World J. Surg. 7, 12–18, 1983

World Journal of Surgery

The Injury Severity Score

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The assets and drawbacks of ISS are documented, utilising 2 groups of patients with blunt multiple trauma. Group I consisted of 80 patients with 417 fractures and 163 major associated injuries. Group A had early fracture stabilization and prophylactic ventilation, Group B had early fracture stabilization without prophylactic ventilation, Group C had delayed fracture stabilization and prophylactic ventilatory support. Utilising the ISS, subgroups of A and C were constructed that had injury severity scores ⩾ 50 (means 57 and 58.7) containing 19 and 11 patients. Group A had a 10% mortality rate, a late sepsis mortality rate of 6%, and ARDS incidence of 26%, and a mean duration of ventilation of 6 days, while group C had a late sepsis mortality rate of 55%, and ARDS incidence of 82%, and a mean duration of ventilation of 26 days. It is concluded, that early operative stabilization of fractures is safe, and in significant part is associated with a reduced number of late sepsis deaths while reducing the duration of ventilator support required, and that prophylactic ventilator support (i.e., continued support after surgery significantly reduces the incidence of ARDS).

Group II consisted of all blunt trauma patients with an ISS greater than 20, admitted during 1981. Sixty-eight patients were admitted and the correlation was sought between ISS and mortality. It was concluded, that death exclusively from central nervous system injury should be analyzed separately from death from other causes in multiply injured patients. Reference is made to other applications of ISS than the documentation of mortality and suggestions are made for improving ISS by including the Glasgow-coma scale and including patients related risk data. A plea is made to devise a standard method for ISS calculation.

Measurement of the severity of injury has, until recently, largely been limited to burn injuries. The severity of a burn can easily be described by percentage of the body surface affected. Taking account of the patient's age and area of burn, Bull and Squire [1] derived a chart of expected probabilities of mortality for different patients. With this probit method, groups of patients could be compared and progress documented. Scoring the severity of burn injury is utilized by all burn centers.

Numerous efforts have been made to devise a similar system for blunt trauma. In 1971, the Committee on Medical Aspects of Automotive Safety published the Abbreviated Injury Scale (AIS) in which the severity of injury is graded for non-fatal lesions from 0 (no injury) to 5 (critical) in 5 body areas [2]. AIS subsequently has been revised in 1976 and 1980, but the revisions were not published in medical papers, making access difficult for researchers outside the United States. An adaptation of AIS was published in 1980 by the American College of Surgeons Committee on Trauma as the Hospital Trauma Index (HTI) [3]. The AIS method is useful to score severity in separate body areas, but does not lend itself to easy description of groups of patients with multiple injuries.

In 1974, Baker et al. [4] demonstrated that in a group of 2,128 patients with injuries caused by blunt trauma, death rates increased in the presence of injuries in a second or third body area of AIS, even when the additional injuries would not in themselves be life-threatening. Adding injuries in a fourth body area of AIS did not improve correlation with survival. Also, Baker et al. demonstrated that squaring the highest AIS values obtained enhanced correlation with mortality. Based on these conclusions, an Injury Severity Score (ISS) was devised, by summing the squares of the 3 highest AIS values obtained for one patient, the maximum being $3 \times 5^2 = 75$. ISS, calculated from AIS, has subsequently been applied to large series of traffic accidents by Bull et al. [5], to traffic and non-traffic accidents by

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0364-2313/83/0007-0012 $01.40

Semmlow et al. [6], and to multiple traumatized patients by Moylan et al. [7]. The correlation of ISS with mortality rates was confirmed, and mortality rates for identical ISS values showed a close match in these 3 publications.

In introducing the ISS, Baker et al. [4] stated that "the ability to compare groups of patients by overall severity makes it possible to evaluate methods of treatment, identify problem areas, and document progress [and] . . . to compare various institutions. . . ." In this paper, 2 series of patients with injuries from blunt trauma will be analyzed to demonstrate these possible applications of ISS. In the discussion, an assessment will be made as to whether these qualities of ISS have been utilized to their full extent.

Material and Methods

The first series describes all blunt trauma patients admitted to the departments of general surgery and intensive care of the University Hospital St. Radboud, Nijmegen, during the period 1977–1981 and conforming to the following criteria: (a) age 14 years or older; (b) scoring 3 or more points on a long bone fracture scale: femur, 2 points; tibia and fibula of the same leg, 1 point; humerus, 1 point; radius and ulna of the same arm, 1 point; (c) surviving at least 1 hour after admission to the hospital; and (d) any other injury.

General methods of management in this group of patients have been described previously [8, 9]. Within this series, artificial ventilation versus spontaneous ventilation as related to the incidence of the Adult Respiratory Distress Syndrome (ARDS), and of early versus delayed operative stabilization of all or the majority of dislocated long bone fractures as related to mortality, are analyzed by means of the ISS.

The second series describes all trauma admissions to the St. Radboud Hospital during 1981, excluding only patients dead on arrival, to document mortality rates as related to ISS. Both series include referred patients.

In both series, HTI [3] was utilized rather than AIS [2] for reasons described previously [8, 10] and summarized in the discussion section. The HTI is a trauma scoring system utilizing 6 body areas: respiratory, cardiovascular, nervous system, abdominal, extremities, and skin and subcutaneous, with an index of 0 (no injury) to 5 (critical). The index 6 (fatal) and the section "complications" were not utilized. HTI was determined directly from patient records independently by a junior and a senior researcher with subsequent discussion determining the final indices. Only findings directly resulting from the injury (e.g., not aspiration occurring in hospital, or blood loss resulting from operations on fractures) and diagnosed during the first 24 hours after injury were scored. The blood pressure, scored in the cardiovascular index of HTI, was the lowest blood pressure obtained before emergency operations were started. When multiple lesions were present in one organ system of HTI, the final index was determined by assimilating 2 major lesions (HTI 3) to 1 severe (HTI 4) and 2 severe lesions to 1 critical (HTI 5). The ISS was then calculated by summing the squares of the 3 highest HTI indices thus obtained. Bull's probit method [11] was utilized to compare expected with actual mortality rates.

Results

Data of Patients with 2 Major Fractures

Eighty patients with at least 2 major fractures conformed to the criteria of the first series of which 27 (34%) patients were referred from other hospitals. These 80 patients had a total of 417 fractures (± 5.2 per patient), 163 associated major lesions (± 2 per patient) (Table 1) and underwent 226 osteosyntheses (2.8 per patient) (Fig. 1). Depending on the therapeutic approach, 3 treatment groups can be identified. In groups A and B, the majority of the unstable long bone fractures were stabilized with internal or external fixation during the first 24 hours after injury. In group C, delayed operative treatment was performed in eligible fractures. In this group, 4 patients died before the general condition was sufficiently stabilized to warrant safe delayed operative fracture treatment. In groups A and C, prophylactic artificial ventilation was instituted on the day of injury, to prevent or attenuate the clinical manifestation of ARDS. In group B, no prophylactic artificial ventilation was instituted, and the patients were allowed to breathe spontaneously after the early osteosynthesis. The division in treatment groups was not random. The decision to ventilate patients mechanically (groups A and C versus B) was based on the score obtained on an ARDS-prevention scale (Table 2). Group B consists of 8 patients with less severe injuries and of 3 patients transferred from another hospital with fractures that had been operated on but without postoperative ventilation. Reticence to perform early osteosyntheses in the most severe cases—in the first year by all involved, in the latter years by one of the trauma teams—resulted in group C.

Analysis by means of ISS shows that the severity of injury cannot be compared in the 3 groups, group C being more severe than group A, and group A more severe than group B (Table 3). Any conclusion as to the mortality is thus impossible. Howev-

Table 1. Eighty patients with 417 fractures and 163 associated lesions.

	No. of patients (%)	No. of lesions
Respiratory[a]	26 (32)	37
Nervous system[a]	29 (36)	36
Abdominal (laparotomy)	13 (16)	25
Crush of extremity	17 (21)	20
Vascular lesion	10 (12)	12
Hematuria	27 (34)	27
Ocular lesion	5 (6)	6
Total		163

[a]Lesions with HTI ≥ 3

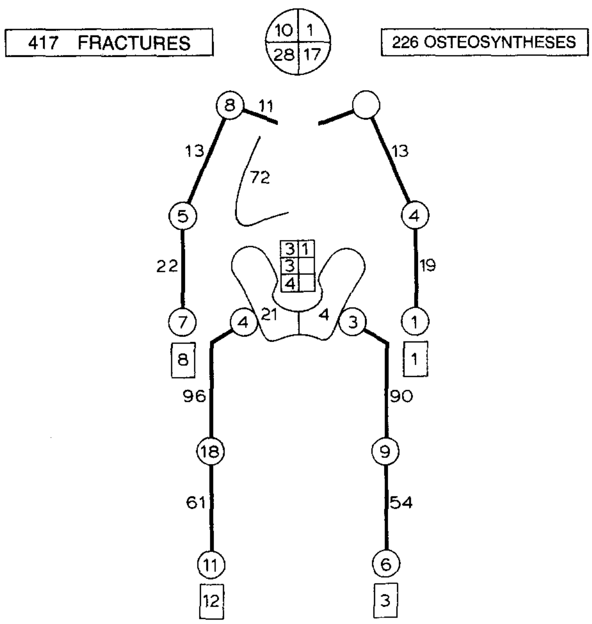

Fig. 1. Distribution of fractures and osteosyntheses in 80 patients with at least 2 major fractures, treated at University Hospital St. Radboud, Nijmegen, The Netherlands, from 1977 to 1981.

er, the incidence of ARDS is significantly higher in group B—with lower ISS values, and no major thoracic injury—than in group A—with higher ISS values, and 16 major thoracic injuries (Table 3). The average ISS of the patients with ARDS was 49.2 ± 9 in group A and 34 ± 10 in group B.

To compare mortality rates, a separate analysis can be performed utilizing only the patients with an ISS ≥ 50 (Table 4). No patient in group B fell into this category. Analysis of this subgroup leads to the conclusion that early osteosynthesis in those critically injured patients is safe and has a lower mortality rate than conservative fracture treatment, because late death from sepsis and the associated multi-organ failure is prevented (Table 4). In group

Table 2. ARDS prevention scale.[a]

Simple Fx foot, ankle, wrist, rib, and mandibula	each	1 point
Forearm, Le Fort II		2
Humerus, tibia, vertebra, Le Fort III		3
Femur, pelvis		5
Ruptured spleen		3
Ruptured liver		4
Transfusion ≥ 4 units of blood		3
Initial blood pressure < 80 mm Hg		4
PaO_2 < 60 mm Hg		5
Flail chest, aspiration		10
Intestinal perforation		6
Contusio cerebri		4

[a]A patient scoring 10 or more points is ventilated artificially as a prophylaxis against ARDS.

A, of 6 patients with an ISS of 66 points 4 survived this overwhelming injury.

As the mean age of patients in different therapeutic groups was at variance, analysis of mortality was performed utilizing Bull's probit method [11], adjusted for age (Table 5). There is some bias in analyzing this patient series coded with HTI, as Bull's probit analysis was based on patients scored with AIS. However, the main reason for the discrepancy between expected and actual mortality rates, as found in all 3 groups, is that Bull's method is based on a patient population treated in 1961. The mortality rates as related to ISS, in comparison to other studies, are plotted in Figure 2.

Data of Trauma Admissions in 1981

During 1981, a total of 1,442 trauma patients were admitted, of which 28 died (1.9%). Sixty-eight of them sustained blunt trauma with an ISS of 20 or more points (Table 6). As this score can only be obtained by at least 2 major anatomic injuries ($3^2 + 3^2 = 18$) or by one severe and one moderate anatomic injury ($4^2 + 2^2 = 20$), and a critical lesion (HTI = 5) in one body area is generally accompanied by lesions in other areas, this ISS of 20 or more reflects multiple trauma.

In our series, a larger percentage of high ISS values is present because 26 referred patients have been included with a mean ISS of 40.4 (Table 6). During 1981, 28 patients died with a mean ISS of 48.5. Analyzing these blunt trauma deaths, 3 clusters can be identified. Two patients (ISS ± 9), aged 83 and 87 years, died after sustaining a femoral neck fracture and a comminuted femoral fracture. Age and general debilitation rather than injury severity were related to their death. Thirteen patients (ISS ± 38.3) died from critical central nervous system (CNS) injury. The individual ISSs were as follows:

Table 3. Mortality and ARDS in 80 patients with 417 fractures.

	Group			
	A	B	C	Total
Prophylactic mechanical ventilation	+	−	+	
Early osteosynthesis	+	+	−	
No. of patients	56	11	13	80
Mean ISS	40.9	26.8	55.5	41.4
Mean age	30 yrs	29 yrs	42 yrs	32 yrs
Mortality	2 (3.6%)	−	6 (46%)	8 (10%)
ARDS	8 (14%)	4 (36%)	10 (88%)	22 (27%)
Major thoracic injury (HTI ≥ 3)	16	−	10	26
Mean duration of artificial ventilation in survivors	2 days	5 days	10 days	

Table 4. Mortality and ARDS in 30 patients with at least 2 major fractures and an ISS ≥ 50.

	Group	
	A	C
Prophylactic artificial ventilation	+	+
Early osteosynthesis	+	−
No. of patients	19	11
Mean ISS	57	58.7
Mean age	35 yrs	45 yrs
No. of associated major lesions[a]	58 (±3 pt)	29 (±2.6 pt)
Mortality	2 (10%)	6 (55%)
Late mortality from sepsis	1/18 (6%)	6/11 (55%)
ARDS[b]	5 (26%)	9 (82%)
Mean duration of prophylactic artificial ventilation in survivors	6 days	11 days
Mean of total duration of ventilation	6 days	26 days[c]

[a]HTI ≥ 3.
[b]Defined as the necessity of artificial ventilation during more than 4 days.
[c]Two patients needed prolonged therapeutic ventilation because of ARDS due to sepsis, and died.

25 (×4), 29 (×3), 43 (×2), 50 (×2), 59, 75. Thirteen patients (ISS ± 64.7) died from injury and/or its complications, excepting pure CNS injury-related death. Two patients (ISS 54 and 66) died within hours from hemorrhage, and 7 patients [ISS 66 (×3), 75 (×4)] died within hours from hemorrhage and coma, possibly related to severe hypotension. One patient (ISS 41) died from ARDS after being referred to our hospital on the third day after injury with established severe ARDS. Three patients [ISS 50, 66 (×2)] died late from sepsis and remote organ failure.

Table 7 demonstrates that the inclusion of patients who died from CNS injury disrupts mortality rates in the middle range of ISS values.

Discussion

AIS Versus HTI

Champion et al. [12] and Dove et al. [13] stated that the rankings of severity in AIS are based on subjective impressions. HTI, on the other hand, utilizes objective diagnoses (e.g., "aspiration" HTI = 5) rather than subjective data (e.g., lung contusion AIS = 3). On average, the same lesion (e.g., minor liver laceration AIS = 5) scores lower in HTI (HTI = 3), leading to lower ISS scores in less severely injured patients [8, 10]. This is reflected in Table 6 in which proportionally fewer admitted patients score an ISS of 20 or higher with HTI than in other series utilizing AIS. By adding the cardiovascular system data, including total volume of blood lost, independently from the source of blood loss, the HTI leads to higher ISS scores than AIS in the more severely injured patients [8, 10]. Since no patient has been described surviving the highest ISS score of 75, it is an asset for HTI to favor higher ISS values in the most severely injured. HTI (and AIS) could be improved by substituting the well-documented Glasgow Coma Scale [14] to the duration of coma, when scoring the nervous system injury, as has been done with burn mortality scales for the "skin and subcutaneous" system.

ISS as a Trauma Scoring System

The value of ISS to document mortality rates has been confirmed by all [4–6, 13, 15, 16]. The main criticism against ISS has been directed at the following points.

Table 5. Expected and actual mortality in 80 patients with 417 fractures. Bull's probit method [11].

	ISS < 50 no. patients	Expected mortality	Actual mortality	ISS ⩾ 50 no. patients	Expected mortality	Actual mortality	Total no. patients	Expected mortality	Actual mortality
Group A	37	12	–	19	18	2	56	26	2
Group B	11	3	–	–	–	–	11	3	–
Group C	2	1	–	11	11	6	13	12	6

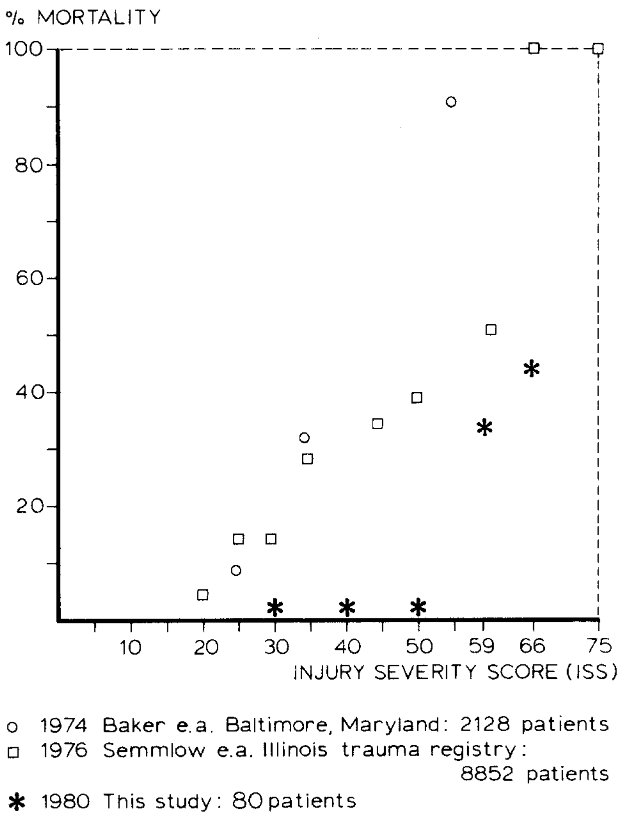

Fig. 2. The mortality rates of the present study as related to ISS, in comparison to other studies.

First, there is no adjustment for age or patient-related risk factors. A solution to the age problem has been offered by Bull's probit method [5, 11]. In a study attempting to scale patient-related risk factors in burns, Fisher et al. [17] demonstrated that only with these additional variables could a highly significant drop in burn mortality be documented in his burn unit. A similar patient risk profile, possibly including age and interval between injury and time of hospital admission, should be added to the ISS system, for instance, by calculating a fourth obligatory HTI-grading from 0 to 5, the maximum ISS then being 100. This suggestion, of course, needs further study.

Champion et al. [12] stated that ISS has been correlated with mortality outcomes only in patient sets with low mortality. However, the patient population with ISS > 50 amounts to 1% of all trauma admissions (Table 6), making a large data bank necessary. In our limited experience, correlation with mortality was excellent, even in the higher ISS areas (Table 7, Fig. 2). Champion et al. also stated that "because combinations of modestly severe injuries may result in a higher ISS than a fatal head injury, ISS does not meet the requirements of an ordinal scale, let alone an interval scale." The problem of CNS death versus ISS is important, since almost 50% of blunt trauma patients die from brain injury as is described elsewhere in this paper and by others [15]. This high mortality rate is not reflected in a higher AIS or HTI value to calculate ISS. Attributing a higher AIS or HTI value (e.g., 6) because a patient dies from brain injury is not logical, because ISS estimates severity of injury and not its complications. A possible solution to this problem is demonstrated in the second patient series in which analysis of mortality is performed in 3 clearly unrelated clusters: death after injury from patient-related risk factors, death from CNS injury, and death from severity of injury. Analysis within each cluster can be performed utilizing ISS as a unit of comparison. The statement that the ISS method requires special personnel, thus entailing significant problems with accuracy and reliability [12], has not been confirmed by others. Accuracy will never be 100% whatever the method utilized.

ISS to Document Mortality and Mortality Rates

ISS was utilized to document the maximum ISS of survivors of blunt trauma: 48 [13], 50 [5], 50 [4], 59 [6], 66 [8]; to document mean ISS of blunt trauma deaths: 34 [13], 37 (non-CNS deaths in Orange county [18]), 45 (non-CNS deaths in San Francisco [18]), 42 (non-CNS deaths [15]), 64.7 (non-CNS death, this paper); and to document death in blunt abdominal trauma; 42.9 [19], 58.4 [20]. Mortality rates as related to ISS can only be documented by analyzing complete groups of trauma admissions. Apparently, this has been more difficult since the most recent large patient population documented dates from the Illinois Trauma Registry patients in 1971–1973 [6]. Figure 2 demonstrates that a large new series of patients with an ISS > 20, documenting mortality, is necessary as a basis of reference

Table 6. Relative frequency of ISS scores, in different series of patients.

	Bull [5]	Semmlow [6]	Moylan [7]	This series
Year of patient admissions	1960	1971–1973	1972–1973	1981
HTI or AIS ISS	AIS	AIS	AIS	HTI
No. of patients	1,333	3,350	823[a]	1,442
Mortality rate (%)	4.9		7.7	1.9
ISS ≥ 20 (%)	8.5	19	11	4.7
ISS > 50 (%)	1.6	0.4	1	2.1

[a]823 multiple trauma patients from a series of 4,566 trauma patients.

Table 7. Mortality rates per ISS group in multiple trauma patients, excluding and including death from central nervous system (CNS) injury.

	Excluding CNS deaths		Including CNS deaths	
ISS	Number	%	Number	%
20–29	0/8	0	7/15	47
30–39	0/12	0	0/12	0
40–49	1/9	11	3/11	27
50–59	2/14	14	5/17	29
66	6/8	75	6/8	75
75	4/4	100	5/5	100
	13/55		26/68	

for further studies. This can only be obtained by banking data from several institutions. These data could then be utilized to adapt Bull's grid of expected mortality [11] and/or to construct a patient-risk profile for blunt injury.

ISS to Identify Problem Areas

In a series of blunt trauma deaths, ARDS was demonstrated to be the cause of death with the lowest average ISS [8], pointing out the necessity of still more aggressive respiratory support. In the same series, the patients dying late from sepsis did not differ as to average ISS from those dying from other causes, except for a higher HTI for extremity injury and for the long bone fractures not being treated by early osteosynthesis.

ISS to Evaluate Methods of Treatment

Limiting analysis of specific therapeutic modalities to patient groups with similar ISS values enhances the ability to draw conclusions. This is demonstrated for early osteosynthesis versus conservative fracture treatment in a group of patients with an ISS ≥ 50 and at least 2 major fractures (Table 4). Similarly, de Boer et al. [20] analyzed 26 trauma patients with an ISS ≥ 50 and a HTI ≥ 3 for abdominal injury, and demonstrated that a delay of 4 or more hours between admission and laparotomy resulted in a significantly higher mortality rate.

ISS to Indicate Need for Specific Therapy and Other Applications

In our hospital, the necessity for prophylactic ventilation has been determined since 1976 by means of an ARDS-prevention scale (Table 2), a patient scoring 10 points being ventilated prophylactically. Correlation of this ARDS-prevention scale with HTI and ISS can be given by the next 2 rules: Ventilate any patient with 2 or more major fractures, and/or with an ISS of 25 or higher. A positive correlation between ISS and length of hospital stay has been demonstrated by Bull [5] and Semmlow et al. [6] and with residual disability by Bull [5]. In our series of 80 patients with at least 2 major fractures, both correlations were positive only after excepting patients with major crush injuries of limbs and severe head injury, who had—irrespective of ISS—by far the longest hospital stays and the worst functional results [21]. An inverse correlation between ISS and length of survival was found by S.P. Baker et al. [4] and C.C. Baker et al. [15]. Analyzing quality of care, Moylan et al. [7] demonstrated that the proportion of unacceptable care increased with higher ISS, especially above 30 ISS points.

Conclusion

The ISS is an excellent method for studying groups of patients with multiple injuries from blunt trauma. Its capabilities have, until now, not been utilized to their full extent, problems being the absence of a uniform scoring method (including or excluding the AIS or HTI = 6 score, scoring from ICDA data or directly from the patient record), the absence of an up-to-date reference series of mortality rates in the ISS area above 20 points, and the absence of a system to include patient-related risk factors. Solving these problems is an urgent matter, because the lack of a well standardized method will lead to a Babylonian scoring confusion.

Résumé

Deux groupes de blessés présentant des contusions multiples ont été étudiés par l'auteur. Les cas de traumatismes cranio-cérébraux sévères ont été exclus de cette étude. Le groupe I était composé de 80 blessés qui présentaient 117 fractures et 163 blessures majeures associés; le groupe II était constitué de 68 blessés dont le test de gravité de la blessure était supérieur au chiffre 20 (2 blessures majeures ou une blessure majeure et une blessure moyenne). Ces deux groupes principaux ont été divisés en trois sous-groupes. Deux de ces sous-groupes (A et B) répondaient a des fractures traitées précocement, le traitement de la fracture s'accompagnant dans le premier cas d'une ventilation prophylactique (A) et dans le second cas de l'absence de cette assistance (B). Le troisième sous-groupe était composé de cas de fractures traitées avec retard, ce traitement s'accompagnant d'une assistance ventilatoire prophylactique (C).

Les sous-groupes A et C groupaient les blessés dont le test de gravité de la blessure était supérieur à 50 (moyenne, 57 et 58,7) soit respectivement 19 et 11 blessés. Le groupe A comprenait 58 lésions majeures s'ajoutant aux fractures, cependant que le groupe C en comprenant 29. Le taux de mortalité s'est élevé à 10% dans le groupe A, 6% étant dû a une infection tardive, la durée moyenne de la ventilation étant de 6 jours, cependant que la mortalité dûe à l'infection tardive s'élevait à 55% dans le groupe C, la durée majeure de la ventilation ayant été de 26 jours.

Cette étude permet de conclure que le traitement précoce de la fracture est la meilleure méthode thérapeutique car elle va de pair avec la réduction du taux de mortalité par infection et de la durée de l'assistance ventilatoire. Au contraire le traitement conservateur de la fracture entraîne l'augmentation de la durée de la ventilation et celle du taux de mortalité par infection.

L'assistance ventilatoire prophylactique prolongée après l'intervention chirurgicale est un facteur considérable d'amélioration du pronostic.

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