore team that I.S.S. also showed a similar relation to mortality and a similarly marked age effect suggested that Probit analysis might again be applicable. We therefore re-analysed the injuries and outcome of the 1333 road accident patients coming to our hospital in one year [6]. These same cases had been previously studied in terms of the disabilities from their injuries. After grouping the cases by age, good Probit fits were obtained for mortality against I.S.S. The 15-44 years group showed an 'LD 50' of I.S.S. 33.7, the 45-64 years group an 'LD 50' of I.S.S. 29.4 and the 65+ years group I.S.S. 20.2. (Table 1).

	Mean age	Cases	Deaths	Probit regression
15 - 44 yrs.	25 yrs.	721	17	$y = 1.748 + .0820\ x$
45 - 64 yrs.	54 yrs.	207	17	$y = 1.558 + .1173\ x$
65+ yrs.	73 yrs.	110	29	$y = 2.031 + .1469\ x$
				(y = Probit, x = I.S.S.)

Table 1. Probit fit of Mortality and I.S.S. in different age groups.

By constructing equal mortality contours for combinations of I.S.S. and age, a grid of expected mortality for different I.S.S. at different ages was obtained (Table 2). In our series there were too few children for analysis so the table is deficient at the younger ages. Such evidence as we have suggests that mortality for children follows that of the young adults. It should be understood that the values in this grid are provisional since they are based only on a single limited series but a further analysis can readily be made as further data becomes available. It is important that all cases both surviving and fatal be included otherwise bias will be introduced.

When we compared I.S.S. values of fatal cases with period of survival we found, as might be expected, that those with higher values tended to die sooner. There was, however, a wide scatter; some with severe injuries were kept alive by intensive care for several days: others with quite slight injuries died later from complications such as pulmonary embolism or chest infection. There was a higher proportion of older patients in this group - a main age-related difference is this liability to develop late complications. When I.S.S. values were compared with hospital treatment times, there was also a large scatter, but mean values of treatment times for given I.S.S. ranges were significantly different (Table 3). Because of the scatter the treatment time of individuals cannot be forecast from the

I.S.S.	15 < 25	25 < 35	35 < 45	45 < 55	55 < 65	65 < 75	75 < 85 yrs.
55 < 60	1.0	1.0	1.0	1.0	1.0	1.0	1.0
50 < 55	.9	.9	1.0	1.0	1.0	1.0	1.0
45 < 50	.7	.8	.9	1.0	1.0	1.0	1.0
40 < 45	.6	.7	.8	.9	1.0	1.0	1.0
35 < 40	.4	.5	.6	.8	.9	1.0	1.0
30 < 35	.3	.3	.5	.6	.8	.9	1.0
25 < 30	.2	.2	.2	.4	.7	.8	.9
20 < 25	.1	.1	.1	.2	.3	.5	.8
15 < 20	0	0	0	.1	.1	.3	.5
10 < 15	0	0	0	0	0	.1	.3
5 < 10	0	0	0	0	0	0	.1
0 < 5	0	0	0	0	0	0	0

Age

Table 2. Approximate probability of mortality for different combinations of I.S.S. and age.

I.S.S. but it can nevertheless be used for groups of cases to estimate, for instance, costs of hospital stay or for comparison between regimes of clinical management.

I.S.S.	Mean hospital stay (days).	(± s.e.m.)
0 - 4	2.7	(± 0.24)
5 - 9	7.3	(± 0.58)
10 - 14	30.1	(± 3.18)
15 - 24	45.7	(± 5.96)
25 - 34	54.5	(± 9.53)
35 - 50	154.5	(± 75.49)

Table 3. Inpatient hospital treatment time in relation to I.S.S.

The findings with disability are similar. We ranked permanent disability on a 5 point scale from the most severe, which included severe brain damage, to minor disability such as slight loss of limb function. Again there was a wide scatter of disabilities within scores, but there was a significant difference of mean scores for the different degrees of disability and all the disabled categories had significantly higher mean I.S.S. values than those without disability (Table 4).

Disability	Mean I.S.S.	(± s.e.m.)
Very severe	32.4	(± 4.70)
Severe	18.5	(± 1.61)
Moderate	12.7	(± 0.62)
Slight	10.1	(± 0.61)
Nil	5.8	(± 0.12)

Table 4. Mean I.S.S. for different degrees of disability.

The analysis confirms that the I.S.S. ratings proposed by Baker et al [3] correspond well to mortality for given ages. The good Probit fit of this relationship suggests that there is a "normal" distribution of susceptibility to injury within age groups. This is closely parallel to our earlier findings in burns patients. This strong "age effect" implies that when I.S.S. is used as a guide to safer vehicle design there will be different effects on mortality depending on the age distribution of the population exposed. No consistent age effect was found in the analysis of treatment times nor of disabilities.

Though I.S.S. gives quite good relationships to these various clinical measures of severity there may be room for improvement. One possibility is that further subdivision might be provided among the severe injuries at present classified as AIS 5. The present AIS 6 and above concern fatal cases and so pre-judge the mortality outcome. A maximum at 5, however, gives the difficulty that a certainly fatal injury in one area - say decapitation - will only yield an I.S.S. of $5^2 = 25$. This score can readily be exceeded by say 3 moderate injuries in 3 different body regions giving an I.S.S. of $3 \times 3^2 = 27$ - and this may well not be fatal. An extension of the scale might also accommodate the present difficulty of multiple injuries within one body region - at present only the most severe one can be taken into account.

Another possible improvement is to increase the weighting values more steeply. The weighting by squares of the I.S.S. is already steeper than the weightings previously proposed by the Cornell Group [1]. Another system proposed by Ryan and Garrett [7] suggests many more categories of severity, particularly among the less severe injuries with a binary system of weighting. We did not find this preferable to I.S.S. in relation to mortality and our impression is that improvements should best be sought by extending the "AIS" to provide higher values for the most severe injuries. This would then generate more appropriate I.S.S. values after squaring.

References:

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