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Long-term outcomes following closed head injury in the elderly

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ABSTRACT

Objective: To evaluate the long-term functional outcome and quality of life of patients 65 years of age and older with mild-to-moderate closed head injuries.

Design: Retrospective review with prospective follow-up.

Patients and Methods: Admission data were obtained through the computerized Trauma Registry of the Yale-New Haven Hospital for patients having suffered head trauma between 7/22/92 and 4/22/95. Inclusion criteria were age ≥ 65 years, closed head injury, and survival beyond one week. Patients were then contacted and administered the Medical Outcomes Study Short Form-36 supplemented by seven additional questions in order to evaluate quality of life.

Results: From the selected cohort of 112 patients, 16 patients were excluded due to death within one week of hospitalization. Of the remaining sample, 24 patients were located and agreed to respond to the survey. The difference in quality of life, between those suffering closed head injury and age-matched national norms, was not found to be statistically significant on any of the eight scales of the MOS-SF 36.

Conclusions: Although this study involved a small, select population, elderly patients with mild-to-moderate closed head injury do not have markedly different quality of life than elderly persons without such injury.

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Introduction

Extent of Trauma in the Elderly and Costs to U.S. Society

As of the 1990 census, the age group over 65 represented 12.6 % of the United States population, approximately 31.2 million people. Using current statistical trends, it is estimated that by 2050, this same age category will comprise 22.9 % of the population, or a total of 68.5 million people[1]. Of note, even in conservative projections over twelve million people will be in the category of 85 and over by 2040, with nearly a million over the age of one hundred[2].

In the year 2010, the state of Connecticut is projected to rank twenty-sixth among states in the total number of persons older than 65[3]. At that time, the elderly will comprise 14.6 % of Connecticut's population, or a change of +16% from 1989. Hence, in this state, trauma in the elderly will place an increasing demand on the state health care systems.

Trauma is the fifth leading cause of death in patients aged 65 and older. According to National Hospital Discharge Survey data from 1984 to 1986, persons aged sixty-five years or greater were responsible for 23% of trauma admissions and 28% of total charges while comprising only 12% of the total population[4]. It is speculated that by 2050, the elderly will account for 39% of all trauma-related hospital episodes.

An alarming consideration of these statistics is that they may underrepresent the true magnitude of the problem. Deaths related to the trauma, but attributed to a complication, may not appear in the national statistics as due to the trauma itself[5]. Thus the problem of trauma in the elderly is perhaps a greater problem than even the data suggest.

This issue is potentiated by the complication of costs of care. DeMaria et al showed in 1988 that Diagnosis Related Group reimbursement did not adequately predict the costs of trauma care in all patients over the age of 80, as well as in patients over 65 with multiple, severe injuries[6]. Unless current policies are changed, serious financial woes are certain to occur.

In short, the problem of trauma in the elderly, of which head trauma is a significant component, is a scourge that will plague society in ever-increasing proportions.

Head Trauma in the Elderly

Head trauma is a remarkably common injury, estimated to occur at a rate of 200 per 100,000 persons[7]. Economically, this injury places tremendous burden on the health care system, accounting for costs between 75 and 100 billion dollars per year, or in excess of 200 million dollars per day[8,9].

Head injury in the elderly may be related to a number of changes common to, (if not inherent in), the aging process[10]. These changes include increasing sensory deficits, generalized unsteadiness, orthostatic hypotension, muscle weakness, and increased

prevalence of arrhythmias. The elderly may have greater predisposition towards syncopal episodes, falls, motor vehicle crashes, and assaults.

Not only do the elderly have significant risk factors for head trauma, but they tend to show greater mortality following the injury. In any age group, head injury is one of the major mechanisms leading to shock. In fact, the elderly patient with head trauma has been estimated to be at a nine-fold greater risk for death than elderly patients with other injuries[30]. Increasing age has been shown repeatedly to be correlated with poorer survival outcomes[11].

There are a number of quality studies detailing patient outcomes as of discharge, such as Pentland's study in Scotland in 1986[12]. Using the Glasgow Outcomes Scale to rate patients within one month of discharge, they established that 93% of patients under 65 experienced a good recovery or showed moderate disability, whereas only 86% of patients over 65 fit into these categories. The study concludes "A minor head injury is often the event that signals the end of independent living for the elderly man or woman living alone."

However, there is a paucity of long-term information concerning these patients. Few attempts have been made to characterize the end result of the traumatologist's interventions beyond discharge from the hospital. This information is important on a variety of levels. First of all, it may help to address the difficult question of resuscitation issues. Secondly, this data may be of prognostic significance for patients and their families. Lastly, studies such as this one promote the advancement of science through monitoring the effects of medical and surgical interventions.

Rationale for a Quality of Life Study

Patient quality of life has been an area of increasing interest over the past two decades. This has been reflected indirectly in the medical literature. For instance, in the nine year period from 1966-1975, there are 93 references containing "quality of life" as a medline keyword, whereas there are 5,820 from the four year period from 1992 through October 1996.

For such a heterogeneous group as "the elderly," quality of life is a particularly important issue. Despite the lack of real data, this is hardly a new concept, or focus of research. As Frederick Zeman aptly stated nearly fifty years ago, "Since some are old at forty years, while others are relatively young at seventy, we have long been aware of the importance of the functional capacity of the aged"[13].

Traditionally, outcomes have been measured in survival. Mortality rates have provided excellent data, especially in the field of trauma, as a very concrete measure of outcome - after taxes, nothing is more certain than death. Mortality, though, may not be entirely useful, as Sullivan pointed out, because it is the health of the living, rather than the dead, in which one is interested[14].

On one hand, it is useful to decide which cases will have the best prognostic outcomes, based on statistical analysis of similar injury, to guide care and to comfort patients and their families. However, on the other hand, it is possible that death is not preventable once certain types of injury have occurred. If this latter scenario occurs, it is

extremely important to define these cases, so that resources are not expended unnecessarily.

Current predictive models of survival, such as the Injury Severity Score, or ISS, has been found to be a poor predictor of survival, let alone functional outcome[15,31]. This lack of precise information may hinder the decision-making process in difficult cases of the traumatized elderly. Additionally, less than half of patients with multisystem trauma may return to their original level of functioning[16]. Perhaps, then, quality of life information may supplement the existing survival data to elucidate the impact of the disease, the cost-effectiveness of the hospitalization, and the impact of treatment on the patient as a whole.

In the elderly, other measures of outcome such as return to work may not be as directly applicable as in younger populations. It cannot be expected to define outcome to such a precise extent that would prove useful in assessing individual patients. However, knowledge of patterns of outcome may help guide difficult decisions in emergency department treatment as well as surgical critical care.

To Quantify a Quality

The definition of "quality of life" has proven even more elusive than for the term "health," which has a widely accepted WHO definition. There is no consensus formula to determine quality of life any more than there is a precise definition to it. Rather, each individual composes their own equation, based on ill-defined feelings and subjective concepts that accurately describe a condition of being without satisfying the scientists urge to dissect its components. "Quality of life" is difficult, if not impossible, to quantify, as it is an inherently subjective impression.

Physicians do not seem to be able to rate a patient's quality of life the same way a patient would, usually erring on the side of underrating quality of life[17,18,19]. This uncertainty has clear implications in the field of critical care, as decisions on the degree of aggressive treatment may rely heavily on predictions of long term quality of life. In one study involving hypothetical cases where patients quality of life was reduced secondary to stroke or respiratory problems, physicians were less likely to resuscitate than patients were[20]. In this instance, if the physician were to perceive and project an inappropriately low quality of life, and consequently not resuscitate a patient, a real and tragic disservice would be performed.

Existing studies involving quality of life have found "good" outcome in elderly patients surviving trauma[21,22]. However, measurement of quality of life has been problematic, examining only activities of daily living or subjective measurement scales.

Additionally, these studies have not focused on head trauma, and the difficulties peculiar to its management and recovery.

In surveying the elderly, there is the additional confound of non-response bias. That is, older persons tend to answer fewer questions and to give less complete responses to administered questionnaires than younger people. Thus, this survey has included the use of proxy respondents and a short survey instrument to minimize these concerns[23].

Statement of Purpose

The aim of this project is to evaluate the quality of life of elderly people two to four years after they have had an acute closed head injury of mild to moderate severity. Mild to moderate severity is defined, for the purposes of this study, to be any type of closed head injury after which the patient survived a minimum of one week. This data can be compared to national norms for non-trauma victims, in an effort to define the outcome of elderly patients following head trauma in terms of their quality of life. Through analysis of this data, it is hoped that an improved understanding of the recovery process after head trauma will be attained.

Methods

Prior to beginning this study, the protocol and consent were approved by the Human Investigations Committee of Yale-New Haven Hospital and the Yale University School of Medicine.

This study includes both a retrospective review of trauma registry data as well as a prospective component consisting of administration of a telephone survey. All patients aged 65 years or greater admitted through the Yale-New Haven Hospital emergency department with the diagnosis of "head trauma" from 7/22/92 to 4/22/95 were considered eligible for this study. The Yale-New Haven Hospital is a tertiary referral center as well as a Level One trauma center, whose emergency department is responsible for approximately 50,000 visits per year.

Previous research has shown that up to one third of patients that die following severe head trauma do so within twenty four hours of admission to the hospital, and that four out of five deaths that will occur do so within the first week[24]. Exclusion criteria were established for those patients with an unequivocally terminal injury: patients were excluded from the data analysis if they died within one week of admission, as this study aimed to determine long term results following acute head injury.

Protocol

Initial injury data for each patient was amassed from the computerized trauma registry system at the Yale-New Haven Hospital.

The locating protocol for the participants was as follows: 1. patient name obtained from trauma registry, 2. patient's telephone number obtained through white pages or directory assistance, 3. if no number obtained, a recheck of the trauma registry was made for alternate addresses or next of kin data, 4. patient's surname in same town checked through directory assistance. There were 46 patients who were not contacted, or an unlocatable rate of 41.1 %.

A questionnaire was administered to all of the patients included in the study via telephone by one interviewer. These questionnaires were administered an average of 35.3 months after the initial insult, with a range from 20 months to 52 months. Oral consent was obtained, followed by the structured interview.

In cases where the primary patient was not able to answer the questionnaire, a proxy respondent was administered all questions.

The Instrument

The instrument used to evaluate the respondents was the Medical Outcomes Study Short Form-36, supplemented by seven additional questions (Appendix A).

The MOS SF-36 was designed to serve as a standardized health survey, striving to be simultaneously brief and comprehensive. The eight areas this survey intends to measure are: physical functioning, role limitation due to physical health, bodily pain, social function, general mental health, role limitations due to emotional problems, vitality, and general health perceptions[25]. The questions it contains were derived from earlier, larger instruments, and has been shown to be a reliable instrument in studies of elderly populations[49].

National norms were generated from data obtained in the 1990 National Survey of Functional Health Status[26]. This instrument incorporated the SF-36 as part of its questionnaire. From the 2,474 people surveyed, the data from the 264 men and women aged 75 years or greater were analyzed to calculate the statistical norms for this age group.

Data analysis

Data was collected by a single interviewer and entered onto a computerized database. Analysis of the MOS SF-36 was carried out through standardized computation and the results compared to age-matched national averages. Statistical significance was determined by comparison to tabulated data provided in the Medical Outcomes Trust SF-36 Manual and Interpretation Guide. Data from the supplemental questions was individually analyzed.

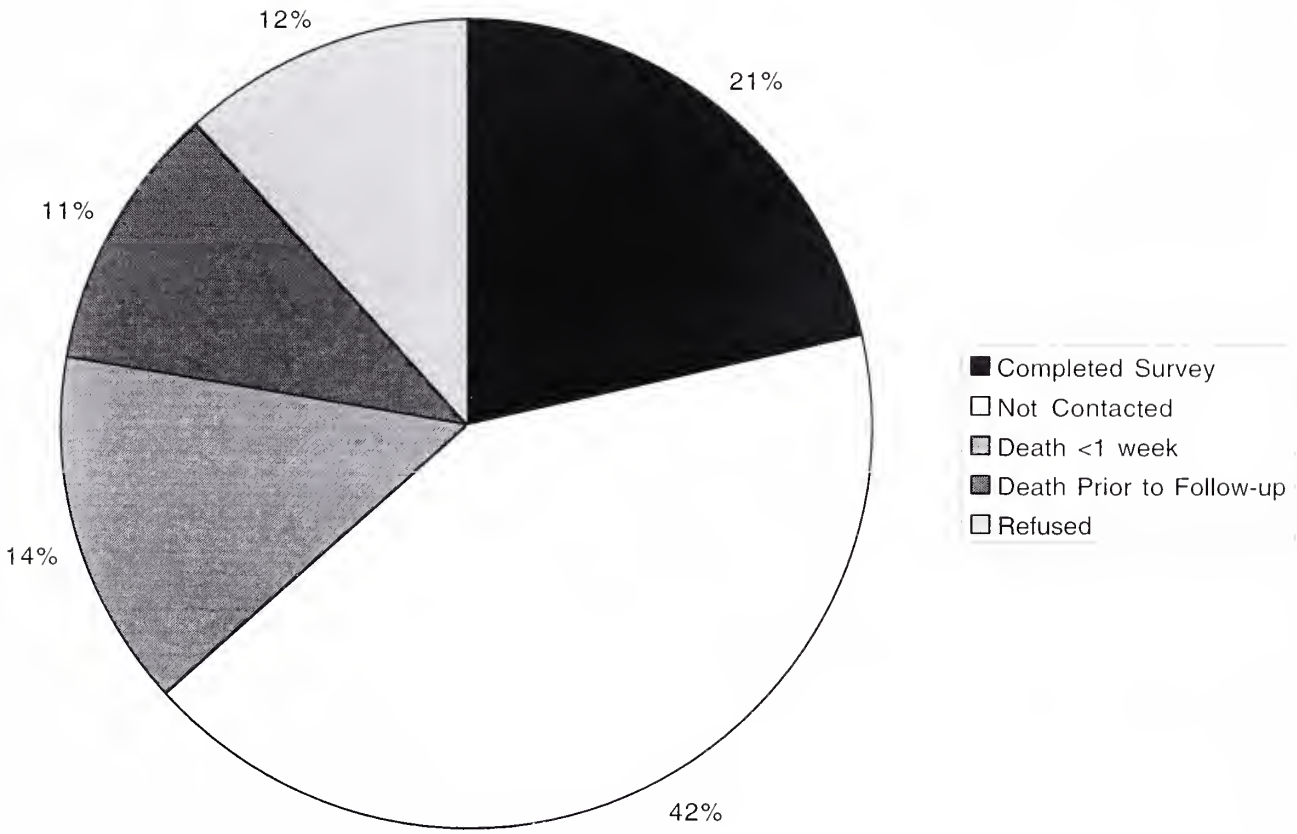
Results

From 7/22/92 to 4/22/95, there were 112 admissions to the study institution of persons sixty-five or older with the diagnosis of head trauma. Sixteen of these admissions were excluded due to death within seven days of admission. Of the remaining 96 patients, four patients died in the hospital prior to discharge but longer than one week after admission. An additional eight died prior to contact in this study, with an average survival of 28 months post-trauma. By report, one patient died of stroke, one of dissecting aneurysm, one of acute congestive heart failure, one due to hemorrhage, and four died of unknown reasons. One patient was responsible for two admissions.

Of the 83 remaining patients, nine refused to participate. The most often cited reason for refusal to participate was the time required to complete the study. In another four cases, the family denied access to the patient, which was considered statistically as a refusal to participate. Forty-six patients were unable to be contacted and were considered lost to follow-up. Twenty-four patients completed the questionnaire, including two proxy respondents, or an eight percent proxy response rate (see Chart 1).

The median age of respondents was 77.4 (range 67 - 91). Thirteen males and females participated in the study. The average Glasgow Coma Score for this group was 13.6 (range 3 - 15, standard deviation 3.01), indicating a mild to moderate degree of closed head injury. Although there was a large range of injuries, with a minimum GCS of

Chart 1: Response Rate.



3 on presentation to the emergency department, twenty of the twenty-four patients had a GCS of thirteen or greater.

The most common mechanisms of injury in the study group were motor vehicle collisions and falls, together accounting for 79.1 percent of the injuries to the respondents (see Chart 2). The Injury Severity Scores for this group averaged 12.9 (range 1 - 25, standard deviation 6.64).

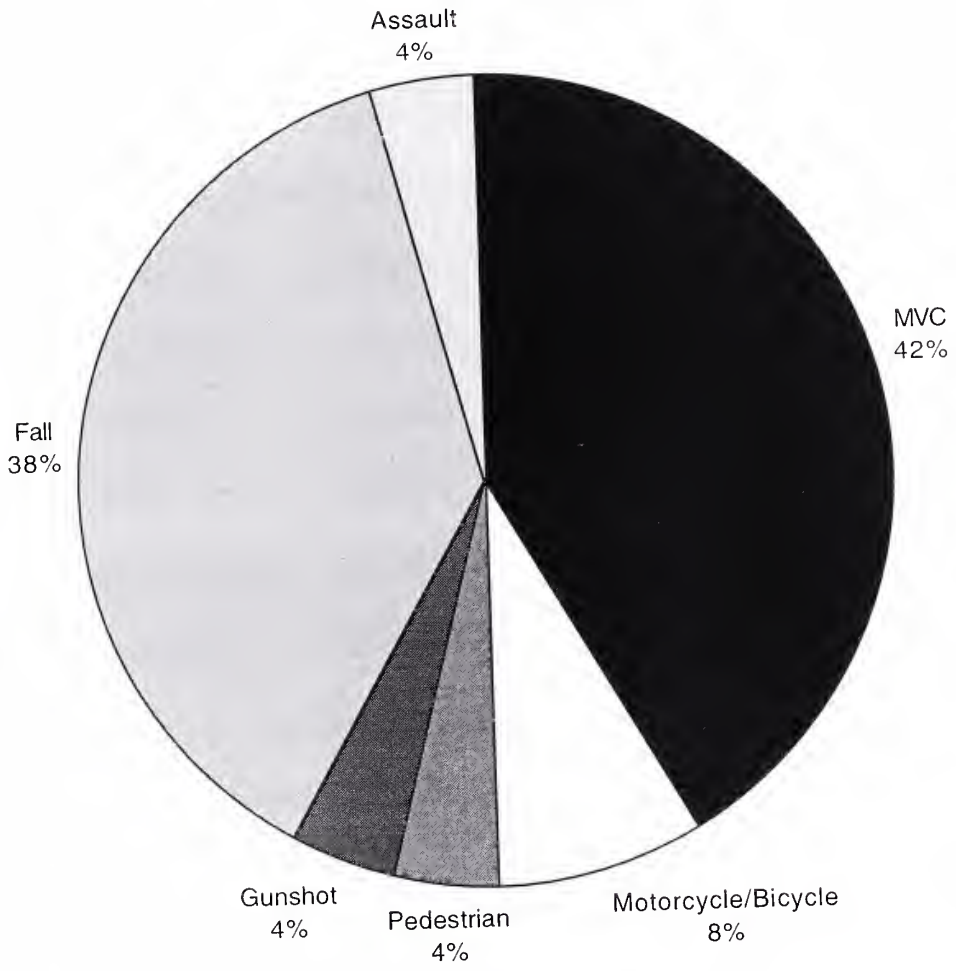
Seventy-five percent of the respondents had a recorded past medical history. These included, (in decreasing order of frequency), hypertension, cardiac conditions, gastrointestinal disturbances, pulmonary conditions, collagen disorders, thyroid disease and diabetes.

Of the respondents, 58% (14/24) were discharged from the hospital directly to home. An additional 29% (seven patients) were discharged to rehabilitation facilities or to short-term nursing care facilities. The remainder of the respondents were discharged to long-term care facilities or to other hospitals.

The average TRISS score for respondents was 0.887, with a standard deviation of 0.186. By comparison, for the group of patients excluded from the study who expired prior to discharge from the hospital, the average TRISS was 0.473.

Seventy-two percent of the elderly people polled have worked in their usual occupation since their injury. Perhaps this is not surprising when one considers that inclusion criteria for this study placed subjects over the conventional age of retirement when they first visited the emergency department. Two to five years later, the subjects were still retired.

Chart 2:
Mechanism
of Injury.



The results of the Short Form-36 questionnaire were tabulated and analyzed in accordance with the procedures defined by the Medical Outcomes Trust[27]. First, all data was recalibrated such that higher scores indicated more positive results (as some questions were negatively worded). This adjusted data was grouped along each of the eight scales by summing question components in the following manner:

General Health:	Question 1 + Question 11a, 11b, 11c, 11d
Physical Functioning:	Question 3a, 3b, 3c, 3d, 3e, 3f, 3g, 3h, 3i, 3j
Role-Physical:	Question 4a, 4b, 4c, 4d
Role-Emotional:	Question 5a, 5b, 5c
Bodily Pain:	Question 7 + Question 8
Vitality:	Question 9a, 9e, 9g, 9i
Social Functioning:	Question 6 + Question 10
Mental Health:	Question 9b, 9c, 9d, 9f, 9h

For each patient, the question responses were summed along each of the eight scales, producing raw scale scores. The raw scores for each of the scales were then transformed to a 100-point scale, using the formula provided by the Medical Outcomes Trust:

$$\text{Transformed Scale} = (\text{Actual raw score} - \text{lowest possible raw score}) \times \frac{100}{\text{possible score range}}$$

The transformed scale data was calculated for each patient and averaged. The data obtained is displayed, along with national norm data, in Table 1.

Scale	Respondents Score	Std Deviation	National Norm	Std Deviation
Physical Functioning	52.3	28.6	53.2	30
Role-Physical	46.9	34	45.3	42
Bodily Pain	51.9	24.3	60.9	26
General Health	57.8	22.9	56.7	21.2
Vitality	50.2	21.5	50.4	23.6
Social Functioning	72.9	29.2	73.9	28.8
Role-Emotional	76.4	28.6	63.2	43
Mental Health	76.5	19.7	74	20.2

Table 1

Table 1. Results of the Medical Outcomes Study SF-36 for the study population and age-matched national norms - average score and standard deviation. The two populations are comparable along each of the eight scales, as described in the text.

For each of the eight scales of the MOS SF-36, (physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional, and mental health), no statistically significant difference ($p<0.05$) between the sample group and the population norms was found. This analysis was performed by comparing the data obtained to tables provided by the Medical Outcomes Trust which provided limits of statistical significance. Although the responding sample in this population was small, a significant difference could have been demonstrated had the results differed from the norms by ten to twenty points, depending on the individual scale being considered. The largest absolute difference occurred on the bodily pain and role-emotional scales, but the power of the study was insufficient for this difference to achieve statistical significance.

For the supplementary questions, twenty-two of the twenty-four respondents (91.7%) indicated that they lived at home or at the home of a relative, with the remainder living in nursing home environments. Thus, 8.3% of respondents were institutionalized, as compared to data from the general elderly population, in which 4.5 % of people over the age of 65 are in nursing home environments[28].

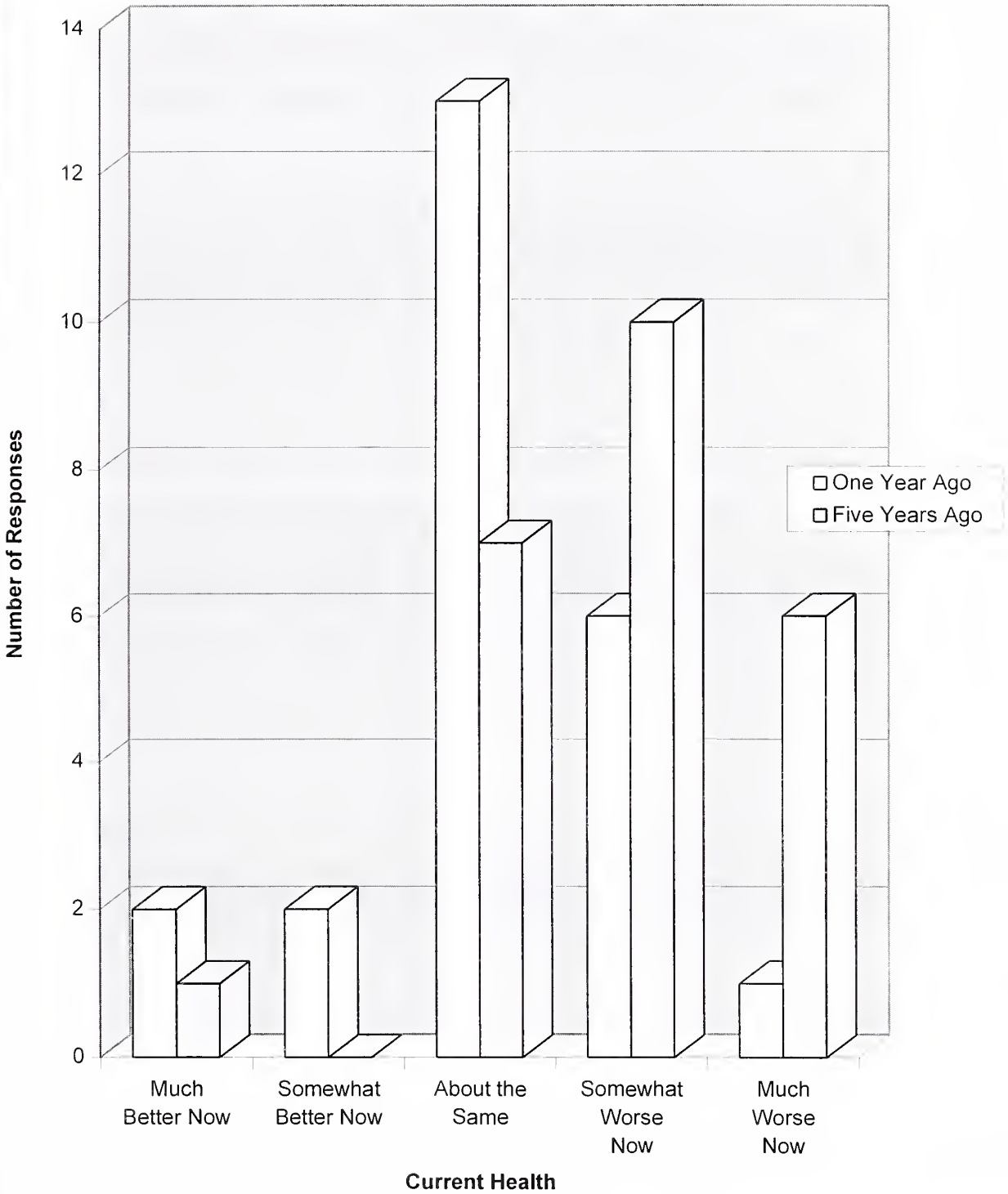
Two questions were designed to determine if intervening events may have occurred that interfered with the MOS SF-36 ability to analyze the quality of life. The first of these showed that nine of the twenty-four respondents did have a hospitalization between the date of their head injury and the date of follow-up. The reasons for the hospitalization were as follows: fall (with no head injury), chronic illness, gallbladder removal, skin cancer excision, stroke, hip surgery, open heart surgery, skin graft, and pneumonia. Only four of the twenty-four respondents reported a visit to the emergency

department subsequent to their initial head injury, for the following reasons: two for falls (without head injury), dehydration, and toe dislocation.

Only one of the twenty-four respondents admitted to any blackouts, and this particular patient had a history of seizure disorder in addition to the closed head injury. Eighteen of the cohort reported no change in occupation between the time of injury and time of follow-up.

An additional question of both the MOS SF-36 and the supplementary questions aimed to determine the patients reaction to aging and the transition from pre-injury status to post-injury status. These questions asked the patient to compare their current health to one and five years ago, respectively. The results obtained are shown graphically in Chart 3, with the twenty of the twenty-four patients reporting their health to be the same or worse than one year ago, and twenty-three reporting their health to be the same or worse than five years ago (pre-injury).

Chart 3: Reported Health Status.



Discussion

The aim of this project was to evaluate the quality of life of elderly people two to four years after having an acute closed head injury of mild to moderate severity. The study involved administration of the Medical Outcomes Study Short Form-36 to willing participants selected from the Yale New Haven Hospital Trauma Registry, with the intent of gaining a better understanding of patient outcome following head trauma.

This study did not demonstrate statistically significant differences between the elderly head trauma participants and age-matched controls. On five of the eight scales, the two groups differed by less than two points on a transformed 100-point scale. This in itself suggests that the quality of life of elderly people who have suffered a mild-to-moderate closed head injury and who survive to one week post trauma may not be substantially different from those who have not experienced such an injury. The therapeutic implications of this finding are significant, as it indicates an aggressive treatment approach is warranted in the initial management of the elderly head trauma patient.

Due to the limited number of respondents in this study, subgroup analysis was not performed to delineate a sub-population for which aggressive treatment is indicated or contraindicated. Due to the large number of cases lost to follow up, it cannot be said with confidence that the results apply to all elderly head trauma patients. A larger, prospective

trial could define these sub-groups, as well as determine prognostic factors for a good functional outcome.

Yet these preliminary results are encouraging, in that they support more aggressive management of elderly trauma patients. Fifteen percent of head injury admissions are accounted for by people over the age of 65[12]. Neurosurgery is no longer reserved for the young alone, as the number and types of operations performed on elderly patients is greater than in past years[29]. As more experience is accumulated with neurosurgery in the elderly population, more research will be required as to the eventual outcome of the patients beyond the measure of survival.

Interestingly, there seems to be a paucity of data on the outcomes of elderly patients with mild to moderate degrees of head injury. In a study conducted in Belgium, Broos et al found that initial mortality of elderly head trauma victims was 18%, but 76.3% of survivors returned home at six month follow up[30]. This study showed no impact of preexisting disease, as well as no effect on survival of either age or ISS. These findings radically departed from the study by Oreskovich et al, who found only 12% of polytraumatized elderly patients returning to their pre-trauma level of independence[31]. Neither study rigorously addressed the quality of life of the surviving patients.

In a 351 member cohort of polytraumatized patients, Mata et al found that there was no difference in trauma outcomes whether or not head injury was present[32]. Instead, this study showed that there was a fairly predictable deterioration in quality of life one year post trauma with a rebound increase by second year follow up. This two year outcome was influenced by three factors: previous quality of life, severity of illness, and

age. Interestingly, quality of life was not statistically different if the patient had experienced severe head injury or not, as in the present study with mild to moderate closed head injury.

Severe head injury is known to be a factor leading to poor outcome in the elderly. One study found only 21% of patients greater than 60 with a GCS of less than five survived to discharge, and all but one of the nine survivors was severely disabled or in a persistent vegetative state[33]. The 1991 study using the Trauma Coma Data Bank found only 7% of patients with severe head injury (GCS <8) had a good outcome at discharge[24]. Age and precise mechanism of injury were the most important predictors of outcome. Mamelak et al found at six months follow up that 60% of patients younger than nineteen with head injury survived, whereas less than 20% of similarly injured patients older than 60 survived[34]. Some researchers have been less optimistic about neurobehavioral recovery even following minor head trauma[35].

However, there have been few studies examining the impact of minor head trauma on long-term quality of life. Follow up in this study occurred two to five years after the initial injury. A recent study by Konopad and colleagues suggests that six months to one year post admission to an intensive care unit for an acute process is sufficient time to evaluate long-term quality of life changes[36]. By that point, any acute problems have stabilized. The present study was of sufficient length to measure long term outcomes in quality of life measures for the study group.

ICU admission in the elderly has not been associated with a significant loss of functional capacity relative to younger populations, to one year of follow up[37,38,39]. Thus,

a patient's age may not be used reliably to predict the functional outcome, or the ultimate quality of life. In the case of the individual patient, no predictor will give a completely accurate picture of outcome, as there are always unexpected results. In light of the results of the present study, no attempt was made to determine predictors of long-term outcome based on presenting data.

In a study of younger adults, Hawkins et al. found that at one year follow up, 25 percent were employed[40]. Ninety percent of trauma victims were able to live at home, and 80% of them were mostly independent of supervision. However, the average age Hawkins' study was only 32, a significantly different population that in the present study. A more recent retrospective analysis showed that among those elderly patients with closed head injury surviving to discharge, significant functional improvement was not noted at 38 months follow-up[41].

In a retrospective study of factors contributing to function and independence following trauma, van Aalst et al found a number of factors to be associated with poor outcome[42]. Poor long term outcome was best predicted by age over 75, head injury, GCS <7, shock on admission, and sepsis. The results of the present study suggest that age and closed head injury alone may not be good predictors of long-term quality of life.

Limitations of the Present Study

The investigators of this study recognize that no research is complete without an assessment of improvements that future research may incorporate. The following section contains potential deficits of the present study, in the hope that other research may build upon this work.

Small Sample Size

This single study has been conducted using a select population, and the generalizability of the results may be consequently limited. In this study, there was a slight male to female preponderance, in contrast to the demographics of the general population. In 1990, for instance, there were only 68.7 men for every 100 women over the age of 65[43].

Heterogeneous Population

Isolated head injury data is difficult to obtain, as 70% of elderly patients with head trauma have concomitant injury[10]. Further, there is an increased incidence of diabetes, coronary artery disease, and pulmonary disease in the elderly, which are all significant factors in the management of a trauma patient[44]. Additionally, the diagnosis of "head trauma" covers a broad spectrum of illness. As this study did not focus on a discrete disease entity, the results obtained may be skewed by one or a few diagnoses.

Exclusion criteria for this study included persons dying within the first week of admission. This was intended to eliminate the sub-population for which long-term care is not offered, those with injury so severe that short term survival was not possible.

Control Group

This study did not adhere to a randomized, prospective design. Instead, a cohort of patients was identified retrospectively and contacted prospectively for follow up. Comparison data was developed through analysis of similar, but not statistically identical populations.

Lack of Premorbid Data

As patients were recruited based on admission data, pre-injury information was not obtained either before or at the time of initial hospitalization. All pre-injury data was obtained through patient recollection at follow-up, and is subject to questionable reliability and validity.

Selection Bias for Treatment

Although once admitted to the hospital, there was no inequity of treatment, one must consider the patient population served by the Yale-New Haven Hospital. As it is a tertiary referral center, some minor trauma may have been treated in local community hospitals, biasing the results away from the healthier patient population. Similarly, the referrals of patients with more severe injuries may have biased the data towards the sicker patients.

Selection Bias for Response

Length of instrument was minimized to offer the lowest barrier to completion, as response rates tend to decline with age[45]. Additionally, all information was obtained by a single interviewer. However, confounds such as depression, illness, or fatigue may alter response rates as well as the quality of the data itself[46]. The elderly may also not be

willing to discuss their problems, either through embarrassment, ignorance, or forgetfulness[47]. Lastly, the responses obtained could conceivably vary with the context of the interview. Since the interview occurred via telephone, it is difficult to speculate whether or not the presence of other individuals may have altered the responses of individual questions.

A significant number of patients from the initial sample (41.1%) were not contacted for follow up. The protocol of this study relied on patients' listing in telephone directories, or listings for family members. Patients who were not contacted may reside anywhere along the spectrum from full functional status to death. Additional searching through professional search organizations may provide answers on the whereabouts and conditions of the persons lost to follow-up. With the complete set of data available, it would be possible to reduce the potential skew of the current results.

An additional problem encountered is the number of patients that died during the follow up period. Bias may have been introduced by not obtaining data from these patients, who may have endured the lowest quality of life.

Intervening Events and Variables

In the interval between the initial injury and the questionnaire administration, many events may have occurred to influence the patient's quality of life. Importantly, the patients aged between one and two years during this period. Additionally, other physical, emotional, or social concerns may have arisen. Attempts were made to identify major events through the instrument, but there is no objective evidence indicating that all significant events were named explicitly.

The Survey Instrument

Multidimensional instruments yield the most comprehensive view of the patient, the nature of the disability, and the impact made on the patient's life by both the disorder and its treatment[48]. Furthermore, the Medical Outcomes Study Short Form-36 is a generic measure of quality of life, that allows interpretation among a variety of disease processes.

However, no single instrument is perfect, providing accurate, reliable data with a minimum of interpretation required. The SF-36 has the intrinsic disadvantage of attempting to quantify a necessarily subjective measure, quality of life. It combines the properties of disease, which can be described scientifically, with the disease process in one individual, which can also have measurable dimensions, along with the perceived impact of the disease on the individual. Such an instrument must have a substantial degree of "softness," although this does not necessarily equate with inaccuracy.

Limitations of the SF-36 inherent in its design include so-called "ceiling" and "floor" effects, or a decreased sensitivity to discriminate levels of functioning at the extremes of very high or very low functioning[49]. Additionally, the brevity of the instrument may make the confidence intervals surrounding each data point too large to prove clinically useful in the evaluation and treatment of an individual patient.

Identifying and describing the extent of cognitive impairment is often difficult. Potential confounds include chronic illness, depression, sensory impairment, fatigue, language barriers, and instrument chosen to measure function[50]. Additionally, it is a

complex task to evaluate cognitive function thoroughly, accounting for individual variability with the added dimensions in this population of age adjustment.

Accordingly, in the present study, no attempts were made at quantifying the cognitive function of the respondents outside of the survey instrument. Patients responded to the telephone survey themselves whenever possible. If the patient was deemed unable to answer by a caregiver or spouse, that individual was administered the questionnaire and the results noted as a proxy response.

Telephone Administration

Face to face contact has long been considered the gold standard among interviews. However, the desired goals of high response rates, high quality data, and low bias have not been shown to be better attained in controlled studies of in-person versus telephone interviews. In a study of elderly veterans, there were only small systematic differences between face to face and telephone interviewing, but the non-systematic differences in responses led the authors to conclude that the two methods were not interchangeable[51]. Telephone administration of the MOS SF-36 was demonstrated to reduce missing data and non-response bias over mail-based administration[52].

Telephone administration may also remove the confounding variables of illiteracy and visual impairment. For the elderly, survey administration via telephone has the advantages of avoiding improper response due to visual limitations of reading printed type, with the disadvantages of increased cost and potential difficulty communicating with hearing impaired patients[53].

Proxy Response

Like physicians, relatives and significant others also tend to underrate a patient's quality of life[17,54]. The responses from a proxy are not exactly interchangeable with those of the patient.

In general, the greater the contact with the patient, the more closely the proxy response agrees with the patient's response[55]. At the same time, the greater the proxy's involvement with the patient, the greater the underestimation of functional and health status. It is not possible to predict in an individual case whether or not the proxy is responding accurately, and if not, in which direction the error is made. While the proxy respondent may have a different perception of the events that occur than the patient does, it is unclear how this perception affects the response interpretation.

Cognitive impairment also interferes with the association between patient and proxy responses[55]. In this study, only two of the respondents were by proxy.

Conclusions

Long-term outcomes in the elderly trauma patient is an area with significant need for further research. In the present study, no statistically significant difference was found in quality of life, as measured by the eight scales of the Medical Outcomes Study Short Form-36, between patients with mild to moderate closed head injury and age-matched national norms. These findings indicate that a large, prospective evaluation of head trauma care in the elderly may be warranted to define the population that experiences the best outcome, and to establish prognostic factors for long-term outcome.

Appendix A - Survey Instrument

Part I: *Medical Outcomes Study Short Form - 36 (MOS SF-36)*

1. In general, would you say your health is:

(Excellent Very good Good Fair Poor)

2. Compared to one year ago, how would you rate your health in general now?

(Much better now than one year ago

Somewhat better now than one year ago

About the same as one year ago

Somewhat worse now than one year ago

Much worse than one year ago)

3. The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

(Yes, limited a lot Yes, limited a little No, not limited at all)

a. Vigorous activities, such as running. lifting heavy objects, participating in strenuous sports.

b. Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf.

c. Lifting or carrying groceries.

d. Climbing several flights of stairs.

e. Climbing one flight of stairs.

f. Bending, kneeling, or stooping.

g. Walking more than a mile.

h. Walking several blocks.

i. Walking one block.

j. Bathing or dressing yourself.

4. During the past four weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health? (Yes No)

a. Cut down the amount of time you spent on work or other activities.

b. Accomplished less than you would like.

c. Were limited in the kind of work or other activities.

d. Had difficulty performing the work or other activities (for example, it took extra effort).

5. During the past four weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)? (Yes No)

a. Cut down the amount of time you spent on work or other activities.

b. Accomplished less than you would like.

c. Didn't do work or other activities as carefully as usual.

6. During the past four weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups? (Not at all Slightly Moderately Quite a bit Extremely)

7. How much bodily pain have you had during the past four weeks?

(None Very mild Mild Moderate Severe Very severe)

8. During the past four weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

(Not at all A little bit Moderately Quite a bit Extremely)

9. These questions are about how you feel and how things have been with you during the past four weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past four weeks:

(All the time Most of the time A good bit of the time Some of the time None of the time)

a. Did you feel full of pep.

b. Have you been a very nervous person.

c. Have you felt so down in the dumps that nothing could cheer you up.

d. Have you felt calm and peaceful.

e. Did you have a lot of energy.

f. Have you felt downhearted and blue.

g. Did you feel worn out.

h. Have you been a happy person.

i. Did you feel tired.

10. During the past four weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)? (All of the time Most of the time Some of the time A little of the time None of the time)

11. How true or false is each of the following statements for you?

(Definitely true Mostly true Don't know Mostly false Definitely false)

a. I seem to get sick a little easier than other people.

b. I am as healthy as anybody I know.

c. I expect my health to get worse.

d. My health is excellent.

Part II: *Supplementary Questions*

12. Please describe your current place of residence

(Live at home Short term facility Nursing home Other.)

13. Does anyone assist you with your daily activities? If so, how much?

(Yes No) (All of the time Most of the time Some of the time None)

14. Compared to before your injury, five years ago, how would you rate your health?

(Much better now than five years ago

Somewhat better now than five years ago

About the same as five years ago

Somewhat worse now than five years ago

Much worse now than five years ago)

15. Since you were at Yale-New Haven Hospital for your head injury, have you had any other hospitalizations? If yes, please describe when and why.

(Yes No)

16. Since you were at Yale-New Haven Hospital for your head injury, have you had any visits to the emergency room? If yes, please describe.

(Yes No)

17. Have you had any blackouts since your head injury? If yes, how often?

(Yes No)

18. Have you worked in your usual occupation since your injury?

(Yes No)

Appendix B - Trauma Scoring

GCS

The Glasgow Coma Scale is an indicator of the consciousness of a patient on a fifteen point scale, with a maximum score of 15 in the conscious, alert patient, and a minimum score of three[56]. The rating scale is scored as follows:

I. Eye Opening

4	Eyes open spontaneously
3	Eyes open to vocal command
2	Eyes open to pain
1	No eye opening

II. Verbal Response

5	Oriented
4	Confused
3	Inappropriate words
2	Incomprehensible sounds
1	None

III. Motor Response

6	Obeys commands
5	Localizes pain
4	Withdraws from painful stimulus
3	Abnormal flexion response to painful stimulus
2	Extension response to painful stimulus
1	None

The value of the GCS is that it is a simple, rapid, and standardized way of describing the level of consciousness of the patient. There is little inter-observer variability, and it has been associated with the Glasgow Outcomes Scale[57].

RTS

The Revised Trauma Score, or RTS[58], was developed in the 1980's as a refinement of the original Trauma Score[59]. The RTS is determined by the Glasgow Coma Scale (GCS,) the patient's systolic blood pressure (SBP,) and the patient's respiratory rate (RR.)

Each of these variables are grouped into ranges, and coded (c) on a scale from a minimum of zero to a maximum of four. The RTS is then calculated by substituting coded values in the following equation:

$$RTS = 0.9368(GCSc) + 0.7326(SBPc) + 0.2908(RRc)$$

RTS ranges from a minimum score of zero to a maximum of approximately eight. Due to the coefficients used in the computation, the resultant score is not necessarily an integer. Higher scores are more favorable.

The advantages of the RTS over the Trauma Score include more reliable outcome prediction and improved estimation of head injury severity[60].

AIS

The Abbreviated Injury Scale first appeared in 1971[61]. It is a classification of a single injury based on severity, from a minimum of one to a maximum of six. Injuries with a score of six are almost uniformly fatal, whereas those with a score of one are minor.

The AIS has undergone numerous revisions, the most recent of which occurred in 1990[62].

ISS

The Injury Severity Score, or ISS, was designed to produce a single numerical description of the patient with multiple injuries, based on the AIS of each region involved[63]. The ISS is calculated by adding the squares of the highest AIS grade in the three most severely affected body regions, and ranges from a minimum of 1 to a maximum of 75. Higher values indicate more serious injury.

The ISS has been shown to correlate with mortality[64]. It has the inherent limitations of the AIS, as well as the fact that it does not weight AIS scores based on body region.

TRISS

The TRISS methodology was conceived and developed in the early 1980's as a means of defining the probability of survival for a single patient[65]. It incorporates the ISS, RTS, and age of the patient, according to the following formula:

$$Ps = (1 + e^{-b})^{-1}$$

where the exponent b is calculated as:

$$b = b_0 + b_1(RTS) + b_2(ISS) + b_3(A)$$

where RTS is the Revised Trauma Score, ISS is the Injury Severity Score, A is the age factor (A=0 if patient age $\leq$ 54, and A=1 if patient age >54), and b_0, b_1, b_2, and b_3 are constant regression weights defined as follows for an adult population[66]:

	Blunt Trauma	Penetrating Trauma
b_0	-1.2470	-0.6029
b_1	0.9544	1.1430
b_2	-0.0768	-0.1516
b_3	-1.9052	-2.6676

These regression weights were obtained through analysis of data from the Major Trauma Outcomes Study in 1987, and represent norms derived from 15,000 blunt injury patients and 7,000 patients with penetrating injuries.

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