Aus der Klinik für Unfall - und Handchirurgie

der Heinrich-Heine-Universität Düsseldorf

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GERIATRIC TRAUMA

Introduction of age ≥70 years as a criterion for trauma team activation and the effect of early intensive management in consideration of the Injury Severity Score

Dissertation

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AIS	Abbreviated Injury Scale
ISS	Injury Severity Score
LAC	Los Angeles County Hospital
TTA	Trauma Team Activation

1. INTRODUCTION

Trauma centers use physiological criteria like abnormal vital signs and criteria related to mechanism and anatomic location of injury to determine if a trauma team is activated. The Los Angeles County and University of Southern California Trauma Center, a level 1 Trauma Center responds 5 minutes of activations and is usually present in the resuscitation room before the patient arrives. TTA patients receive the highest priority with regards to X-rays, CT scans, laboratory investigations, ICU admissions and operating rooms. The trauma attending on call is in house on a 24-hour basis and leads all trauma team activations. Trauma Team activation criteria are promulgated by the American College of Surgeons and also individual trauma centers. Trauma victims transported to the trauma center who do not meet either the TTA criteria are transported to a Level 2 or Level 3 Trauma center receive care from the emergency department staff.

One consequence of Trauma Team Activation criteria is over triage. That is unnecessary activation of the trauma team for patients who do not require immediate surgery or intensive care unit admission. The Injury Severity Score provides a useful retrospective definition of major trauma victim. The functional goal of trauma-systems triage is to send the severely injured people to trauma center while avoiding overload of these centers with patients who can properly managed elsewhere.

The main question it answers is:
Is old age ≥ 70 years with none of the other physiologic criteria a valid criterion for activating the trauma team?
Is there a correlation between significant injured elderly patients (aged 70 years or more) who do not exhibit any of the standard physiological criteria for trauma team activation i.e. hypotension, tachycardia, or unresponsiveness to pain?

For clarifying these question a database was created to define the usual criteria for TTA including mortality, need for nonorthopedics operative intervention and ICU admission within 24 hours. The Injury Severity Score was used and provided a useful retrospective definition of major trauma victim ≥70.

In addition on the basis of these findings a prospective validation of old age ≥70 years was required to evaluate the quality and commitment of trauma care. In the Los Angeles County and University of

Southern California Trauma Center the TTA criteria were modified and included age 70 and more and a protocol of early aggressive monitoring and resuscitation was introduced to assess the effect of the new policy on outcome and cost efficacy.

2. PATIENTS AND METHODS

2.1.1. Study design

This was a trauma registry based study and included patients who met the major trauma team activation criteria. The patients were admitted to the Los Angeles County and University of Southern California trauma centre, during the period January 1993 until August 2001. From the time of their admission until their discharge or transfer the patients ≥ 70 were registered and their process documented. The personal data of the patients, especially information about detail of the accident and the clinical situation at the place of the accident are taken into the account upon arrival at the hospital. The aim of the study was to prove which patients should have been classified as major trauma victims although they did not meet the Los Angeles TTA criteria.

2.2. Admission criteria

2.2.1. Study period

All patients satisfied the defined criteria were documented during the period between January 1993 until August 2001.

2.2.2. Age

All Patients ≥ 70 years old were included in this study.

2.2.3. Gender

Female and males were included in the study.

2.2.4. Admission criteria

The Field triage decision scheme recommended by the American College of Surgeons Committee on Trauma (12) provides an algorithm for triage using multiple components. A major injured person meeting one of the trauma admission criteria as shown in figure 1 is immediately transported to one of the Level 1, 2 and Level 3 Trauma Centers.

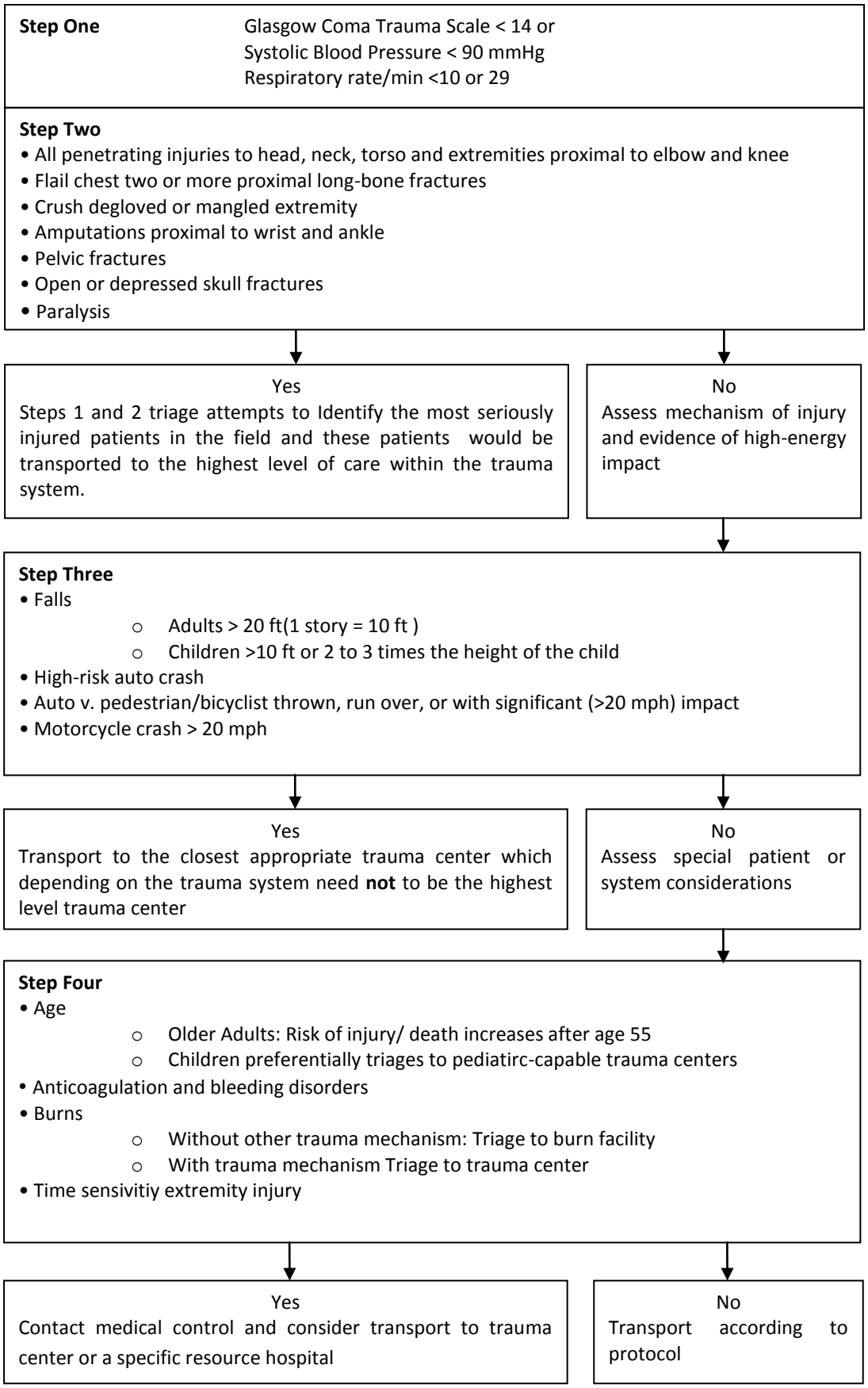

Figure 1: - Trauma Triage Decision Scheme recommended from the American College of Surgeons 2006 (12)

A Level 1 trauma centre is a regional resource trauma centre that has the capability of providing leadership and total care for every aspect of injury from preventation through rehabilitation. In – house availability of the attending trauma surgeon is the most direct method for providing this involvement. The Los Angeles County and University of Southern California Medical Center is the largest level I approved of American College of Surgeons academic trauma center in the United States.

The trauma attending (consultant) is in house on a 24-h basis, leads all trauma team activations and directly supervises all procedures performed in the operating room. The trauma team responds within 5 minutes of Trauma Team activation Criteria as shown in table 1 and is usually in present in the resuscitation room before the patient arrives. The team includes attending and senior residents from the Division of Trauma and Critical Care and the Department of Emergency Medicine. TTA receive the highest priority with regard to investigations, ICU admission and operating rooms. They are monitored continuously in the emergency room and radiology department by senior or attending staff.

1. Systolic blood pressure < 90 mmHg
2. Pulse > 120/min
3. Respiratory rate < 10 or > 29 Breaths / min
4. Unresponsiveness to pain
5. Emergency Physician Judgement
6. Gunshot wound of the trunk
7. Age ≥70 years

Table 1: LAC and USC Medical Center Standard Trauma Team Activation Criteria 1-6; Second study period 1 – 7 in group 2

2.2.5. Patient groups

First study period:

It included patients who met the trauma center criteria and were ≥ 70 years old and were admitted during the period January 1, 1993 to June 30, 2000 to the LAC and USC Medical Center.

Second study period:

The study patients were divided in two groups:

Group 1: included patient admitted during January 1 1993 till February 29 2000 before age ≥ 70 became a TTA criteria with an Injury Severity Score greater than 15.

And Group 2 included patients ≥ 70 years old with an Injury Severity Score greater than 15 admitted during March 1 2000 till August 30 2001 when age ≥ 70 was an absolute trauma TTA criterion and a policy of early advanced hemodynamic and tissue perfusion monitoring and resuscitation and ICU admission was in place.

2.2.6. Drop out criteria

Interhospital transfers and patients not meeting the trauma registry criteria were excluded from the study. Ground – level falls even with major fractures are not included in the trauma registry.

Ground Level falls even with major fractures and subacute or chronic subdural hematomas were not included at the trauma registry.

2.3. Documentary parameter of polytrauma patients

2.3.1. Study population

Age

Gender

Duration of Intensive Care Unit and Hospital stay

2.3.2. Mechanism of injury

Motor vehicle versus pedestrian's injuries

Traffic Accidents: Motorvehiscles accidents

Falls from a height

2.3.3. Primary diagnostic

The trauma attending (consultant) on call is in house on a 24-h basis, leads all trauma team activations and directly supervises all procedures performed in the operating room before the patient arrives. The trauma team response within 5 minutes of TTA and is usually present in the resuscitation room before the patient arrives. The team includes attending and senior residents from the Division of Trauma and Critical Care and the Department of Emergency Medicine. TTA patients receive the highest priority with regard to investigation, ICU admission and operating rooms, X-Rays and CT scans. In group 2 liberal use was made of non-invasive cardiac output monitoring and tissue perfusion with non-invasive measurement of transcutaneous oxygen and carbon dioxide, early intubation of the patient in the emergency room before going to the radiology department, admission to the ICU (even for fairly minor injuries) and insertion of a Swan Ganz catheter.

2.3.4. Types of injury

Head, Chest, Abdomen and Skeletal injury, Blunt and Abdominal trauma.

2.3.5. Degree of injury

An Excel (Microsoft Corporation, Redmond Washington, USA) database was created for the purpose of this study and included the anatomical scoring systems: Abbreviated Injury scale and the Injury Severity Scale.

The Abbreviated Injury Scale is an anatomical score which scores from 1 (minor) to 6 (fatal). Each injury description is assigned in a unique 6 – digit numerical code in addition to the AIS severity score Over 1200 injuries listed in the Abbreviated Injury Scale 1990 Revision booklet (29). As summarized in table 1 the first digit identifies the body region, the second digit identifies the type of anatomic structure; the third and fourth digits identifies the specific anatomic structure or the specific nature of the injury; the fifth and sixth digits identifies the level of injury within a specific body region and anatomic structure. The digit to the right of the decimal point is the AIS score.

A	B	C C	D D .	E
Body region Code	**Type of Anatomic Strukturen**	**Specific Anatomic Strukturen**	**Level**	**AIS**
1 Head 2 Face 3 Neck 4 Thorax 5 Abdomen 6 Spine 7 Upper Extremity 8 Lower Extremity 9 Unspecified	1 Wohle Area 2 Vessels 3 Nerves 4 Organs 5 Skeletal 6 Head	Whole Area Skin- 02 -Abrasion 04 -Contusion 06 -Laceration 08 -Avulsion 10 Amputation 20 Burn 30 Crush 40 Degloving 50 Injury - NFS 60 Penetrating 90 Trauma, other than mechanical <u>Head - LOC</u> 02 Length of LOC 04, 06, 08 Level of Consciousness 10 Concussion <u>Spine</u> 02 Cervical 04 Thoracic 05 Lumbar	To the extend possible, within the organizatio-nal framework of the AIS, 00 is assigned to an injury not further specified	1 Minor 2 Moderate 3 Serious 4 Severe 5 Critical 6 Invariably fatal

Table 2: The Abbreviated Injury Scale

The Injury Severity Score (ISS)

The Injury Severity Score (ISS) is an anatomical scoring system that provides an overall score for patients with multiple injuries. Each injury is assigned an Abbreviated Injury Scale (AIS) Score and is allocated to one of six body regions Head, Face, Chest, Abdomen, Extremity and External. Only the highest AIS Score in each body region is used. The 3 most severely injured body regions have their score squared and added together to produce the ISS score. The ISS Score values from 0 to 75. If an injury assigned an AIS of 6 (fatal) the ISS score is automatically assigned to 75.

Body Region	Injury description	AIS	AIS ² Top Three
Head and Neck			
Face			
Chest			
Abdomen and Pelvic			
Body Pelvis and Limbs			
Body surface			
		ISS = is the sum of the squares of the highest AIS severity scores from three above-described body areas	

Table 3: Injury Severity Score (ISS)

2.3.6. Therapy

ICU admission within 24 hours

Duration of ICU and hospitals stay

Operating intervention (excluding orthopaedic procedures)

2.3.7. Complications

Mortality, Cause of death, Non-orthopaedic Operation, Permanent handicap in survivors

2.3.8. Hospital parameters

Hospital charge, Hospital stay

2.4. Statistical Analysis

Statistical analysis a comparison of categorical variables between patient groups was performed using the Chi-Square test for categorical variables and the t test for continuous variables.

A p value less than 0.05 ($p < 0.05$) was considered to be significant.

3. RESULTS

3.1. Patients documentary report for the first study period

3.1.1. Study population

During the first study period there were 883 trauma patients ≥70 years of age admitted at the Los Angeles County and University of Southern California Trauma centre. There were 531 males (60 %) and 352 females (40%). The mean age was 77.8 years old. Overall 223 (25 %) met at least one of the standard criteria for TTA. The remaining 660 patients 75 % did not meet any of the criteria.

	Patients with TTA Criteria	**Patients with no TTA criteria**	Total
Number	223	660	883

Table 4: Patient Demographics

3.1.2. Mechanism of injury

The most mechanism of injury in the patients with Trauma Team Activation was Pedestrian traffic accidents with 106 Patients (47 %) versus falls from height by 256 Patients (39 %) with no Trauma Team Activation Criteria. Pedestrian traffic accounted for 287 injuries (33%), Falls from height for 285 (32%), traffic accidents in 200(23 %) and other causes in 111(12%).

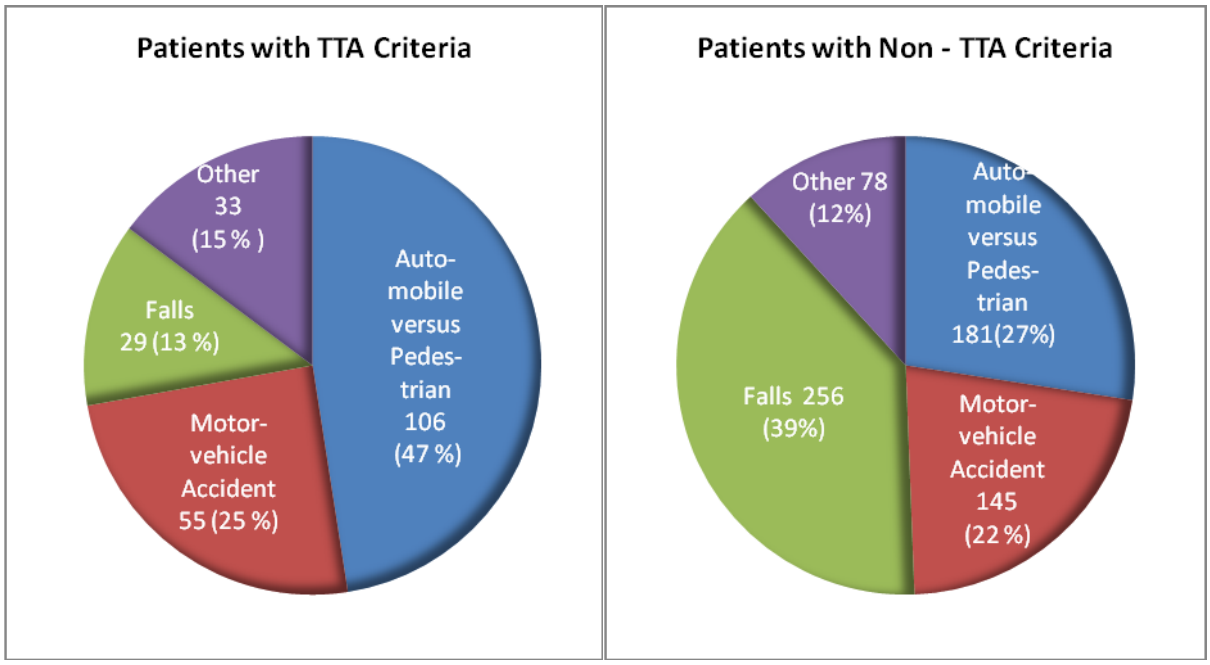

Figure 2: Mechanism of injury in the two groups

3.1.3. Degree of Injury

Injury Severity Score and Outcomes

The mean ISS was 19.2 in TTA patients and 10.4 in non-TTA in 19 patients there was no ISS recorded because of inadequate autopsy reports. Most patients 64 % had an ISS ≤ 15, 26 % had an ISS 16-30 and 5 % had an ISS >30 did not have any of the standard criteria for TTA.

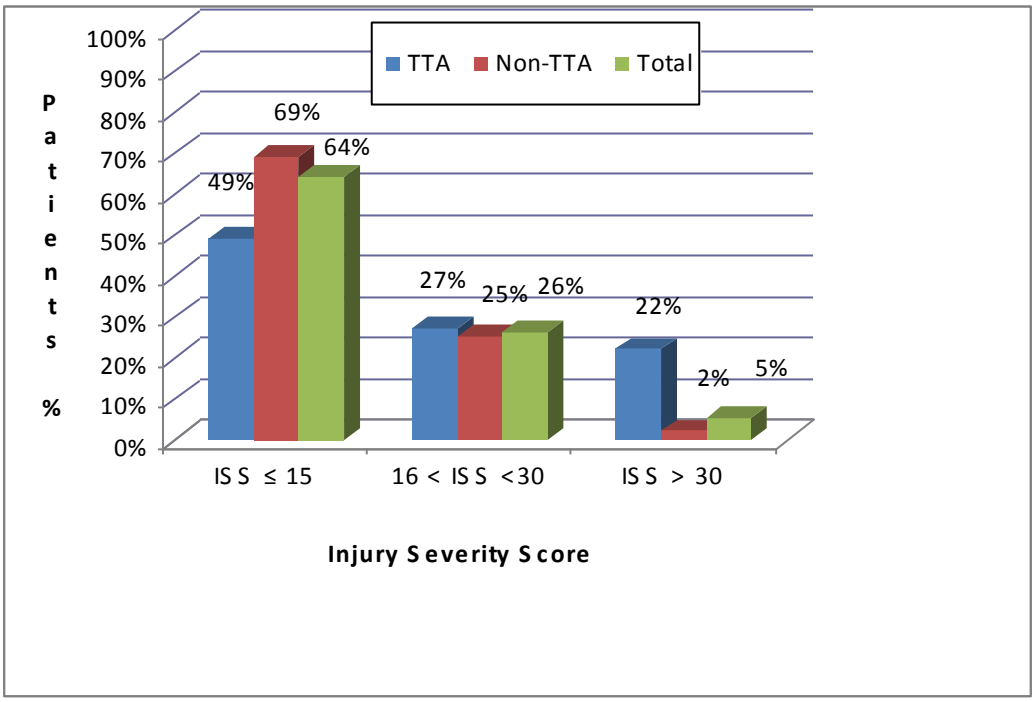

Figure 3: Injury Severity Score

3.1.4. ICU admission and non-orthopaedic operation

Overall, 244 patients (28%) required ICU admission within 24 hours of hospital admission with 39 % of patients with TTA criteria and 24% of patients with no TTA criteria as shown in Table 4.The main ICU stay was 8.9 days for TTA patients and 8.3 days for non - TTA patients. A nonorthopedic operation was required in 35% of patients with TTA criteria and 19% with no TTA criteria.

	Patients with TTA Criteria	**Patients with no TTA criteria**	Total	p-value
Number	223	660	873	
ICU admissions within 24 hours	87 (39 %)	157 (24 %)	244 (28 %)	P < 0,001
Non-orthopaedic operation	79 (35%)	126 (19 %)	205 (23 %)	P < 0,001
Mortality	111(50 %)	103(16%)	214(24%)	P<0,001

Table 5: Mortality and need for ICU admission or major non orthopedic operation according to TTA criteria

3.1.5. ICU admissions

Fourteen percent of patients with ISS ≤ 15, 59 % of patients with ISS 16-30, and 54% of patients with ISS > 30 required ICU admission within 24 hours.

	ISS Score ≤ 15(%)	ISS > 15 (%)
Patients TTA Criteria	27/110	61/110
Patients with no TTA criteria	53/458 (12 %)	113/186(61%)
Total	80/568 (14 %)	174/296(59 %)

Table 6: ICU admissions within 24 hours according to ISS and TTA criteria

3.1.6. Mortality according to ISS and TTA criteria

Analysis of deaths revealed a mortality of 50% for the patient with TTA criteria and 16 % for the Patients with no TTA criteria. ISS was related to the mortality as shown in Figure 4 with increasing ISS was a gradual increase in mortality that exceeded the overall mortality for the geriatric group.

Figure 4 illustrates the distribution of the deaths within the geriatric group as related to the ISS and TTA criteria. The overall mortality for patients with ISS ≤ 15 was 9%, in patients with ISS 16-30 it was 47% and with ISS ≥30 it was 80 %.

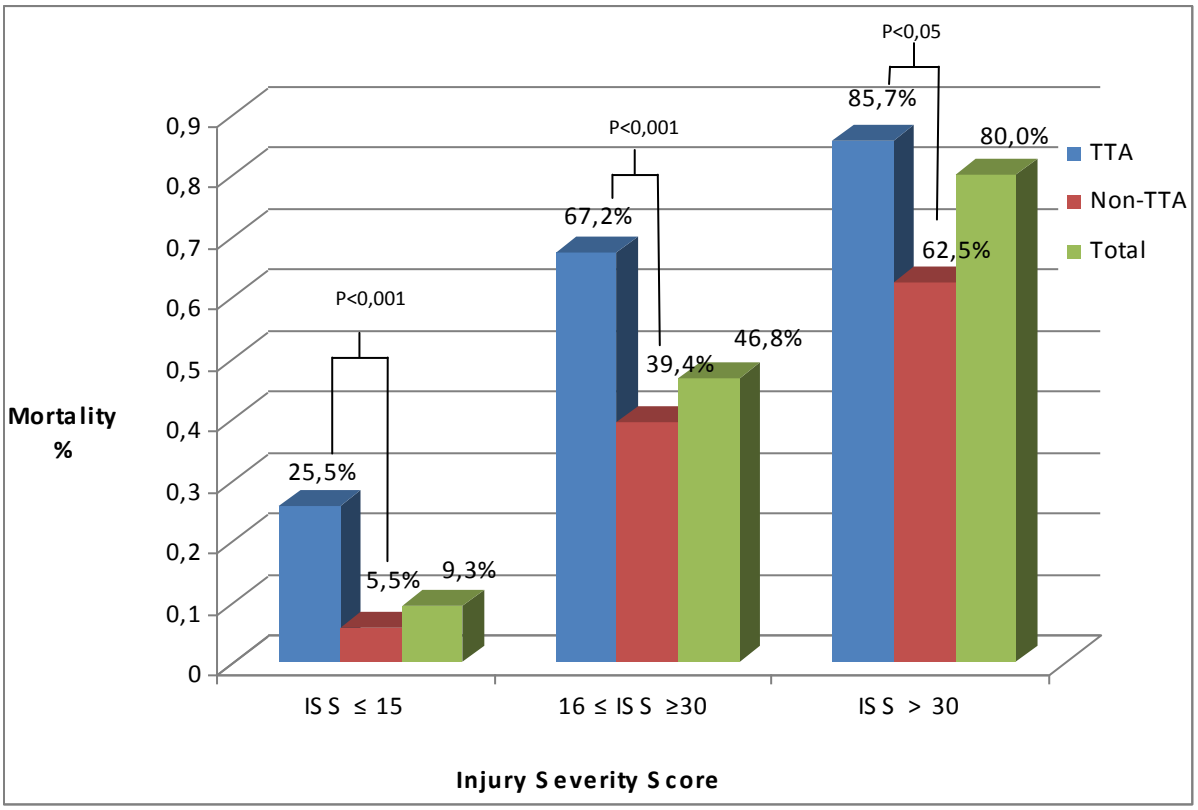

Figure 4: Mortality percentages for both the TTA and non TTA groups according to the Injury Severity Score

3.1.7. ICU admission and non orthopedic operations according to Mechanism of Injury and TTA Status

Overall 18 % (51/287) of patients involved in pedestrian accidents, 15% (27/200) of MVA and (67/285) 24 % of falls who did not meet the standard TTA criteria and required ICU admission within 24 hours as illustrated in Table 7. The need for non orthopaedic operations regarding falls were similar for each group although the incidence of pedestrian injuries were half as much in patients with no TTA criteria.

	Number of patients	ICU admission within 24 hours	Non-orthopaedic operations
Pedestrian: TTA	106	49 (45%)	45 (42%)
Pedestrian: Non TTA	181	51 (28 %)	39 (22%)
MVA: TTA	55	21 (38%)	17 (31%)
MVA:Non-TTA	145	27 (19 %)	16 (11%)
Fall: TTA	29	6 (21%)	5(17%)
Falls: Non-TTA	256	67 (26 %)	45(16%)

Table 7: ICU admission and non-orthopedic operations according to mechanism of injury and TTA criteria

3.1.8. Mortality according the injury type

Our analysis concerning all mechanism of injury revealed mortality rates from 5% to 63% with falls injury to be the most lethal for non TTA group. Figure (5) illustrates that for the TTA group the pedestrian injuries had the most mortality with 63 %.

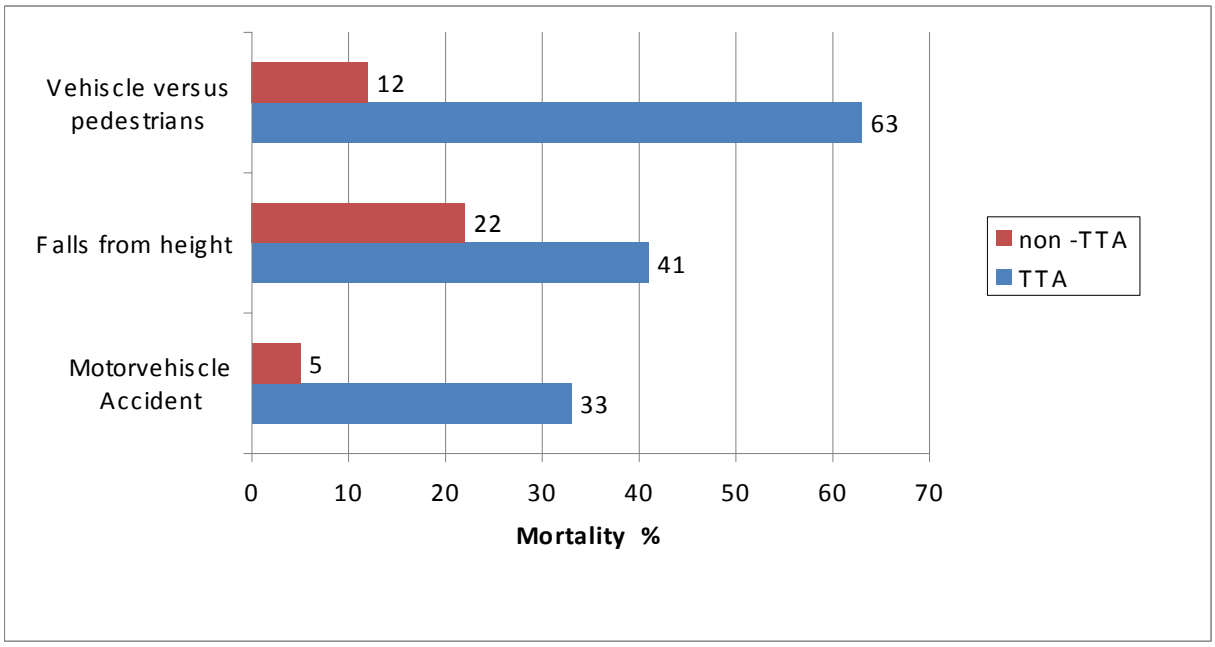

Figure 5: Comparative information about mortality according to the group with TTA and non TTA by the injury type

3.2. Second study period: the effect of the new policy on outcome after 70 years old became a TTA Criterion

3.2.1. Study population

During our second study period there were 1080 trauma patients ≥70 years old who were admitted at the trauma center. There were 260 patients in Group 1 with the standard criteria for Trauma Team activation during January 1993 till February 2000. Group 2 formed 76 patients with the standard Trauma Team activation Criteria and age ≥ 70 years old as shown in table 1. The two groups were similar with regard to age and gender. An overall comparison of the demographics from the two groups is illustrated in table 8.

	Group 1	Group 2	p*
Number of patients	260	76	
Gender (% Males)	156(60%)	42(55 %)	0·51
Mean age (Years)	77	78	

Table 8: Data of Patients ≥ 70 years old and ISS >15

3.2.2. Types of injury

While the majority in both group were injured by blunt mechanism, penetrating trauma counted for 5 %.

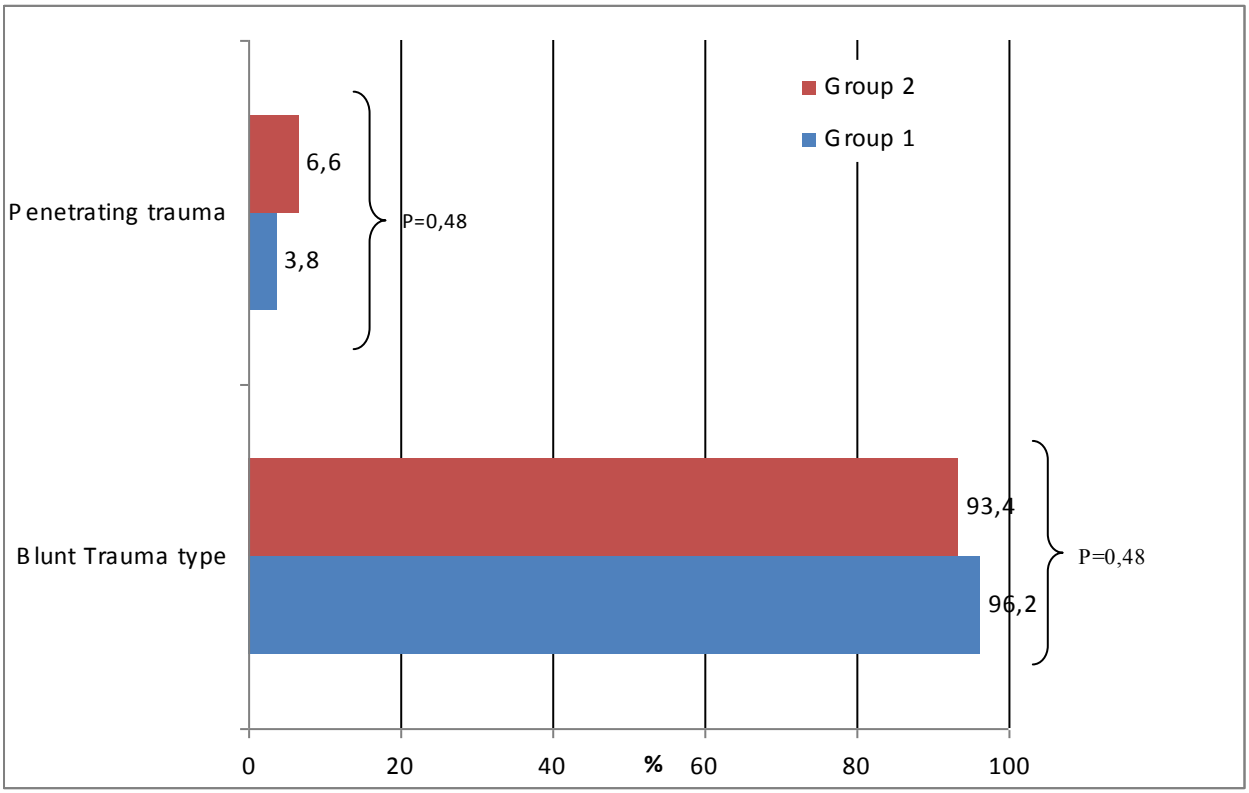

Figure 6: Incidence of types of injuries in the two groups

The mean ISS for the two groups were not appreciably different (25 versus 24).

3.2.3. The most severely injures body area

The most severely injured body area with AIS≥3 was the head followed by the chest.

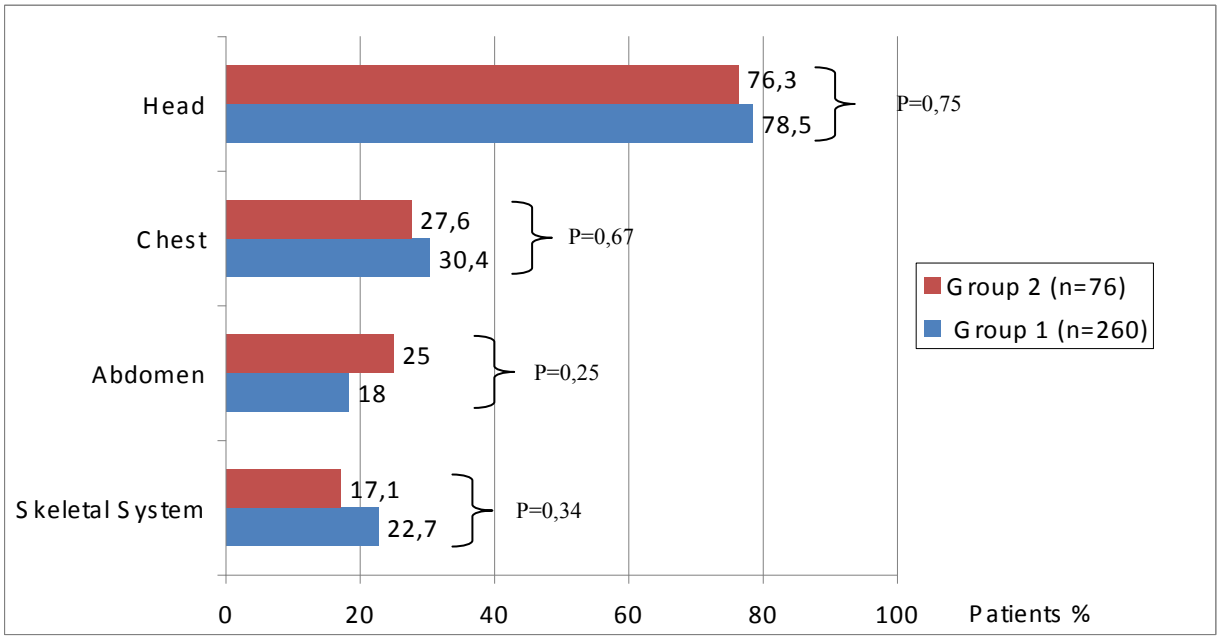

Figure 7: The overall most injured body areas measured by AIS ≥3

3.2.4. Outcome for patients aged 70 years or more with an Injury Severity Score above 15

Table 10 illustrates a comparative number of outcomes for the two groups. The ICU and hospital stays were similar in both groups, although there was a trend toward higher hospital charges in group 2. The overall mortality was 49 % (166 of 336). The mortality in group 2 was significantly lower than in group 1 (34.2% vs. 53.8%). The incidence of permanent disability in survivors was 12.0 % in group 2 and 16.7 % in group 1.

	Group 1	Group 2
Number of patients	260	76
ICU stay(days ± SD)	5,2 ± 9.8	4,5
Hospital day (days ± SD)	10.2 ±13.3	10,7 ± 13,8
Hospital charges ($)	49.644	64,249
Deaths (%)	140 (53.8%)	26(34, 2%)
Permanent Handicap in survivors (%)	20 (16.7%)	6 (12%)

Table 9: Age ≥ 70 years and ISS > 15: Outcomes

3.2.5. Outcome for patients aged 70 years or more with an Injury Severity Score above 20

In the subgroups of patients with ISS >20 were 204 patients with and the overall mortality from (129 deaths) 63.2%. The overall mortality in group 2 was significantly lower than in group 1 (46.9% versus 68.4%). The incidence of permanent disability in survivors was 7.7% in group 2 and 24.5% in group 1 (p= 0.12) Other outcome parameters such as ICU and hospital stay and hospital charges were not significantly different.

	Group 1	Group 2	p*
Number of patients	155	49	
ICU stay(days ± SD)	4,9 ± 8,3	3,5 ± 6,0	0, 26
Hospital day (days ± SD)	9,6 ± 12,9	9,1 ± 8,9	0, 83
Hospital charges ($)	45,745	53,327	0, 52
Deaths (%)	106 (68,4 %)	23 (46.9 %)	0, 01
Permanent Handicap in survivors (%)	12 (24,5 %)	2 (7,7%)	0, 12

Table 10: Age ≥ 70 years and ISS>20: Outcomes

4. DISCUSSION

4.1. General considerations

The geriatric population represent worldwide the fastest growing group of the general population. While in the United States McKenzie (42) predict that by 2050, 40 % of all trauma patients will be aged 65 or more. Only few publications have described managing elderly trauma patients differently than younger patients (60). Especially prehospital triage instruments perform in a geriatric population are rarely investigated (60). The care of critically injured patients can be optimized by the early presence in the emergency room of the trauma team under the leadership of an expert trauma surgeon. Early recognition of life-threatening injuries and appropriate resuscitation and timely definite treatment result in better survival and fewer organ failures. According to Wyatt JP et al (79) underestimating the triage category effect less interventionist approach and appearance of senior and expert medical staff which result in a less outcome for this patient group.

However logistically and financially it is not possible to activate the trauma team for all cases and some form of triage is necessarily in order to avoid missing patients who might benefit from TTA although the level of acceptable over triage has not been established. The standard criteria for major resuscitations and attending presence in the emergency room recommended in the Resource for Optimal care for the injured Patients (2006) do not include old age (12).

The geriatric population has a distinct injury pattern, post injury course and outcome than the younger patients. Therefore it is important to respect the physiological changes of ageing that affect evaluation and management of this special group of our population.

4.2. Injury pattern

4.2.1. Fall

Falls are the most common cause of accidental injury in the aged 65 and over (11). According to Duthie et al (20) and Lucht (39) chronic diseases and disabilities that impair sensory cognitive, neurological or musculoskeletal function are associated with the tendency to fall and estimated 25 to 44 per cent of falls are caused by underlying medical problems.

In our casuistic fall with TTA criteria is the last prevalent cause of injury and with no TTA criteria the first cause of injury compared to Champion (11) and Ferrera (22) with falls as the leading injury mechanism as shown in table 12.

Ferrera (22) includes also low mechanism falls with a mortality rate of 9% and high mechanism falls with 55 % compared to our findings with 22% to 44% mortality with no TTA and TTA criteria. We attempt to evaluate high mechanism falls injuries.

Lilley et al (38) describes in a special review of literature on accidents involving older people a weakness of comparing literature on falls. As shown in table 12, comparison on publication of falls are complicated by the variety of classifying and defining falls and by the different population studied. As mentioned above the general definition of a geriatric population begins at 65 (45).Our study group includes patient ≥ 70years old compared to Ferrera (22) and Champion (11) with a study population of ≥ 65years. Also many of these studies include low mechanism falls injury.

4.2.2. Automobile versus pedestrians

The elderly are involved in crashes as pedestrians are more commonly than in other age group including children. A comparison of our data and from Champion (11) and Ferrera(22) shows that pedestrian accidents have the highest incidence of mortality.
Mackay (41) et al and Mc Coy et al (44) showed that elderly trauma patients have more serious and significant injuries especially to the lower extremity and head than younger victims. In our clinical analysis patients with TTA and non TTA criteria with pedestrian accidents have the highest ICU admission rate and highest non-orthopaedic operation rate of all Injury types.

4.2.3. Motor vehicles accidents

Elderly people involved in motor vehicles accidents older than 70 years old comprised 13 % of all motor vehicles fatalities and 18 of % pedestrian fatalities (38). Although the elderly group has the lowest incidence of intoxicated driving, visual or cognitive impairment leads to dangerous driving occurrence e.g. misjusting distance and speed. In a study of 6000 crashes 312 involved elderly occupants McCoy et al (44) found the resultant injury pattern was independent of age with exception that the elderly suffered more sternal fractures 11% versus 1,5 than their younger counterparts.

	Our findings	Champion et al 1989	Ferrera et al 2000
Age	≥ 70	≥ 65	≥ 65
Falls			
Patients	With TTA 13% With noTTA 39%	40.6%	Low mechanism falls 55% High mechanism falls 9%
Mortality	With TTA 41% With no TTA 22%	11.7%	Low mechanism falls 9.1% High mechanism falls 13.6%
MVA			
Patients	With TTA 25% With no TTA 22	28%	27%
Mortality	With TTA 33% With noTTA 5%	20.7%	14%
Vehicles versus Pedestrian			
Patients	With TTA 47% With no TTA 27%	10%	3%
Mortality	With TTA 63% With no TTA 12%	32.%	25%

Table 11: Comparison of literature for the geriatric trauma patients and common associated mechanism of injury types and mortality modified (11, 12)

Penetrating Trauma

In our studies we reported a number of 3,8 % in Group 1 and 6,6 % in group 2 patients with penetrating trauma with an Injury Severity Score greater than 15. Kohn et al (34) showed in agreement with numerous study (3, 27, 31, 33) that gunshot wound to head, neck or torso is as predictive as most physiologic criteria for severe injury and should recommended as a first tier to trauma team activation. Finelli et al (23) found that the mortality for stab wounds in those younger than 65 was 4,7 % and those older than 65 was 17,3 %. With gunshot wounds the mortality was 19,5 % in the young a compared to 52,1 % in the old

4.3. Physiological changes and elderly trauma by bodily system

The general definition of a geriatric population begins at 65 (45). An understanding of the physiologic and anatomic changes associated with aging as shown in table 13 is important to recognize pattern of injury in the elderly and to respond appropriately.

Age related cardiovascular changes

1. Stiffening of the aorta and peripheral vessels
2. Increase in left ventricular wall thickness
3. Conduction abnormalities
4. Decreased cardiac output
5. Increased peripheral vascular resistance
6. Less ability to increase heart rate
7. Hypertension

Age related respiratory system

1. Decreased elasticity of chest wall
2. Diminished response to chemo receptors
3. Diminished ciliary clearance
4. Less effective cough
5. Increased Work of breathing
6. AaDO2 gradient increase
7. V/Q mismatch
8. Decrease in surfactant
9. Chest-wall stiffness
10. Atrophy of respiratory muscles
11. Decreased number of alveoli
12. Decreased FEV

Renal systems

1. Decreased glomerulifiltration rate
2. Decreased drug clearance rime
3. Inefficient concentrating and diluting
4. Poor angiotensin response
5. Diminished control of acid base balance
6. Diminished tolerance to hypotension and nephrotoxic drugs

Neurological System

1. Decrease in brain size
2. Less functioning neurons

Musculoskeletal system

1. Decrease in bony mass
2. Stiffening of ligaments and joint

Table 12: Summary of physiological changes with aging identified in the literature review (modified 25)

4.3.1. Age related cardiovascular changes

The cardiovascular system is affected by age, the increased stiffness of the systemic aorta and systemic arteries cause an increase in peripheral vascular resistance (43). The blood vessels are less resilient and contribute to a higher systolic blood pressure in the elderly. (43). The left ventricular dilatation and left ventricular wall thickness is due to the increased blood pressure and contraction begins from a greater preload than for younger patients.

There are major problems regarding the initial evaluation and management of the geriatric trauma patient. Firstly the initial vital signs can be misleading normal due to many factors. Tachycardia may be absent due to the inability of the elderly patient to launch a normal physiological respond to trauma. The cardiovascular system response of the elderly can be unpredictable and often fails to respond to endogenous or exogenous signals. Medication for hypertension or cardiac disease such as Beta Blockers, calcium channel blockers may affect the clinical presentation. A normal blood pressure or mild hypotension with hypertensive disease may in reality signify significant hypotension with tissue hyper perfusion.

In our first study we reported that 63% of geriatric patients with ISS > 15 and 25 % of patients with ISS > 30 did not have any of the standard hemodynamic criteria for TTA. Many of these patients decompensate easily and without warning, often in the radiology suite or non monitored area making successful resuscitation and survival less likely.

There are two fundamental principles of resuscitation of the elderly 1) Early recognition of shock and 2) the maintenance of tissue perfusion. Early (< 12 to 24 hr) treatment of shock, payment of oxygen dept and presentation of inflammatory mediator response to ischemia are vital for patients survival (48).The safety margin between hypovolemic shock an overresuscitation and cardiac failure can be dangerously narrow and can be avoided early by expert supervision . In our second study period of group 2 liberal use was made of non – invasive cardiac output monitoring and tissue perfusion with non –invasive measurements of transcutaneus oxygen and carbon dioxide, early intubation of the patient in the emergency room before going to the radiology department, admission to the ICU and insertion of a Swan - Ganz catheter

Scalea and colleagues (60) demonstrated an improved survival rate of 53% in patients older than 65 years of age with diffuse blunt trauma with early (<2.2 hr) invasive monitoring using a pulmonary artery catheter, with those treated the previous year and who underwent monitoring at 5.5 hours after admission with a survival rate of 7%. Most elderly patients had a decreased cardiac output and venous saturation, showing normal vital signs in the emergency department.
Scalea ' s expeditious placement of pulmonary artery catheter and treatment to augment oxygen delivery as necessary to meet oxygen consumption has also been demonstrated to improve survival in trauma victims as well in as in high-risk surgical patients (6, 66, 82, 83).

With the development of non-invasive techniques, cardiac output and tissue perfusion can be monitored early and reliable soon after admission to the emergency department (69, 73).
As Brown et al (8) showed that non-invasive cardiac index with using bioimpedance technology in elderly > 70 years patients is reliable and correlates well with standard use of pulmonary artery catheter and thermo dilution techniques.

Cardiac contusion

Myocardial contusion results mostly from vehicular impact during an automobile accident in which the steering wheel is involved (37, 25). The major problem of cardiac contusion in trauma patients is the diagnostic problem and invasive monitoring is recommended

Aortic injury

Loss of elasticity and atherosclerotic plaques of the great vessels may predispose elderly patients to disruption of the vascular intima and media due to rapid deceleration (37). Traumatic rupture of the aorta (TRA) counts for a large percentage deaths immediately following a motor vehicle accident (37). 10 to 20 % of the patient with TRA reach the hospital alive with stable vital signs (19). If a TRA is not diagnosed is not diagnosed and treated within the 6 hours over the half of the patients surviving the initial aortic injury die within the 6 hours (19).

The helical CT scan of the mediastinum is the investigation of choice at the Los Angeles Trauma centre. It differentiates between a widened mediastinum due to hematoma or supine position and is sensitive in identifying aortic injuries including intimal tears. Other authors recommend contrast aortography with the only diagnostic test with consistent accuracy (1, 26).

The aortic arch angiogram is used in patient groups with stable vital signs and suspicious CT scan or in patients undergoing angiography for other reasons like angiographic embolization of liver lesion. The transoesophageal echocardiogram was performed in patient at the Intensive care unit who cannot be moved for CT scan and aortography. Intrinsic changes and diseases of the aorta makes successful repair more difficult. The elderly patient awaiting surgery must be carefully monitored and systolic blood pressure must kept below 120 mm Hg (75).

4.3.2. Age related respiratory system

The chest wall of the elderly person is usually less elastic and more susceptible for fractures. According to Mithoefer (46) and Pontopidan (53, 54) the lung of the elderly loses much of its elasticity with an increased residual volume 35-45 % compared to 20 –25 % in young adults, with a decrease in expiratory and inspiratory reserve volumes and vital capacity. The ability of the central and peripheral chemo receptors to respond to hypoxia and Hypercapnoea is reduced by as much as 50 per cent in the elderly (43).

Fail chest and pulmonary contusion

Chest wall injuries can result in significant morbidity and mortality in the older trauma patients. In our patient group chest injury was the second most severely injury area with an AIS ≥ 3
A fail chest is defined as at least two fractures in the adjacent ribs or costal cartilage result in a free floating segment (37). The high morbidity associated with a flail chest is not from the dramatic movement from the chest but instead from the patient's refusal to take a deep breath and cough. Consequently these leads to hypoventilation, atelectasis and pneumonia, which result in sudden deterioration and respiratory failure. Early epidural anaesthetic is recommended with a decreased need for absolute mechanical ventilation support (57, 65).
But still elderly people are extremely intolerant of hypoxia and factor like altered mental status, pre-existing disease require earlier intubation a mechanical ventilators (61).
The other problem is pulmonary contusion which is less common in the elder older trauma patient than in younger and paediatric trauma patients.
The stiffer rib cage usually fractures rather than compresses but cause open laceration of the lung with following pneumothorax or hemothorax. Intraaveolar oedema, interstitial oedema and tissue inflammation result to decrease lung compliance and ventilation perfusion mismatches. Hypoxia may not be identiable by respiratory distress or tachycardia until respiratory failure appears.
In our patient group chest injury was the second most severely injured area with an AIS ≥ 3

Loss of respiratory reserve in the elderly patients makes careful monitoring of the pulmonary status imperative. Early arterial blood gas evaluation is also important because it may reveal an unexpected metabolic or respiratory acidosis (45, 78). Broos et al (7) showed that the need for early intubation

followed by long term assistant ventilation was predictive of survival. The threshold for intubation should be lower in older patients before irreversible hypoxic damage of vital organs occurs.

4.3.3. Renal systems

Renal plasma flow, glomerula filtration rate and the concentration ability of the kidneys significantly decrease in the elderly (12). A significant renal impairment may exist in elderly patients in spite of normal serum creatine levels. The decreased renal function that occurs with aging in conjunction with a loss of cardiac function causes elderly traumatized patients to require increased amounts of fluids to maintain an adequate urinary output at a time when even minimal overloading may cause severe heart failure.

4.3.4. Age related neurological changes

The brain undergoes a progressive loss volume with age with less functioning neurons. The Dura adheres more tightly to the skull reducing the risk of an epidural haematoma (16, 50).
But brain atrophy and fragile bridging veins predispose to subdural hematomas or significant bleed as a result to a minor blow to the head. Anticoagulation medications predispose to in cranial haemorrhages even after minor injury (24).

In our patients the most commonly severely injured body area with AIS of 3 or more was the head with 78.0 % per cent in group 1 and 76.3 % in group 2. Pennings et al (51) studied head injury patients with Glasgow Coma Scale Scores of 5 or less and compared 90 elderly patients to a group of younger patients matched for ISS, AIS and RTS. Seventy- nine percent of the elderly patients died in the hospital compared to 36% of the younger patients (51).

Zietlow et al (84) and others found severe neurotrauma is a significant predictor of outcome and elderly patients with a Glasgow Come Score of 8 and less have mortality rates of 80 %. Seelig et al (64) reported that patients with acute subdural haematoma who underwent a craniotomy within 4 hours had a better prognosis than those with delayed surgical intervention. But Wilberger et al (77) pointed out that in a study of 101 patients with acute subdural hematoma the ability to control intracranial pressure is more critical to outcome than the timing of surgery. If the ICP can be kept below 45 mmHg, whether with hyperventilation, osmotic agents or timely surgery then the outcome will be improved. A liberal and lower threshold for ordering a CT scan for geriatric patient in who moderate to severe head injury is suspected because of its reliability in identifying not only subdural bleeds but also subarachnoidal haemorrhages and parenchymal bleed.

Like Broos et al (7) study with multiple injured patients of 65 years and older showed that early intubation followed by long term assistance ventilation is predictive of survival by GCS ranges from 3 to 8.

The consequences of the all these changes is a standard approach of monitoring , liberal use of CT Scan, early and controlled intubation, reduction of cerebral oedema and early drainage for the intracranial mass lesions. Hypotension must be treated aggressively to maintain cerebral perfusion.

4.3.5. Abdominal trauma

Evaluating and management of abdominal injuries in the elderly trauma patient is difficult. The physical examination of the elderly trauma patient is frequently unreliable. Inflammatory conditions as peritoneal irritation may not be present and impaired commitment and associated injuries contribute to a delay of recognition (1). Elderly people are less tolerant of explorative laparatomy and shock with intraabdominel bleeding and peritoneal contamination. Therefore the prompt and accurate diagnosis of intra- abdominal trauma requiring operation is imperative. In comparison to our study with 25 % in group 1 and 18 % Group 2 with abdominal injuries Oreskovich (49) reported a up to 35 % rate of elderly multiple trauma patients with significant abdominal injuries. Finelli et al (23) compared the mortality of 180 elderly patients ≥ 65 years to a similar injured patient group of <65 years with abdominal injuries. The older people had a 4.7 times higher death rate than the younger patient group (81.2 % vs. 17.2 %).

At the LAC Centre abdominal ultrasound and CT scan are the most useful investigations for solid organ injuries, intraabdominel hematomas and free blood in the peritoneal cavity. Both

investigations have limited value in diaphragmatic perforations and pancreatic trauma. Peritoneal lavage can be used as complimentary test to the CT scan. Elderly patients had often previous abdominal surgery and with the presence of significant paralytic ileus, and with our patient group it was a relative contraindications to lavage. A lavage result positive for blood was not itself an indication for laparotomy. Nonoperative management of the solid organ injuries (e.g. Liver spleen) is less successful than in younger populations Age alone should not serve as a predisposition against aggressive care in the elderly population and a delay of laparotomy and unnecessary investigations is unwarranted (76).

4.3.6. Skeletal injury

Osteoporosis and skeletal muscle atrophy predisposes elderly trauma patiens to fractures from relative mild trauma (50).The most common osteoporotic fractures in elderly individuals are vertebral compression fractures, Colles fracture of the wrist, and hip fractures. Fractures of the ribs, pelvis and skulls are common (12).

Femoral shaft and neck fractures are common in the elderly and are best treated by early stabilization (21). Multicenter studies have established the significant reduction in mortality by early fixation with a significant reduction in mortality by early fixation of fractures with multiple injuries in younger and older age groups with a decrease in deep venous thrombosis, pulmonary embolism pneumonia and cutaneus pressure ulcerus (5). In contrast Schultz (62) described the “appropriate time for surgery should be accurately determined and chosen on the basis for optimal physiological balance. The mortality rate in the monitored group was 2, 9 % versus 29 % in a similar but unmonitored group even though the mean interval between admission and operation in the monitored group was 3,7 days (62).

4.4. Post injury course

4.4.1. Trauma scoring systems in the elderly trauma population

The Injury Severity Score was developed in 1974 by Baker et.al. (2) from the Abbreviated Injury Scale to evaluate motor vehicle victims with multiple injuries. The Injurity Severity Score was used to compare the severity of injuries with an original study group of 2,128 victims; it was observed that the mortality increased with the AIS grade of the most severe injury (29).

The weakness of the ISS is that many different injury patterns can yield the same ISS score and injuries to the different body regions are not weighted (29). Also not asses long – term consequences and the age of the accident victim are not taking account in the Injury Severity Score.

As table 13 shows some ISS values or interval cohorts contain data on patients with heterogeneous injuries who have different survival and death prognoses and are poor for prediction and outcome

Injury Body region	Percent Mortality
Head and Neck	17,0
Face	0
Thorax	6.1
Abdomen	10.5.
Extremities	0

Table 13: Mortality rates for patients subgroups of AIS = 4 and ISS = 16 cohorts (11)

Various authors have been examined trauma scoring systems and their association with survival, assistance with patient triage and in predicting outcomes but none are specific for the elderly patients, especially for comparison in the elderly patient group (80).

Oreskovich and other (49) demonstrated that ISS did not accurately predict mortality. He and his colleagues found that mean ISS in a group of 100 people over 70 years old between survivors and nonsurvivors were 19 versus 17, where as an ISS of 19 would have predicted mortality rate of 3 %. These contradictory data are best described by the small number of nonsurviving patients in Oreskovich studies.

A Belgian study of 126 multiple injured patients over 65 years old and older found no significant difference in age or ISS between survivor and nonsurvivors although they found the Glasgow come Scale as a many other authors as a good predictor of survival and functional recovery (7)).

The failure of ISS score was primarily based on anatomical than on physical grounds. There is limited research for the Revised Trauma Score a physiological score which is based of the GCS, the systolic blood pressure and the respiratory system. Van Alst et al (72) found that the RTS as a simplified physiological tool is reliable predictor of mortality.

Another score is the TRISS Score which combines the revised trauma score, age of the patient and the injury severity score and the mechanism of injury. Despite the RTS van Alst (72) found also the TRISS methology predictive of survival. A prospective British study found the TRISS methology to show correlation with the probability of survival except for elderly people with single orthopedic injuries in which there were major differences between observed and expected outcome (74).
Another British study confirmed TRISS methology score for elderly people and suggested that the ISS / age is more reliable (9).

In contrast other authors have shown that the ISS correlates well with mortality. Finelli et al (23) reviewed cover 46 000 patients entered in the Multiple Trauma Outcome Study and confirmed the original work with Baker et al (2) in which persons older than 50 years had a higher mortality rate than younger patients for any given level of ISS. Bull (1975) (10) found an age-dependent relationship and determined that the lethal dose for 50 % patients was an ISS of 40 for ages 15-44, 29 for age 45-64 and 20 for ages 65 and older.

In our studies, mortality was as well strongly associated with Injury Severity Score. The mortality rate for patients with ISS > 30 was 80.0 % compared with 9.3% in patients with ISS ≤ 15. In the current series 63% of patients with severe injuries (ISS>15) and 25 % of patients with critical injuries ISS > 30 did not meet the hypotension or tachycardia criteria for TTA. Secondly, due to the lack of significant physiological reserves, elderly patients decompensate easily and often without warning, even with minor injuries. In the present study the overall mortality in patients with ISS ≤ 15 was 9.3%.

The introduction of age ≥ 70 years as a criterion for TTA resulted in a major reduction of mortality. The group of patients with no conventional TTA criteria benefited the most by the new policy. The overall mortality rate was reduced from 47% to 25.0% after age ≥ 70 years became a TTA criterion. In

patients with ISS >20 and no traditional physiological TTA criteria the mortality reduced from 68.4 % to 46, 9 %.

4.4.2. Therapy and socioeconomic impact

Studies demonstrated that geriatric patients have a longer hospital and intensive care unit stay and mortality rate than younger trauma patients (30, 11). The longer ICU and hospital stay cause an increase cost among the geriatric trauma group and the main emphasis will be on the growing population of the elderly. As Mc Kenzie (42) reports in his study with 25 % of hospital costs for trauma are caused by 12 % of the American population over 65 years old. A similar Swedish study of Sjorgen in 1991 (67) reported that those over 60 years of age which are almost 16 % of the population consume 42 % of the resources for trauma care.

Table 15 shows the comparison of hospital and ICU length and hospital costs with other studies but results are contrary.

Our outcome of patients	2000	ISS ≥ 15	
	Age	Before ≥70 age becomes a TTA criterion	After ≥70 becomes a TTA criterion
	Number	260	76
Mean length of ICU stay (days)			
ISS > 15		5.2	4.5
Subgroups with ISS > 20		4.9	3.5
Mean length of Hospital stay (days)			
ISS > 15		10.2	10.7
ISS > 20		9.6	9.1
Mean length of Hospital charges in (thousand)			
ISS > 15		49. 644	64. 249
ISS > 20		45.745	53.327

Young et al (81)	1998		
	Age	18-64	≥65
Mean length of ICU stay (days)			
ISS 16-25 (n)		8.19 (118)	8.55 (29)
ISS > 25		9.6 (132)	11.4(25)
Mean length of Hospital stay (days)			
ISS 16-25		14.1	10.8
ISS 16-25		18.2	18.4
Hospital cost (US $)			
ISS 16-25		25.154	15.914
ISS > 25		36.811	30.445

Covington et al (13)	1993				
	Age	15-64	65-74	75-84	≥85
	Number	15776	1222	1110	476
Mean length of ICU stay (days)					
ISS 16-24		6.6	12.9	13.3.	9.6
25+		12.4.	15.0	10.2	10.1
Mean length of Hospital stay (days)					
ISS 16-24		14.9	20.2	21.3	16.8
25+		26.8	22.1	20.0	19.4
Hospital charges in (thousand)					
ISS 16-24		21.1	30.2	28.5	18.4
25+		41.6	36.9	29.6	27.2

Table 14: Comparison of hospital and ICU length and hospital costs with other studies but results are contrary

Young et al (81) compared 159 trauma patients over 65 with 828 patients with 18 to 64 years of age. The results were further grouped by Injury Severity score with similar results among the length of hospital and intensive care units stays among the younger and elderly group. Young (81) even demonstrated a lower per capita cost of hospital care even for high ISS for the elderly with a higher reimbursement than for younger trauma victims. He explained his results that 50 % of the patients older than 80 years with multiple injuries their family requested withdrawal of support before a terminal stage of care had been reached, reducing costs. Secondly 98 % of elderly patients had some form of insurance, mostly Medicare which covered 81 % of the reimbursement of the elderly as opposed to 72 % of younger patients.

Other studies dispute these findings and have documented the high cost of trauma among the elderly and not enough rates of reimbursement (17, 58, 84).
De Maria et al (17) reported that DRG reimbursement especially for trauma patients over 65 years old showed no correlation between hospital costs and reimbursement and severely injured patient over 80 years old with complications.

As shown in Table 15 Covington controlled the groups for ISS and found with exception of the ISS > 25 as severe injury the elderly had higher mean hospital charges and longer mean ICU and hospital length of stay as the younger group. An explanation for the high mean hospital charge is the prolonged stay in acute care facilities. Long-term beds, for e.g. nursing home and rehabilitation facility beds were not available in 28 % of the elderly trauma patients.

In our study the duration of ICU and hospital stay was similar in the two groups of aged 70 and more with an ISS outcome above 15 and 20. Although there was a trend toward higher hospital charge after age 70 years old became a TTA criterion
More than 20 % of the American population will be older than 65 years of age by the year of 2040 (45).Trauma is the fifth most common death in the elderly people over 65 and the elderly trauma patient becomes a significant public health issue regarding the inadequacy of trauma care reimbursement with overwhelming the financial resources of trauma centres. A consequence of reviewing the literature is that specific comparison of ICU costs and charges are not developed in controlled studies. Table 15 shows the lack of comparison between studies classifying age. Our population group ≥70, Young et al with age ≥65 versus 3 subgroups of old age in Covington studies

4.4.3. Functional outcome

The long term outcome in geriatric patients who survive their injuries has been studied and results are extremely variable. Oreskovich et al 1984 (49) reported in which 85 % of the elderly trauma victims survived but only 8 % returned to home In direct contrast DeMaria et al (17) showed that 89 % of patients returned home and fully 57 % were fully independent.

Van Aalst et al (72) showed that factors influencing function and independence following severe injuries in the geriatric patient were shock on admission the presence of severe head injury age greater 75 years and the development of infectious complications were all found to be poor outcome factors. The results of van Aalst (72) supported that of De Maria (17) and showed that the majority of survivors of severe injury 67 returned to a level of independence.

In our study the incidence of permanent disability in survivors was 12.0 percent in group 2 when age 70 years was an absolute TTA criteria and liberal use of non-invasive cardiac output, early intubation of the patient in the emergency before going to the radiology department, and insertion of a Swan Ganz catheter and 16,7 per cent in group 1.

Oreskovich et al (1984) used a population with patient over equal 70 years old with multiple injuries, De Maria et al (17) used patient over equal 65 years with blunt trauma excluding penetrating injury, burns and isolated orthopaedic injury. Van Aalst et al (72) patient over 65 years and with an Injury Severity Score over equal 16 with blunt trauma and our study patient over equal 70 <years with an Injury Severity Score greater than 15. In all of these studies variability in the measures of functional outcome makes comparison somewhat difficult.

4.5. Future Directions further studies

At present literature associated to elderly trauma patient is limited and further research is required.

- Research into the molecular basis of stress response to injury and management of trauma and critical illness of elderly trauma patient
- Development of a special scoring system for elderly trauma patients
- Greater focus on functional outcome studies after injury to uncover those factors that predict a poor functional result
- Further evaluation and outcome studies of old age as a trauma team activation criteria
- Injury preventation is a significant advance in reducing the morbidity and death in the elderly

5. SUMMARY

In a previous study from the Los Angeles County hospital we reported that during a 7,5-year period 883 trauma patients meeting trauma centre criteria and ≥70 years of age were admitted to the centre. Overall 223 patients (25 %) met at least one of the standard TTA criteria. The mortality in this group was 50 %, the ICU admission rate was 39 % and a non-orthopaedic operation was required in 35 %. The remaining 660 patients (75%) did not meet any TTA criteria. The mortality was 16% the need for ICU admission was 24 % and non –orthopaedic operations were required in 19 %.

63 % of geriatric trauma patients with ISS >15 and 25 % of patients with ISS >30 did not have any of the the standard hemodynamic criteria for TTA.

In the second study there were 336 patients ≥ 70 years old with Injury Severity Score > 15. There were 260 in group 1 and 76 in group 2. The two groups were similar with regard to mechanism of injury, age gender ISS and body area AIS. The mortality in group 1 was 53.8 % and in group 2 was 34.2 % (Chi Square Test, p=0.003). The incidence of permanent disability in the two groups was 16.7 % and 12.0% respectively (p=0.01).

In the subgroups of patients with ISS > 20 the mortality was 68.4 % and 46.9 % respectively (p=0,01) and the incidence of permanent disability in the two groups was 24.5 % and 7.75 % respectively (p=0.01).

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7. LEBENSLAUF

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8. ABSTRACT

Aus der Klinik für Unfall - und Handchirurgie

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Direktor: Univ. - Prof. Dr. med. Joachim Windolf

Geriatrische Polytraumatologie

Einführung des Alters ≥ 70 Jahre als Kriterium für eine Trauma Team Aktivierung und die Auswirkung des frühzeitigen Intensivmanagements unter besonderer Berücksichtigung der Verletzungsschwere nach der Injury Severity Score

vorgelegt als Dissertation 2009 von Daphnie Averkiou

ABSTRACT

Ziel der vorliegenden Untersuchungen war es die Frage zu klären, ob das Alter ≥ 70 Jahre ein gültiges Kriterium für die Aktivierung des Trauma Teams ist. Darüber hinaus galt es zu klären, ob es eine Korrelation zwischen der Verletzungsschwere bei Patienten ≥ 70 Jahre gibt, die nicht die sonstigen physiologischen Parameter für die Aktivierung des Trauma Teams zeigen.

Im Zeitraum von 7,5 Jahren erfüllten 883 Polytraumapatienten die Trauma Team Aktivierungskriterien und waren ≥ 70 Jahre alt. Somit konnten diese Patienten in das Los Angeles Tauma Krankenhaus aufgenommen werden. 223 (25 %) der Polytraumaverletzten haben mindestens ein Trauma Team Aktivierungskriterium erfüllt. Die Mortalität in dieser Gruppe betrug 50 %, die Intensivstationsaufnahmen waren 39% und Operationen waren bei 35% der Fälle erforderlich. Die verbleibenden 660 Patienten (75 %) erfüllten nicht mindestens eines der Standard Trauma Team Aktivierungskriterien. Die Mortalität in dieser Gruppe lag bei 16%.

Eine Intensivaufnahme war in 24 % der Fälle erforderlich und Operationen bei 19 % der Verletzten notwendig. 63 % der geriatrischen Patienten mit einer Injury Severity Score >15 und 25% der Verletzten mit einer Injury Severity Score > 30 hatten nicht mindestens eines der hämodynamischen Kriterien für die Trauma Team Aktivierungskriterien.

In einer zweiten Studie hatten 336 Patienten, mit einem Alter von ≥ 70 Jahren, einen Injury Severity Score von >15. Dazu wurden 2 Gruppen gebildet. Gruppe 1 umfasste die Patienten bei dessen Alter ≥ 70 Jahre noch nicht als Trauma Team Aktivierungskriterium berücksichtigt wurde. Die Einführung des Alters ≥ 70 Jahre, als Trauma Team Aktivierungskriterium in Gruppe 2, zeigt einen deutlichen Rückgang der Mortalität. Die Mortalitätsrate reduzierte sich von 53,8 % auf 34,2 %. Bei den Patienten mit einer Injury Severity Score von > 20, einem Alter von ≥ 70 Jahre und ohne eines der physiologischen Standard Kriterien für die Trauma Team Aktivierungskriterien, reduzierte sich die Mortalität von 68,4 % auf 46,9%. Die Studie demonstriert eine Verbesserung des Outcomes bei älteren Polytraumapatienten und wird als permanentes Trauma Team Aktivierungskriterium eingesetzt.

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