PAPERS AND ORIGINALS

Measuring the severity of injury

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Summary

The injury severity score as a method for measuring the severity of injury has been found useful for epidemiological and metabolic research. Comparison with plasma cortisol concentrations confirmed that the method could distinguish between minor and moderate injuries. Before using the method one must decide on the need to weight the score for age. This is necessary when studying some relationships—for example, mortality and severity—but not others—for example, plasma cortisol concentration and severity.

Introduction

From whatever point of view injured patients are studied it is essential to be able to measure the severity of their injuries; only then can they be compared one with another or collected into groups of equal severity. With the possible exception of burns, where the area of the burn and the percentage that is full-thickness are obvious criteria, this has never been simple and the difficulties have discouraged people from carrying out necessary research on accidents. Previous work[1 2] would often have benefited from the use of some generally accepted system of classification. American preoccupation with motorcars and the accidents associated with them has led several groups in that country to study the problem of the severity of injury in depth, and several grading systems have been proposed.

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One of the most recent systems is the injury severity score (ISS) devised by Baker *et al.*[3] This uses the abbreviated injury scale (AIS) of the Joint Committee on Injury Scaling of the American Medical Association, the American Association of Automotive Medicine, and the Society of Automotive Engineers. Although the values in this scale were originally decided on clinical judgment by using it now as a defined and established scale their method avoids the subjective nature of some previous methods,[4 5] which could classify patients only into broad groups (minor, moderate, and severe) and often depended on information obtained during treatment—for example, at operation. The ISS method may also distinguish different severities within the three natural groups. The use of the method on 2128 victims of road traffic accidents in Baltimore by Baker *et al*[3] gave very promising results, which were confirmed by Bull[6] in 1333 road traffic accident victims admitted to the Birmingham Accident Hospital. The casualty pattern was very similar in the two cities.[7]

We needed a general method of assessing the severity of injuries that would be applicable to all types of accidents, not only road traffic accidents. The method would have to apply to outpatients as well as inpatients and be useful for metabolic and pathophysiological studies as well as epidemiological investigations. As Bull[6] had been able to extend the ISS method to burns and head injuries (J P Bull, personal communication), it seemed the method to examine first, particularly as it had been used successfully to study the mortality distribution in non-vehicular trauma in Illinois.[8]

Methods

Baker *et al*[3] divided the body into six regions: (*a*) head and neck, (*b*) face, (*c*) chest, (*d*) abdominal and pelvic contents, (*e*) extremities and pelvic girdle, and (*f*) general (external). The limits of these regions and their injuries are defined in the 1976 revision of the AIS booklet. The injuries in the six regions were graded, in increasing severity, from 1 to 5 according to the injury scale dictionary in that booklet. The ISS was then calculated as the sum of the squares of the highest AIS values in each of the three most severely injured regions of the body. An example is shown in table I. Only the three most severely injured regions contribute to the ISS and the contribution from any one region is that of its major injury only. Since all the extremities count as one region the contribution from the limb injuries in the example (table I) was 9. If the fractures in the two parts of the legs had been on the same side the contribution to the score would have been 16.

TABLE I—*Example of calculation of injury severity score in victim of road traffic accident who had injuries in four regions*

Region	Injury	AIS value	AIS²
Face	Abrasion near eye	1	
Head	Unconscious <15 min; no fracture; no neurological signs	2	4
Abdomen	Retroperitoneal haemorrhage	3	9
Extremities	Fracture four pubic rami	3	
	Fracture right acetabulum	2	
	Fracture right tibia (displaced)	3	
	Fracture right fibula	2	
	Fracture left femur (displaced)	3	9
		ISS score	22

The ISS values used for this appreciation of the technique were obtained from 174 patients who suffered fatal accidents from various causes (group 1) and a mixed group (group 2) of 189 accident patients in whom the metabolic responses to injury were being investigated. The patients in group 1 are discussed in the accompanying paper.[9] Of the 189 patients in group 2, 114 were male, seven died, 83 were outpatients, and 64 had been injured in road traffic accidents.

Plasma cortisol was measured on heparinised plasma by a protein binding method (Cortipac kit; Radiochemical Centre, Amersham). Informed consent to venepuncture was obtained when blood samples were not needed for diagnostic purposes.

Results and comments

There was no difficulty in using the AIS tables to calculate an ISS value. The method was very quick and as soon as a diagnosis had been made an ISS value could be awarded. In about 6% of patients in group 2 the initial score had to be changed in the light of subsequent events. The system outlined subgroups which, on general clinical grounds, would be classed as minor (ISS <7), moderate (ISS 7-12), and severe (ISS >12). In group 2 the numbers in these subgroups were 87, 76, and 26 respectively. The subgroups would be typified by a Colles fracture (ISS 4), a displaced fracture of the shaft of the femur (ISS 9), and a flail chest with an undisplaced fracture of the tibia and fibula (ISS 20). There were also clinically realistic gradations within the subgroups. In random series that include both fatal and non-fatal cases most of the ISS scores are less than 20—90% in the very large group (8852) from the Illinois Trauma Registry and 96% in group 2. ISS values greater than 9 usually indicate multiple injuries. Nearly all (93%) of the patients in group 1 had multiple injuries.

THE ISS SCALE

The ISS scale is discontinuous, the gaps becoming more frequent as the scores approach the maximum possible value of 75. The theoretical frequency of the scores, assuming a frequency of one for all possible scores (0-5) in three regions, is shown in table II. This feature of the scale was not taken into account by Baker *et al*[3] when they studied the relation between mortality and severity. Bull[6] also found that he could ignore it when using probit analysis to study this relation. His data fitted a linear scale, and a logarithmic transformation gave no improvement. Consequently the linear scale was used to study cumulative mortality in Group 1.[9]

WEIGHTING FOR AGE

The relation between mortality and the ISS value is influenced by age.[3] Bull[6] found that the score at which half the patients died fell from $39{\cdot}7 \pm 2{\cdot}9$ (mean ± SD) for the 15-44 year age group to $29{\cdot}4 \pm 2{\cdot}5$ for the 45-64 age group and to $20{\cdot}2 \pm 1{\cdot}6$ for those over 65 years. In mortality studies the ISS value must be weighted for age and this can be done by correcting the ISS value to that for the 45-64 year age group using Bull's probit lines. This was done for Group 1.[9]

An age correction may not always be necessary. Plasma cortisol concentrations were measured in 50 patients (32 male) whose injuries scored 4 on the ISS scale and in 47 (25 male) whose injuries scored 9. The samples were taken when the patient first presented at the accident and emergency department—that is, before treatment. None of the patients had any other significant disease. Plasma cortisol concentrations (table III) in both injured groups were higher than those seen during the normal circadian fluctuations, which seldom exceed 552 nmol/l (20 μg/100 ml).[10 11] This circadian rhythm is known to be disrupted by trauma.[11 12] The concentrations were consistently higher in patients with injury scores of 9, and analysis of variance showed that the difference in severity contributed significantly to the between-group variance, whereas differences in age did not.

TABLE III—*Plasma cortisol concentrations in patients with injury severity scores of 4 or 9. Numbers of patients are shown in parentheses*

ISS	Age (years)	Within 8 h after injury and 12 h of eating	Within 8 h after injury and 24 h of eating	Within 31 h after injury and 24 h of eating
		Mean (± SD) plasma cortisol (nmol/l)		
4	18–39	681 ± 7 (15)	683 ± 7 (18)	683 ± 7 (18)
	40–65	593 ± 12 (13)	672 ± 11 (17)	657 ± 11 (20)
	66–86	701 ± 7 (8)	732 ± 7 (9)	767 ± 6 (12)
9	8–17	894 ± 3 (5)	853 ± 4 (6)	853 ± 4 (6)
	18–39	893 ± 5 (15)	869 ± 6 (17)	869 ± 6 (17)
	40–65	800 ± 12 (6)	821 ± 9 (10)	793 ± 9 (11)
	66–90	847 ± 5 (5)	844 ± 5 (6)	758 ± 6 (13)
		Analysis of variance		
F	Between ages	2·41 (NS)	0·43 (NS)	0·96 (NS)
	Between severities	14·04 ($P<0{\cdot}005$)	10·84 ($P<0{\cdot}005$)	7·52 ($P<0{\cdot}01$)

NS = Not significant.
Conversion: SI to traditional units—Cortisol: 1 nmol/l ≈ 0·036 μg/100 ml.

This pattern was observed whether the samples were taken within eight hours of the injury or up to 31 hours after it. Similarly the results were not affected by whether or not the patient had eaten within the 12 hours before sampling. Although an age correction is unnecessary for plasma cortisol concentrations after injury, one cannot generalise, and the possibility will have to be examined in every case.

TABLE II—*Theoretical frequency of injury severity scores assuming unit frequency of all possible AIS scores (0-5) in each of three body regions*

ISS score	Theoretical frequency	ISS score	Theoretical frequency	ISS score	Theoretical frequency	ISS score	Theoretical frequency
1	3	20	6	39	0	58	0
2	3	21	6	40	0	59	3
3	1	22	3	41	9	60	0
4	3	23	0	42	6	61	0
5	6	24	3	43	3	62	0
6	3	25	9	44	0	63	0
7	0	26	12	45	6	64	0
8	3	27	4	46	0	65	0
9	6	28	0	47	0	66	3
10	6	29	12	48	1	67	0
11	3	30	6	49	0	68	0
12	1	31	0	50	9	69	0
13	6	32	3	51	3	70	0
14	6	33	6	52	0	71	0
15	0	34	9	53	0	72	0
16	3	35	6	54	3	73	0
17	9	36	3	55	0	74	0
18	6	37	0	56	0	75	1
19	3	38	6	57	3		

The small standard deviations in table III support the view[3] that patients with the same ISS have sustained injuries of equal severity.

Discussion

Our initial experience with the use of the ISS technique has been very encouraging, both in epidemiological[9] and metabolic studies. The plasma cortisol concentration is a sensitive measure of severity, and the difference in its concentration in the groups of patients with ISS values of 4 and 9 confirms that there was a real difference in the severity of their injuries. The use of the ISS method in further metabolic studies will be reported later.

Injury severity scoring can be done by an inexperienced person without error as the categories in the AIS list are sufficiently broad to cover minor variations in the injuries. It may seem remarkable that any worthwhile scale for the severity of injuries can be obtained by reading numbers out of a book but such is the case. The "trick," if it can be called that, lies in squaring the AIS values for the three areas with the most severe injuries before adding to obtain the ISS value, but this gives the best correlation between severity and mortality.[3]

At first sight there are some anomalies. The ISS value for a patient with a fracture of one femur could be the same as that for a patient with fractures of both femurs and the pelvis. Except for penetrating injuries the ISS values seem to be related to the amount of force needed to cause the injuries. The great force needed to produce such injuries would almost certainly have damaged other regions and so raised the score. Anomalies of this kind were not found in our patients and the ISS values seemed to reflect the clinical severity of their injuries correctly. Nevertheless, the detailed correlation between severity and biochemical changes on which we are engaged may suggest refinements of the ISS technique. Penetrating injuries—for example, stab wounds—may provide exceptions[3] and the use of the method for such injuries and for elective surgical operations has not yet been explored.

Quite apart from its research value the ISS method has clinical uses. Discrepancies between the proposed ISS value and the clinical appearance of the patient may be useful in drawing attention to errors in the diagnosis. Similarly the building up of a high score from a number of injuries, individually classed as minor, may draw the attention of the inexperienced clinician to the greater needs of the patient—for example, for transfusion. It must, however, be emphasised that the ISS is not intended as a prognostic index and should not be used as such. Other techniques have been proposed for this.[13]

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Airway patency in fatal accidents

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Summary

The state of the airway in patients who had fatal accidents over a five-year period was correlated with the severity of injury sustained. Necropsy of patients dying in hospital up to 72 hours after an accident showed that those with obstruction of the airway had less severe injuries than those in whom no such obstruction could be found. This suggests that airway obstruction contributed to their death. A similar distinction could not be shown for the patients who died before they reached hospital, indicating that airway management before arrival at hospital was probably satisfactory.

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Introduction

Many accident victims die before they reach hospital, and it is generally believed that fewer would do so if some medical expertise were available before and during the ambulance journey. In particular, it is thought that skilled management of airway obstruction would prevent many deaths in transit.[1] It has never been easy to evaluate the effectiveness of prehospital treatment, mainly because of the difficulty of comparing patients presenting with a wide variety of injuries. In an accompanying paper Stoner *et al*[2] describe the injury severity score (ISS) developed by Baker *et al*,[3] which appears to overcome this problem. Described here is the application of the ISS in assessing one aspect of patient care—the management of the airway in the victims of fatal trauma.

Method

All deaths reported to the coroner in the Salford area over a five-year period were reviewed. With the permission of the coroner 6095 necropsy reports were examined, and those relating to road traffic accidents, industrial and home accidents, assaults, and suicides involving violence were extracted.