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New Paradigms in Trauma Care
an analysis of a trauma centre registry

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To my mother

Para a minha mãe

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Summary

Rational

Trauma is a leading cause of burden worldwide namely in young and healthy people. Portugal, mainly in relation to the road traffic collision number, has a particular problem. Despite its epidemiologic relevance there is a lack of data to allow a reliable characterization of the problem, namely in terms of severity and outcome. When addressing the care of trauma patients there are current paradigms like the *trimodal mortality* and the *golden hour*, that are not only linked but are also the basis for the design of most of the trauma systems in the world. However the controversy about the best model for the care of trauma patients in the pre-hospital environment goes on with the scoop and run model (also known as BLS and based on the described paradigms) competing with the stay and play model (also known as ALS). It has been emphasised that to find benefit with ALS in pre-hospital one must find the specific trauma population that will maximise and profit from ALS.

Aims

The aims of this thesis are to discuss the *trimodal mortality* and the *golden hour* current concepts and to raise new paradigms in the sense of original and innovative perspectives and implications for the care of trauma patients.

Research questions

The thesis addresses 5 research questions.

1 Is the *trimodal mortality* pattern applicable in a Portuguese Trauma System?
2 Is time to definitive treatment at trauma centre an independent factor contributing to mortality?

3 Does the early treatment of life threatening events have implications for trauma mortality?

4 Does rurality have implications on trauma patient's outcome?

5 Does the early treatment of life threatening events have negative implications on disability and quality of life of trauma survivors?

Methods

This study is based geographically and operationally in the HGSA trauma system involving a catchment area of about 2 million habitants in the north of Portugal. The study that is the basis for this thesis was developed since 2001 in three different and continuous phases. First, in 2001, a trauma registry was developed in HGSA, the trauma centre for severe trauma patients in the trauma system. Then a population based study was performed in all the trauma system area to study only trauma deaths. The trauma registry includes patient, pre-hospital, first hospital and trauma centre variables. Severity coding was done using TRISS methodology. Finally in 2003 the follow-up clinic was built and the trauma patient disability and quality of life assessment started. The studied exposure and outcomes were: place of treatment of life threatening events, time to trauma centre, rurality, mortality (in-hospital and after discharge), disability and quality of life at 6 months.

Main findings and the new paradigms:

1 Mortality distribution in our trauma system has a Tetramodal pattern.

2 A Golden Approach – treating life threatening events prior to transfer to trauma centre – is more important to decrease mortality than a *golden hour*.

3 Treating life threatening events early in the pre-hospital setting (pre-hospital ALS) decreased the mortality of severe trauma patients transferred to the trauma centre (mainly from rural areas) but had no measurable effect on disability or quality of life of trauma survivors.

4 ALS in the pre-hospital setting did not have a measurable benefit in mortality, disability or the quality of life of severe trauma patients directly admitted to the trauma centre.

5 Trauma related disabilities and compromises in quality of life are still important at 6 months after injury.

Main recommendations:

1 Special attention should be paid to prevention. To decrease deaths at the incident scene injury prevention initiatives are the most important ones as deaths happening at the scene are inevitable.

2 The development of an effective trauma system and EMS is paramount. To reduce the second peak of death there must be continuous and articulated effort to support key issues in the chain of treatment, namely: the development of pre-hospital EMS and in-hospital emergency care; the development of trauma teams and trauma education in general; efforts on trauma system development to improve initial stabilization and expedite pathways of transfer to definitive care.

3 Special attention should be drawn to ICU availability and treatment of severe head injury. Concerning the 2 days peak of mortality, ICU treatment is of paramount importance because mortality is increased due to severe head injury and aging of the population. In the last decades we observed enormous advances in resuscitation strategies, acceptance of *damage control* and improvement in diagnostic technology. Now we must put more effort into researching the optimal management of head injuries and old patients in the ICU environment. That recommendation is also important to deal with the latest 2 weeks peak of mortality (12%), important to prevent infection and multiple organ dysfunctions.

4 The pre-hospital design of trauma systems and EMS should keep the ALS medically based team mainly in areas to whom the trauma centre is a long distance or more than one hour away. The pre-hospital presence of an ALS team that is able to deal with life threatening events improves transferred patient mortality even if this prolongs time spent to reach the trauma centre.

It is paramount to establish patient, family and society awareness about the burden of trauma. Rehabilitation strategies that link the other elements of the trauma system would be essential to close the loop of care for trauma patients along with a well designed system to facilitate a social, familiar and employment (when applicable) integration in society.

6 The recommendations described above are impossible to accomplish without the development of a national trauma registry.

Resumo

Introdução

O trauma é uma causa importante de morte, incapacidade e diminuição da qualidade de vida em todo o mundo. Em Portugal este cenário é ainda mais grave tendo em conta uma sinistralidade e uma taxa de mortalidade imputada ao trauma das maiores da Europa. Apesar desta realidade, em Portugal pouco se sabe acerca da gravidade e resultado em termos de mortalidade ou incapacidades resultantes do trauma. Não há, do nosso conhecimento, registos prospectivos de trauma a nível nacional, condição essencial para avaliar e caracterizar o problema, procurando respostas e avaliando resultados. Quando falamos no desenho de sistemas de trauma há que ter em consideração conceitos como o da *mortalidade trimodal* e o da *hora de ouro*. Estes conceitos são o suporte para a organização dos sistemas de trauma em todo o mundo e, apesar de nem todos estarem de acordo com eles, tem sido difícil refutá-los. Estes conceitos estão ligados ao modelo de tratamento dos traumatizados no pre-hospitalar designado por *scoop and run* ou BLS. Na Europa, e também em Portugal, os sistemas de trauma estão geralmente baseados na presença de médicos e enfermeiros no pré-hospitalar (ALS) defendendo a estabilização clínica no local *stay and play* antes do transporte ao hospital. O debate ALS *vs.* BLS no pre-hospitalar está longe de finalizado, não tendo até agora os estudos permitido afirmar uma vantagem definitiva do ALS na mortalidade ou morbilidade. Com alguma probabilidade para diferentes realidades e para diferentes doentes a resposta poderá variar.

Objectivos

Os objectivos desta dissertação são discutir os actuais conceitos da *distribuição trimodal* e da *hora de ouro* lançando novos e originais pradigmas que melhor respondam à questão: qual será o melhor modelo de sistema de trauma.

Questões a investigar

Para cumprir os objectivos foram levantadas 5 questões:

1 Será a mortalidade trimodal aplicável ao nosso sistema de trauma?

2 Será o tempo que o doente demora desde o acidente até ao centro de trauma um determinante da mortalidade?

3 Terá o tratamento precoce de situações que ameaçam a vida um impacto positivo na mortalidade ?

4 Será a ruralidade um factor independente do resultado do trauma?

5 Terá o tratamento precoce de situações que ameaçam a vida um impacto negativo na incapacidade e qualidade de vida dos sobreviventes?

Metodologia

Este estudo recruta doentes do sistema de trauma em que o HGSA é o hospital de referência para politraumatizados graves, representando uma área geográfica com cerca de dois milhões de habitantes. Este estudo foi iniciado em 2001 com a construção e lançamento do registo prospectivo de trauma do HGSA. Em 2006 foi feito o estudo populacional de mortalidade em trauma. O registo inclui dados relativos ao doente, ao pré-hospitalar, ao primeiro hospital e ao HGSA. A metodologia TRISS foi usada para codificação e estratificação da gravidade. Em 2003 foi iniciada a consulta de *follow-up* desenhada para fazer o seguimento dos sobreviventes aos 6 meses após o acidente. Estudámos como medidas de resultado o local de correcção dos eventos que ameaçaram a vida, o tempo desde o acidente até ao HGSA, a ruralidade e ainda a mortalidade e a morbilidade (incapacidades e qualidade de vida).

Resultados principais e os novos paradigmas

1 No sistema de trauma descrito a mortalidade tem uma distribuição tetramodal.

2 Tratar os eventos que ameaçam a vida antes da chegada ao centro de trauma - *golden approach* - tem um impacto positivo na mortalidade, superior ao de encurtar o tempo que decorre desde o acidente até á chegada ao HGSA.

3 Tratar os eventos que ameaçam a vida no pré-hospitalar (ALS no pre-hospitalar) diminui a mortalidade dos doentes transferidos para o centro de trauma mas não tem impacto mensurável na incapacidade ou qualidade de vida dos sobreviventes.

4 O ALS no pre-hospitalar não diminui a mortalidade dos doentes admitidos directamente ao centro de trauma nem tem impacto na incapacidade ou qualidade de vida dos sobreviventes.

5 Seis meses após o acidente os traumatizados graves têm ainda incapacidades relevantes que lhes reduzem a qualidade de vida.

Recomendações

1 A prevenção deve ser o fulcro de qualquer sistema de trauma. Continuamos, apesar de toda a evolução em termos de tratamento, a observar que mais de metade da mortalidade ocorre no local do acidente e só a prevenção pode impedí-la.

2 O desenvolvimento dos sistemas de trauma passa também pelo pré-hospitalar e pelas salas de emergência dos hospitais pois é aí que nas primeiras horas se verifica o segundo pico da mortalidade. O desenvolvimento de equipas de trauma no pré-hospitalar e nos vários hospitais que abordam e tratam doentes traumatizados é fundamental para que haja uma metodologia comum nesta abordagem.

3 Uma especial atenção deve ser colocada na disponibilidade e tratamento em Cuidados Intensivos. É precisamente nos Cuidados Intensivos que se verifica o terceiro pico da mortalidade correspondendo predominantemente a doentes com traumatismo crâneo-encefálico grave e mais idosos. Um maior investimento no tratamento em âmbiente de Cuidados Intensivos não só poderá permitir a redução do terceiro pico da mortalidade mas também do quarto pico mais tardio.

4 O desenho dos sistemas de trauma deverá manter os cuidados de suporte avançado de vida (ALS) no pré-hospitalar principalmente se a distância ao centro de trauma for grande, levando a que o tempo de chegada seja superior a uma hora (predominantemente trauma proveniente de áreas rurais).

5 É fundamental o investimento na reabilitação dos sobreviventes de trauma permitindo-lhes a recuperação máxima e o retorno ao emprego, à sociedade e ao laser.

6 As recomendações descritas nos pontos anteriores são difíceis, senão impossiveis, de cumprir se não se implementar um registo nacional de trauma.

List of Publications

Core Papers

The four papers shown bellow are the core structure of this thesis. These papers will be referred in the text, like other references, by authors name and date and will also be listed in the references. These texts are available in the Addenda, which previous reading would allow to the reader an easier understanding of this thesis. Publications will be listed in this section in chronological order.

Gomes E, Araújo R, Carneiro A, Dias C, Lecky F, Costa-Pereira A. **Mortality distribution in a trauma system: from data to health policy recommendations**. *European Journal of Trauma and Emergency Surgery* 2008;34:561-9. (Addenda 1) (original article – 2008a)

Gomes E, Araújo R, Carneiro A, Dias C, Costa-Pereira A, Lecky F. **The importance of pre-trauma centre treatment of life-threatening events on the mortality of patients transferred with severe trauma**. *Resuscitation 2010. In press.* (Addenda 2) (original article – 2010a)

Gomes E, Moreira D, Chaló D, Dias C, Neutel E, Aragão I, Costa-Pereira A. **O doente politraumatizado grave: implicações da ruralidade na mortalidade, incapacidade e qualidade de vida.** *Acta Médica Portuguesa 2010. In press.* (Addenda 3) (original article – 2010b)

Gomes E, Dias C, Araújo R, Costa-Pereira A, Lecky F. **Survival and quality of life after severe trauma and its relationship to different pre-trauma centre approaches: ALS versus BLS revisited** (submitted)

Other Related Papers and Abstracts

During the three years of the duration of this thesis I was also an author of other papers or presentations concerning the same subject – trauma outcome. Most of the abstracts and papers used the same trauma registry or follow-up registry that is described in this thesis. Those papers and abstract are not part of the thesis core structure but will be listed here and when referred in the text it will be by authors name and date. Publications will be listed in this section in chronological order.

Gomes E, Dias C, Araújo R, Carneiro A, Costa-Pereira A. **Trauma system deaths: are we far from the "trimodal distribution**"?. *Int Care Med*, 2006. Vol. 32 (S1); P91(Abstract – 2006a)

Gomes E, Neutel E, Cardoso T, et al. **Posttraumatic Stress Disorder without memories in trauma patients**. *Resuscitation*, 2006 ; Vol.69 (1) : O-72. (Abstract)

Gomes E, Neutel E, Cardoso T, et al. **Trauma severity and quality of life in survivors of severe trauma**. *Resuscitation*, 2006 ; Vol.69 (1) : O-73. (Abstract – 2006b)

Santos R, Gomes E, Neutel E, et al. **Mortality and quality of life after penetrating trauma**. *Resuscitation*, 2006 ; Vol.69(1): P55. (Abstract – 2006c)

Fernades C, Machado C, Gomes E, et al. **Healthcare givers are optimistic about the quality of life of severe trauma patients.** *Resuscitation*, 2006 ; Vol.69 (1) : P-142. (Abstract)

Gomes E, Neutel E, Dias C, Carneiro A. **Early and Late outcome determinants in severe head trauma**. *Int Care Med*, 2006. Vol 32 (S1); P88. (Abstract – 2006d)

Thies K, Gwinnutt C, Driscoll P, Carneiro A, Gomes E, Araújo R, Cassar MR, Davis M. **The European Trauma Course - from concept to course**. *Resuscitation.* 2007 Jul;74(1):135-41 (original article – 2007a)

Edwards A, Di Bartolomeo S, Chieregato A, et al. **A comparison of European Trauma Registries. The first report from the EuroTARN Group**. *Resuscitation* 2007;75(2):286-97. (original article – 2007b)

Gomes E, Araujo R, Dias C at al. **Severe head trauma patients need more intensive care than a golden hour: mortality distribution in a trauma system**. *Int Care Med*, 2007, vol33 (S2), P39. (Abstract – 2007c)

Gomes E, Araujo R, Dias C at al. **ARDS is not a determinant of quality of life of severe polytrauma with thoracic trauma**. *Int Care Med*, 2007, vol 33 (suppl 2), S212. (Abstract – 2007d)

Kjetil R, Coats TJ, Lefering R, Di Bartolomeo S, Steen P, Røise O, Handolin L, Lossius H and Utstein TCD expert panel. **The Utstein template for uniform reporting of data following major trauma: A joint revision by SCANTEM, TARN, DGU-TR and RITG**. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine* 2008, 16:7. (original article – 2008b)

Alves LS, Gomes E, Dias C et al. **Caracterização dos traumatizados dentários e maxilo-faciais por acidentes de viação e trabalho – da epidemiologia aos resultados.** *Revista Portuguesa de Estomatologia, Medicina Dentária e Cirurgia Maxilofacial* 2008; 29(4): 197-204. (original article)

Graça A, Santos P, Fontes S, Cardoso T, Carneiro A, Neutel E, Gomes E. **Severe trauma, ICU, glycaemia and mortality.** *Int Care Med*, 2008. 34 (suppl 1); S149. (Abstract)

Antunes R, Santos M, Graça A, Gomes E, Cardoso T, Neutel E, Carneiro A. **RIFLE criteria in criticaly ill injured patients – is there a predictive ability?**. *Int Care Med*, 2008: 34 (suppl 1) ; S198. (Abstract)

Santos M, Antunes R, Graça A, Gomes E, Cardoso T, Carneiro A, Neutel E. **Significance and implications of Tropinin I elevation in critically ill trauma patients.** *Int Care Med*, 2008: 34 (suppl 1); S156. (Abstract)

Lott C, Araujo R, Cassar MR, Di Bartolomeo S, Driscoll P, Esposito I, Gomes E, Goode P, Gwinnutt C, Huepfl M, Lippert F, Nardi G, Robinson D, Roessler M, Davis M, Thies KC. **The European Trauma Course (ETC) and the team approach: Past, present and future**. *Resuscitation.* 2009 Jul 23. [Epub ahead of print]. (original article – 2009a)

Moreira D, Gomes E, Chaló D, Dias C, Neutel E, Aragão I. **Does rurality affect the outcome of trauma patients**?. *Int Care Med*, 2009: 35 (suppl 1); S66. (Abstract – 2009b)

Duarte R, Gomes E, Dias C, Neutel E, Aragão I. **Hypomagnesaemia in trauma patients**. *Int Care Med*, 2009: 35 (suppl 1); S251. (Abstract)

Gomes E, Antunes R, Dias C, Araújo R, Costa-Pereira A. **Acute kidney injury in severe trauma assessed by RIFLE criteria: a common feature that might not affect patient mortality**. *Scandinavian Journal of Trauma and Emergency Medicine* 2010, 18:1. Epub 5 January 2010 (original article – 2010d)

Research Projects

During part of the period of elaboration of this thesis, and after the publication of the first results, I actively participated together with my supervisor in a study that was submitted to the Fundação para a Ciência e Tecnologia (FCT) as a research project and approved for financial support. This project is entitled: *Trauma grave - implicações da mortalidade e morbilidade na prática clínica* [PIC/IC/83120/2007].

List of Abreviations

ABCDE	Airway, Breathing, Circulation, Disability, Exposure
AIS	Abbreviated Injury Scale
AIS 98	Abbreviated Injury Scale 1990, updated 1998
ALS	Advanced Life Support
BLS	Basic Life Support
ED	Emergency department
EMS	Emergency Medical Service
EQ-5D	Euroqol EQ-5D test
GA	Golden Approach
GCS	Glasgow Coma Scale
GOSE	Glasgow Outcome Scale Extended
HGSA	Hospital Geral de Santo António
HRQol	Health Related Quality of Life
ICU	Intensive care Unit
INE	Instituto Nacional de Estatística
ISS	Injury Severity Score
LOS	Length of Stay
RTS	Revised Trauma Score
TC	Trauma Centre
TRISS	Trauma and Injury Severity Score
WHO	World Health Organization

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I Introduction

The first chapter introduces the trauma burden and the rational behind the thesis namely the current concepts of trauma care (the *trimodal mortality* and the *golden hour*) and why they need to be discussed.

II Aims and research questions

The second chapter concerns the aims of the thesis and the research questions that were raised.

III Generic methods

The third chapter conveys the methodological issues that are common to this entire thesis. The trauma system and trauma centre that are the geographic and operational basis for this thesis are described in detail. The prospective trauma registry and severity methodology used are characterised. To close the loop of care the follow-up methodology is explained in detail. Finally outcomes are discussed.

IV Mortality in trauma – a population study

This chapter discusses the concept of the *trimodal mortality* pattern of deaths in trauma. New paradigm that rose is also outlined – a Tetramodal Pattern explains better the mortality in a modern trauma system. This chapter is based manly on one of the core papers [Gomes et al., 2008a].

V Mortality in trauma – a trauma centre based study

This chapter discusses the concept of the *golden hour* in trauma care. New paradigm that rose - a Golden Approach is more important to decrease mortality than a *golden hour* - is also outlined. This chapter is based manly on two of the core papers [Gomes et al., 2010a (in press)] [Gomes et al., 2010b (in press)].

VI Morbidity in trauma – a six months follow-up study

This chapter discusses the concept of the *golden hour* in trauma care regarding overall outcomes (mortality and patient centred outcomes). New paradigms that rose – A Golden Approach does not increase unfavourable patient centred outcomes – The choice of pre-hospital approach (ALS vs. BLS) for a trauma system should be careful and individualized – are also outlined. This chapter is based manly on two of the core papers [Gomes et al., 2010b (in press)] [Gomes et al., 2010c - submitted].

VII Discussion

In this chapter first common limitations are discussed and then a summary of the main findings is considered. In the end unanswered questions are outlined and the need for further research is reinforced.

VIII New paradigms and main recommendations

Finally, recommendations based on the new paradigms outlined in this thesis are provided. Recommendations refer to trauma patient care and design of trauma systems.

IX References

References are listed in alphabetic order.

X Addenda

In the addenda are depicted the trauma registry and follow-up registry along with the core papers of this thesis.

Introduction

GLOBAL BURDEN OF TRAUMA

Trauma is a cause of death and disability worldwide. According to the Global Burden of Disease Study, injuries are responsible for 5.1 million deaths and for 15.2% of Disability Adjusted Life Years lost [Krug, 2004; Murray and Lopez, 1997]. Road traffic collisions, work related injuries, self inflicted injuries and interpersonal violence are the major aetiological factors. Recent World Health Organization (WHO) publications identify trauma as the leading cause of death worldwide in people from 5 to 44 years of age. It is estimated that by the year 2020 trauma will be the 3rd commonest cause of death in the world [Krug et al., 2000]. According to the WHO more than 1.2 million people die just in road accidents every year and as many as 50 million people are injured or disabled. In 2002, road traffic accidents accounted for almost 23% of all deaths from injury [Dyer, 2004]. In Europe the problem is similar with trauma as the primary cause of death up to 44 years of age [Krug et al, 2002].

Trauma in Portugal

Portugal, with a population of about 10 million people, heads the list of European countries in terms of trauma incidence and mortality [WHO, 2005]. Trauma is one of the major causes of death and injury in Portugal. Road traffic accidents are the leading cause followed by work accidents, interpersonal violence and self-inflicted injuries. Data from the Portuguese Statistics National Department (INE) show that in the year 2004 the total number of road traffic accidents was 63.668 with 53.144 victims. These included 1.135 Fatalities, 4.190 seriously injured and 47.819 slightly injured. Portuguese in-hospital mortality by external cause from ICD-9 was related to trauma in 10.964 people [INE, 2004]. More detailed data, namely from hospital admissions are difficult to obtain in Portugal, making it difficult to achieve detailed figures.

Reports from the European Transport Safety Council show some good news. Portugal's level of road deaths has been dropping consistently in the last years to reach 124 deaths *per* 1.000.000 inhabitants but is still above the European Union average. Prevention programmes had an important role in the changes. Significant modifications to the 1994 Road Code, the main road traffic law in force in the country, were introduced in 2005. Among others, there has been an increase in sanctions for driving under a more restrictive level of blood alcohol and psychotropic drugs, excessive speed and infringements of the use of seatbelts or child restrain systems. In 2002, Portugal has adopted its first National Road Safety Plan. The Plan comprises a set of measures that concern either the strategic level (continuous education of road users; a safe road environment; legal framework and enforcement) or the operational level. The European Transport Safety Council reports from Portugal that from 1990 to 2005, the number of injury accidents was reduced by 18%, whereby the number of serious injuries was reduced by 69% and the number of deaths by 53% [TSC, 2006].

To our knowledge there are no prospective trauma registries in Portugal apart from the one that is the basis for this thesis. For that reason the knowledge of the epidemiology, severity and outcome of trauma patients in Portugal is scarce.

The Loop of Care for the Care of Trauma Patients

In trauma care, as in other diseases, the final result depends on several and different elements or actions derived from the structure of care it self or from the process of care. The basic structure for the care of the trauma patient is the trauma system. A trauma system is an organized, coordinated system for the provision of care to all injured patients in a defined geographic area. The elements of a trauma system are usually: access to care, pre-hospital care, hospital care including operating room and Intensive Care Unit (ICU) care and rehabilitation facilities. The essential elements of regionalized trauma care include the classification of all hospitals in the region according to the level of trauma care they can provide and the designation of tertiary (level I) as the hospitals where patients with major trauma should be treated [Sampalis et al., 1999]. It has been reported that an organised trauma system has a significant impact with regard to trauma mortality reduction [Celso et al., 2006; Demetriades et al., 2005; MacKenzie et al., 2006; Nathens et al., 2001]. A well performed chain of survival is crucial for these patients starting at the incident scene (pre-hospital) and continuing to the place of definitive treatment at the trauma centre, followed by rehabilitation so that the patient can return to work and social activities. The European Section of the WHO pointed out that high-quality trauma care can decrease the mortality rate by as much as 30% [WHO, 2005]. Effective medical care processes typically embody a feedback loop, in which care providers continually assess patient condition and take action to improve it.

Pre-hospital Care Controversy

Most trauma victims gain access to the health care system through the Emergency Medical System (EMS). The role of the EMS is more complex than just simply transporting a trauma victim to a medical facility. In pre-hospital care there are two conflicting strategies that can be applied to a trauma victim: *rapid transportation* versus *field stabilization* [Border et al., 1983].

In *rapid transportation* the victim is moved as fast as possible to a trauma centre and minimal time is spent in pre-hospital care. The concept behind it is the *golden hour* concept that will be discussed later. In the medical literature synonyms for *rapid transportation* are *scoop and run* and Basic Life Support (BLS). BLS is a level of care that provides non invasive emergency care. The goal of BLS is to transport the patient to definitive trauma care as soon as possible. It includes the provision of basic airway management (e.g. clearing and keeping the airway open with basic manoeuvres), and control of external haemorrhage. BLS is less costly because it requires limited equipment and training.

In *field stabilization* strategy, patient is stabilized prior to transport, including the identification and treatment of life threatening situations. Synonymous for *field stabilization* are also Advanced Life Support (ALS) and *stay and play*. This approach results in slower access times to hospital care. ALS involves the possibility of invasive procedures. In contrast to BLS systems, ALS provides advanced therapy to the patient at the scene, rather than waiting until arrival at a hospital including more sophisticated airway management (e.g., endotracheal intubation), cardiac monitoring and defibrillation, interventions to correct pneumothorax, haemothorax and cardiac tamponade and administration of medications between others. ALS is relatively expensive to maintain and requires considerable training of medic or paramedic staff [Messick et al., 1992].

However words like scoop, run and play are misleading even if there is intent to simplify complex issues with current language. All efforts should be made to talk about the level of care, knowledge and skills and most important the actions that are needed in trauma situations. The skills cannot be attributed to a specific profession (nurses, doctor or paramedics) because the skills of nurses, doctors and paramedics are not the same in every country. From this point on in this thesis ALS and BLS will be the key words for identifying these different strategies.

The choice of the optimal pre-hospital model for the care of the trauma patient causes continuing disagreement between experts, despite endless discussions and analyses in the literature. Several studies advocated the positive relationship between ALS and mortality in the pre-hospital environment [Abbott et al., 1998; Baxt and Moody, 1987; Bunn, 2001; Celli et al., 1997; Liberman et al., 2000]. Other studies are in favour of the BLS model in pre-hospital [Ivatury et al., 1987; Potter et al., 1988; Sampalis et al., 1993; Sampalis et al., 1997; Stiell et al., 2008]. This issue will be further discussed below.

The "golden hour" Concept

The *golden hour* concept says that if you act properly and soon enough, in the first hour following trauma, then the patient has better chances of survival. Although not *a given*, this concept has been understood as synonymous with rapid transportation to definitive care in the level I trauma centre. This concept comes from United States of America wartime experience mainly in the Vietnam War. Although there is no clear supporting evidence [Lerner and Moscati, 2001], this concept is key in the genesis of all the modern emergency systems that deal with trauma patients worldwide [Blow et al., 1999; McNicholl, 1994; Osterwalder, 2002; Tallon, 2002]. In Europe there has been traditionally some resistance to adopt the *golden hour* concept and most EMS are physician based with ALS performed in the pre-hospital environment. This is also the case of Portugal.

The Concept of "Trimodal Mortality"

Another concept linked to that of the *golden hour* is the *trimodal mortality* pattern of deaths associated with trauma. This concept is based upon a frequently quoted paper, in which Trunkey described trauma deaths in San Francisco over a two year period [Trunkey, 1983]. This data is more than two decades old and comes from a country where the causes of trauma and the system for dealing with it differ from Europe namely Portugal. In this *trimodal distribution* trauma mortality can be classically grouped into three peaks: immediate, early, and late deaths [Baker et al., 1980]. The first peak of death occurs at the time of the injury. It may be instantaneous or within the first few minutes and is due to overwhelming primary injury to major organs or structures such as brain, heart or great vessels. Prevention is the only tool that can be used to reduce the incidence of these injuries. The second peak lasts from the end of this first period to several hours after the injury has taken place. It is during this time that many causes of morbidity and mortality are preventable by avoidance of a secondary injury due to hypoxia, haemorrhage or any process that leads to inadequate tissue perfusion and oxygenation. Most trauma care is focused to this period using a systematic and skilled assessment and treatment ai-ming to reduce mortality and disability. This is the classically defined *golden hour*. The third peak of death occurs days or weeks after the injury and is usually associated with sepsis and multiple organ failure. Recently in the United States this concept has been challenged. Demetriades and co-wor-kers described a non trimodal distribution of trauma deaths in Los Angeles County [Demetriades et al., 2005; McGwin et al., 2009]. In Europe there are some data contradicting the *trimodal distribution* of trauma mortality [Di Bartolomeo et al., 2008; Wyatt et al., 1996]. The review of the literature addressing this subject led to one of the aims of this thesis.

Patient centred Outcomes - Closing the loop of care

Mortality is the worst consequence of any disease namely trauma. Additionally, for each death from trauma many more injuries cause hospitalization, often with permanent disability. As technology improves, more people who suffer severe injury survive and even the less severe forms of trauma can result in significant problems that may persist, or even arise only after the trauma. To characterize the total burden of trauma the effects of nonfatal injuries should therefore be added [Krug et al., 2000]. The literature shows that a substantial number of severely injured patients suffer from long term disabilities that have implications for the return to work and social activities [Holbrook et al., 1998; Holbrook et al., 1999; MacKenzie et al., 1998; Patel et al., 2005; Vles et al., 2005]. Even patients that appear physically recovered, may have problems reintegrating into family, work, or school that can become apparent afterwards contributing to a decrease in the quality of life [Dijkers, 2004].

Health as defined by WHO is a *state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.* More recently, the concept has been extended to include health-related quality of life. The definition of quality of life linked to health is the perception by individuals of their position in life, in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns.

This wide-ranging and patient centred concept is affected not only by physical health but also by people's social relationships, psychological state and level of independence, and by their relationship to salient features of their environment. Often, trauma patients receive excellent acute care, but then are lost to rehabilitation. The loop of care must be closed. A significant number of these patients can achieve good function, but will require continuous and possibly life long access to various components of an interdisciplinary rehabilitation team. This ensures maximized quality of life, and is one of the most efficient and cost-effective solutions in the long run. This process should start at the initial contact with the patient and family. It should involve close collaboration between the family, patient, emergency physician, intensivist, surgeons, psychiatrists, rehabilitation medicine and facilities, the workplace and community groups [Dowdy et al., 2005; Hibbard et al., 2002].

Aims and Research Questions

The aims of this thesis are to discuss and challenge the *trimodal mortality* and the *golden hour* concepts and to raise new paradigms in the sense of original and innovative perspectives and implications for the care of trauma patients.

The thesis addresses 5 research questions:

Question 1

Is the *trimodal mortality* pattern applicable in a Portuguese Trauma System?

Question 2

Is time to definitive treatment at trauma centre an independent factor contributing to mortality?

Question 3

Does the early treatment of life threatening events have implications for trauma mortality?

Question 4

Does rurality have implications on trauma patient's outcome?

Question 5

Does the early treatment of life threatening events have negative implications for trauma disability and quality of life of trauma survivors?

Generic Methodology

Conceptual Framework

In this chapter the common methods behind all the core papers are described in detail. In each of the next threee chapters the respective methods section has specific and detailed explanations. The study that is the basis for this thesis was developed since 2001 in three different and continuous phases. First, in 2001, a trauma registry was developed in HGSA. Then a population based study was performed in the whole trauma system area. Finally in 2003 the follow-up clinic was built and the trauma patient disability and quality of life assessment started. Table 1 gives an overview of the thesis conceptual framework.

Table 1 | Thesis conceptual framework

Current concepts	Research Questions	New paradigms
"trimodal mortality"	**RQ 1:** Is the "trimodal mortality" pattern applicable in a Portuguese Trauma System? [1, 3]	*The Tetramodal Mortality pattern*
"golden hour"	**RQ 2:** Is time to definitive treatment at trauma centre an independent factor contributing to mortality? [1]	*The Golden Approach paradigm*
	RQ 3: Does the early treatment of life threatening events have implications for trauma mortality? [1]	
	RQ 4: Does rurality have implications on trauma patient's outcome?	
	RQ 5: Does the early treatment of life threatening events have implications for disability and quality of life of trauma survivors? [1, 2]	

Data Source: [1]HGSA trauma registry; [2]HGSA follow-up registry; [3]Population based data collection

Setting

The Trauma System

The trauma system described within this thesis includes part of the city of Oporto and 4 districts of the north of Portugal (Bragança, Vila Real, Aveiro (partial) and Porto (partial)). The trauma system includes several small hospitals (corresponding to level IV/V trauma centre: Hospital de Bragança; Hospital de Macedo de Cavaleiros; Hospital de Mirandela; Hospital de Chaves; Hospital de Oliveira de Azemeis, Hospital de São João da Madeira, Hospital de Espinho) and only 3 hospitals with intensive care facilities (corresponding to level III/II trauma centres: Centro Hospitalar de Vila Nova de Gaia; Hospital de São Sebastião; Hospital de Vila Real). That system comprises a geographical area of 15.761.9 square kilometres with a population of 2.530.987 people, from whom almost 50% live in the major urban centre, Porto and its surroundings [INE, 2004] as seen in Figure 1 also. Figure 2 depicts the hospitals and pre-defined pathways concerning the trauma system of HGSA. It is important to say at this stage that the trauma system geographical area had several changes over time (and namely during the last 3 years) and that the described area is actually the HGSA trauma system.

The EMS within this region consists of a dispatch centre that answers all emergency calls (112) and sends the most appropriate resource available. One helicopter and 10 fast vehicles with trained medical doctors are available for this response [Gomes et al., 2004]. The EMS in this region changed also changed over these three years reflecting the objective of our health system administration to increase the medical support in the pre-hospital environment. The decision whether or not to dispatch a physician to the field is reached on the basis of the information received on the phone and the available resources. As the resources are not uniform for the same seve-rity of trauma, different approaches are possible from an ALS vehicle with doctor and nurse to a BLS ambulance staffed only by fire-fighters with basic skills. If an ALS resource is not available BLS ambulances attend the scene and transport the patient to the nearest hospital with an emergency department (ED). If an ALS vehicle is dispatched to the scene, the on scene physician makes the transport decision and can bypass the nearest ED for transportation directly to HGSA. Such ALS teams with medical involvement are mostly available in or around urban areas. As a consequence the level of trauma care in the designated area is not uniform. In Portugal the trauma centre levels, according to the American College of Surgeons [1990], are not used for accreditation; most first hospitals with ED are comparable to level III trauma centres and if a neurosurgical and/or intensive care referral is needed the patient is transferred to HGSA, the level I trauma centre for this region.

Most patients in this trauma system come from urban areas (62%). Nineteen percent of the patients arrive from rural areas and another 19% from semi - urban areas. Urban areas are defined as having a population density superior to 500 inhabitants/km^2; semi-urban areas are defined when there is a population density inferior to 500 inhabitants/km^2 but superior to 100 inhabitants/km^2. Rural areas are by exclusion areas where the population density is inferior to 100 inhabitants/km^2 [Gomes et al., 2010b (in press)]. A more in-depth review of population density in the trauma system geographical area can be obtained in *Tipologia das áreas urbanas, 1998* from INE [INE, 1998].

The Trauma centre

HGSA is a 600 bedded university hospital with neurosurgical cover and intensive care facilities. No other hospital within this trauma system has emergency neurosurgical coverage. HGSA is the level I trauma centre for the city of Porto and a part of the north of Portugal. HGSA has about 130.000 emergency department casualties per year with about 1.800 trauma patients [HGSA, 2009]. None of the hospitals in the trauma system have neurosurgery emergency coverage except HGSA. HGSA has no Paediatric or Cardiothoracic Surgical coverage. Patients aged less than 16 years old and those who are expected to need expertise in cardiothoracic surgery are by protocol diverted to another specific hospital. Figure 1 shows the trauma system geographical area for HGSA. Most of the severe trauma patients arrive at HGSA after being transferred from other hospitals in the trauma system (72%) confirming that HGSA is the tertiary hospital for trauma patients in this area. Medical pre-hospital EMS attendance was present in 53.6% of the patients that arrived to the trauma centre. Most of the patients that arrive to the trauma centre need Intensive Care and are discharged from the ED directly or indirectly to the ICU in 70 % of cases [Gomes et al., 2010d; Gomes et al., 2010a (in press); Gomes et al., 2008a; Gomes et al., 2007c; Gomes et al., 2010b (in press)].

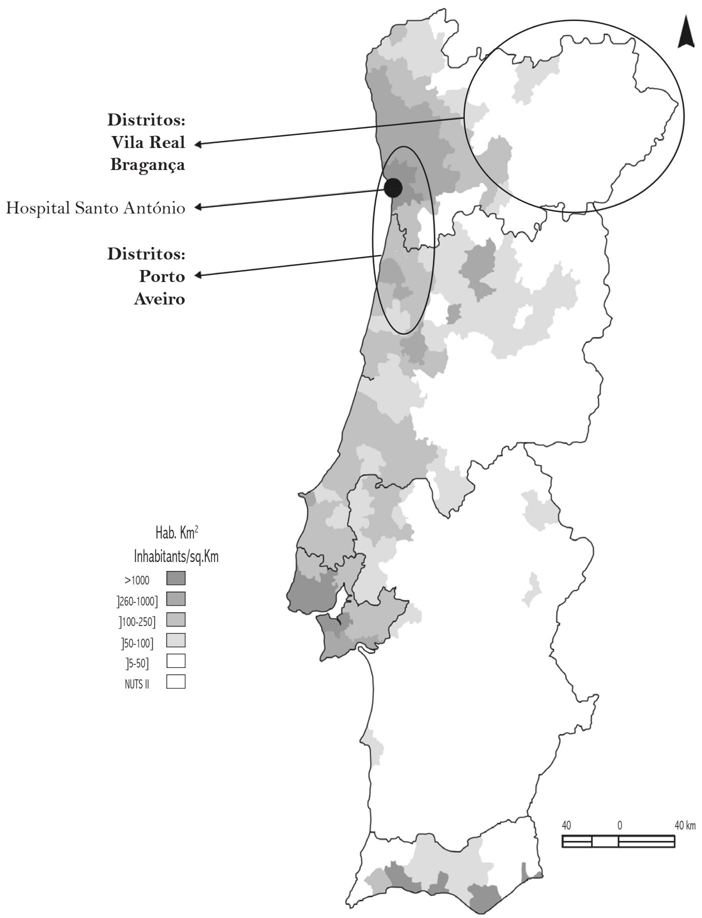

Figura 1 | The HGSA trauma system.

(Source: statistics Portugal, provisional stimates for resident population, from the national cartographic series on a scale of 1:50.000, official administrative map of Portugal, March 2008)

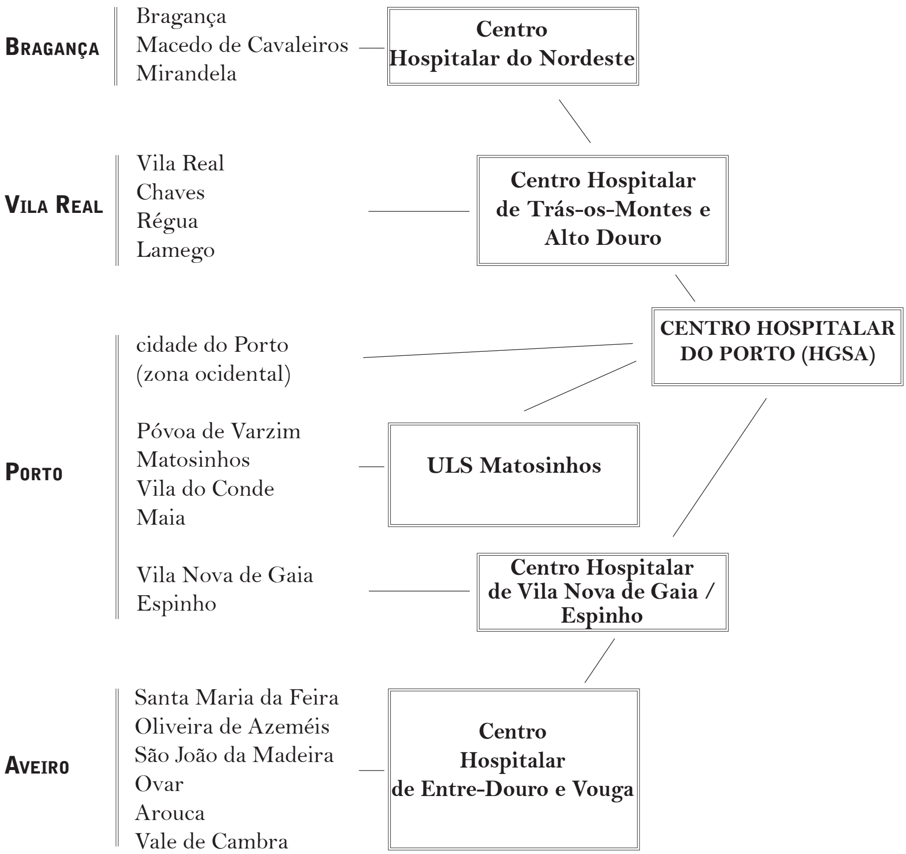

Figura 2 | Hospitals and pathways in the HGSA trauma system.

To the left side districts of the north of Portugal are identified, then all hospitals are depicted and to the right the pathways of transfer are shown. The continuos lines are the usual pathways. In case of head injury direct pathways from the scene or small hospitals to trauma centre are preferably used.

The Trauma Registry

Overview

A trauma registry provides detailed description of various aspects of trauma patients and their care. The registry can identify major causes, pattern and mode of injury occurrence, identifying the population at risk. The registry continued over a period of time, will reveal temporal changes in occurrence and pattern of trauma. A registry can serve as a basic ground tool for clinical and interventional trials. The registry helps in developing and understanding prognosis in trauma management and anticipating future risks. Information from a trauma registry will ultimately reveal the socioeconomic burden and health needs of a community.

To decide what and how much data to collect and how to score severity is a crucial issue when studying trauma. The first important trauma registry was the Major Trauma Outcome Study (MTOS) that started in 1975 in the United States of America. The MTOS cohort has been widely used as a benchmark for comparing outcomes in patients with trauma using the TRISS methodology. It can be used to identify unexpected outcomes in populations and in individual patients [Champion et al., 1990].

Within Europe the Trauma Audit & Research Network (TARN), originally an off shoot of US MTOS, is a group of hospitals from all over England, Wales, and even other countries in Europe [Yates et al., 1992]. The TARN has been operating for the past 20 years and is located at the University of Manchester, United Kingdom (UK). In other words TARN is concentrating the trauma data collected from all hospitals in the UK, analysing it and producing epidemiological, clinical and audit reports [Patel et al., 2005]. Using its vast experience in data collection and analysis, TARN took the initiative to start a European Registry. During 2007 a paper on trauma registry and data collection in Europe was published in Resuscitation [Edwards et al., 2007]. In 2008 a group of experts revised the Uttstein template (previously proposed by Basket [Dick and Baskett, 1999] on trauma registries on the light of present knowledge and a limited core of data points were proposed to standardize trauma registries in Europe [Kjetil G Ringdal, 2008].

VARIABLES DESCRIPTION

The trauma registry started in 2001, uses most of the core data points from the initial and revised Uttstein template and participated for the European trauma registry. Below I make a general description of the variables. Some of the variables, namely the severity scores and the outcome variables are paramount for this study and they are described with higher detail in separated sections. Data field definitions are based on internationally accepted standards when possible, among them International Classification of Diseases, 9th revision (ICD-9) [1990] employed for definition of external causes of injury, and mainly detailed coding guidelines for each data field from the Uttstein template and the revised Uttstein Template for Uniform Reporting of Data following Major Trauma [Kjetil G Ringdal, 2008]. The registry is formally owned by UCIP, HGSA, Centro Hospitalar do Porto, Porto, Portugal. The data base that is used to store data for the registry is shown in Addenda 4.

The author of this thesis is educated in injury coding (AIS 98) through a standard course of the Association for the Advancement of Automotive Medicine and was responsible for all severity coding.

Inclusion criteria for the trauma registry are all trauma patients that imply trauma team activation for the emergency room of HGSA. All deaths at arrival were excluded.

Patient variables

Gender and date of birth were collected for all patients. An anonymous number is attributed to allow unidentified data.

Accident variables

Date and time of the incident, type of trauma and mechanism of injury information was collected.

Pre-hospital variables

Data variables are divided in two fields - how is the patient and what was done to the patient and the following variables were collected: respiratory rate, heart rate, systolic blood pressure, Glasgow Coma Scale, oxygen, intubation, ventilation, venous access, CPR, immobilization, thoracic drainage, cardiac tamponade drainage, manitol, blood, fluids. Time from dispatch call to arrival at the scene and time when transport to hospital started was also collected.

First hospital variables

Data variables are divided in two fields as for the pre-hospital variables - how is the patient and what was done to the patient and the following variables were collected: respiratory rate, heart rate, systolic blood pressure, Glasgow Coma Scale, oxygen, intubation, ventilation, venous access, CPR, immobilization, thoracic drainage, cardiac tamponade drainage, manitol, blood, fluids, interventions in the operating room. Time at arrival in first hospital and time to arrival at the trauma centre were also collected.

Trauma centre variables

Data variables are divided in two fields as for pre-hospital and first hospital - how is the patient and what was done to the patient and the following variables were collected: respiratory rate, heart rate, systolic blood pressure, Glasgow Coma Scale, oxygen, intubation, ventilation, venous access, resuscitation, immobilization, thoracic drainage, cardiac tamponade drainage, manitol, blood, fluids, interventions in the operating room. Time to first CT scan, X Ray and ultra sound was also collected. All lesions were described in detail using the sheet protocol, data from images and review of clinical notes. Outcome status variables and severity scoring are described in detail bellow and are variables also collected at the trauma centre.

Severity Scores

Severity scoring is a crucial issue in any trauma registry. Attempting to summarize the severity of injury in a patient with multiple traumas with a single number is often challenging. Consequently, multiple alternative scoring systems have been proposed, each with its own problems and limitations. Characterization of injury severity is crucial to the scientific study of trauma, yet the actual measurement of injury severity began only 50 years ago. The ability to predict mortality associated with trauma is perhaps the most fundamental use of injury severity scoring. Unfortunately, trauma mortality prediction in the individual patient is limited as is the use of any other severity index for individual cases. The most important role for injury severity scoring is then in trauma care research. In this trauma registry the TRISS methodology is used for severity scoring and will be described bellow.

RTS

The Revised Trauma Score (RTS) is one of the more common physiologic scores. It uses 3 specific physiologic parameters, the Glasgow Coma Scale (GCS), the systolic blood pressure (SBP), and the respiratory rate (RR). Parameters are code from 0-4 based on the magnitude of physiologic derangement. The RTS has 2 forms depending on its use. When used for field triage, the RTS is determined by adding each of the coded values together. Thus, the RTS ranges from 0-12 and is calculated very easily. An RTS of less than 11 is used to indicate the need for transport to a designated trauma centre [Champion et al., 1981; Champion et al., 1989]. The coded form of the RTS (ranging from 0 to 7.84) is used more frequently for quality assurance and outcome prediction. The coded RTS is calculated as follows, in which SBPc, RRc, and GCSc represent the coded values of each variable: RTSc = 0.7326 SBPc + 0.2908 RRc + 0.9368 GCSc. The GCS is scored between 3 and 15, 3 being the worst, and 15 the best. It is composed of three parameters: Best Eye Response (no eye opening-1; eye opening to pain-2; eye opening to verbal command-3; eyes open spontaneousely-4), Best Verbal Response (no verbal response-1; incomprehensible sounds-2; inappropriate words-3; confused-4; oriented-5) and Best Motor Response (no motor response-1; extension to pain-2; flexion to pain-3; withdrawal from pain-4; localising to pain-5; obeys commands-6) [Teasdale and Jennett, 1974].

AIS

In 1969, researchers developed the Abbreviated Injury Scale (AIS) to grade the severity of individual injuries. AIS is an anatomical scoring system. Since its introduction, researchers modified the AIS, most recently in 2005, and reviewed it in 2008 [Gennarelli and Wodzin, 2006]. The AIS is a consensus--derived, anatomically based system of grading injuries on an ordinal scale ranging from 1 (minor injury) to 6 (lethal injury) [Greenspan et al., 1985; MacKenzie et al., 1985].

ISS

Baker et al introduced the Injury Severity Score (ISS) in 1974 as a mean of summarizing multiple injuries in a single patient. The AIS is the basis for the Injury Severity Score (ISS), which is the most widely used measure of injury severity in patients with trauma. The ISS is defined as the sum of squares of the highest AIS grade in the 3 most severely injured body regions. The six body regions are defined, as follows: thorax, abdomen and visceral pelvis, head and neck, face, bony pelvis and extremities, and external structures. Only one injury per body region is allowed to be part of the index, this being one of the ISS limitations. The ISS ranges from 1-75, and an ISS of 75 is assigned to anyone with an AIS of 6 or non-survivable injury [Baker et al., 1974]. An ISS over or equal to 16 indicates a major trauma patient [Young et al., 1991].

TRISS

The predictive capability of any prediction model usually improves with the inclusion of additional relevant information. Champion and colleagues exemplified this concept with the development of the Trauma and Injury Severity Score (TRISS). This test combines both anatomic and physiologic measures of injury severity (ISS and RTS, respectively) and patient age in order to predict survival from trauma. Recognizing the difference between blunt and penetrating injury, researchers developed separate models for each mechanism. TRISS quickly became the standard methodology for outcome assessment [Boyd et al., 1987]. TRISS uses a logistic regression equation and determines the probability of survival (Ps) of a patient using the following formulae: Ps = 1 / (1+e-b); where 'b' is calculated from the following formula: b=b0+b1(RTSc)+b2(ISS)+b3(ageindex). RTSc is the coded version of the RTS, and patient age is categorized such that age is equal to zero if the patient is younger than 55 years and age is equal to one otherwise. The coefficients will differ for blunt and penetrating trauma using a specific table of values (b0 = -0.4499 for blunt and -2.5355 for penetrating; b1 = 0.8085 for blunt and 0.9934 for penetrating; b2 = -0.0835 for blunt and -0.0651 for penetrating; b3 = -1.7430 for blunt and -1.1360 for penetrating). This is the original model for calculation of the injured patients' probability of survival. Because of its limitations, namely in Europe where the characteristics of trauma are different from the United States other models have been developed and used in other trauma registries [Bouamra et al., 2006]. Severity of trauma will be determined in the different papers and studies within this thesis using TRISS methodology.

Outcomes

Mortality

Traditionally outcome has been considered in terms of mortality or survival. Mortality was divided into hospital mortality and post-discharge mortality. Hospital mortality was defined as death occurring during patients stay in the acute hospital. After discharge mortality was defined as death occurring either at the rehabilitation hospital or at home.

Patient centred outcomes

<u>Disability</u>

For the purpose of this thesis disability will be measured using the Glasgow Outcome Scale Extended (GOSE). GOSE is a simple hierarchical scale developed to allocate people into broad outcome categories (Addenda 6). It was first developed for head trauma patients but can also be used in non traumatic situations. The scale reflects disability and handicap rather than impairment; that is, it focuses on how the injury has affected the function in areas of life rather than on the particular deficits and symptoms caused by injury [World Health Organization, 1980]. It is not intended to provide detailed information about the specific difficulties faced by individual patients, but to give a general index of overall outcome [Clifton et al., 1993]. The GOSE was developed to address the limitations of the original Glasgow Outcome Scale (GOS). The GOSE extends the original 5 GOS categories to 8. The 8 categories are: Dead, Vegetative State, Lower Severe Disability, Upper Severe Disability, Lower Moderate Disability, Upper Moderate Disability, Lower Good Recovery, and Upper Good Recovery. A structured interview has been provided to improve reliability of rating. Compared to the GOS, the GOS-E has been shown to be more sensitive to change in mild to moderate TBI [Wilson et al., 1998].

Quality of life

Quality of life is one of the most important and key non-mortality outcome measures after severe injury and critical illness. Health related quality of life (HRQOL) describes the degree of well-being of one individual's life as it is affected by accident, injury, disease and treatments. Because of the acute nature of trauma and it's relatively transitory effects, to measure HRQOL after injury is difficult as it changes over time. How much of the patients changes are due to illness rather than the management of the disease is not known. In severe trauma patients it has been measured using general tools like Euroqol-5D [Brooks, 1996; Brooks et al., 1991]. The EuroQol Group first met in 1987 to test the feasibility of jointly developing a standardised non-disease-specific instrument for describing and valuing health-related quality of life The EuroQol instrument (EQ-5D) has been in the public domain since October 1991 as a standard five-dimensional format [Brooks et al., 1991]. The instrument was simultaneously developed in Dutch, English, Finnish, Norwegian and Swedish. From them several translations, namely the Portuguese, have been made.

For the purpose of this thesis quality of life will be measured using EQ-5D. EQ-5D is a standardised instrument for use as a generic measure of health outcome (Addenda 7). Applicable to a wide range of health conditions and treatments, it provides a simple descriptive profile and a single index value for health status. EQ-5D is designed for self-completion by the patients and can be used either by postal surveys, in clinics and face-to-face interviews. It is cognitively simple, taking only a few minutes to complete. Instructions to respondents are included in the questionnaire. The current

EQ-5D has a 3-level and 5-dimensional format. In this instrument, health is defined along five dimensions: mobility, self-care, usual activities, pain/ discomfort, and anxiety/depression. Each dimension has three levels: no problem, moderate problem, or severe problem. In the second part of the EuroQol instrument, respondents recorded their health status on a visual analogical scale (VAS), between 0 (worst imaginable health state) and 100 (best imaginable health state). EQ-5D covers the main health domains that are affected by injury. It was therefore thought to describe well a heterogeneous injury population and to discriminate among specific injuries.

Exposures

Place of treatment of life threatening events

In addition to the trauma registry data points, supplementary information was collected after retrospective review of the patient's clinical notes: type of life threatening event; type of life threatening event treatment and the location where the treatment was performed.

Life threatening event were identified after a retrospective review of all the clinical notes from the pre-hospital scene, first hospital and HGSA. Life threatening events were defined as problems in the airway (A), breathing (B), circulation (C) or neurological disability (D) that may endanger life if not immediately identified and controlled as taught in trauma courses. When several life threatening events were identified in the same patient, we considered the first one in alphabetic order to be treated, as defined by medical educational principles.

Moreover we divided the patients into pre-hospital, first hospital and trauma centre depending on the moment when life threatening events were treated. So the patients in the pre-hospital group had pre-hospital treatment of the life threatening event; patients in the first hospital group didn't have pre-hospital treatment to their life threatening event that was treated in the first hospital; trauma centre group includes patients that arrived at the trauma centre with life threatening events not treated previously. The treatment of life threatening events in the pre-hospital setting implied the availability of an ALS team.

ATLS® and the European Trauma Course® [Lott et al., 2009; Thies et al., 2007] are examples of educational tools addressing that model. The Airway Breathing Circulation Disability approach (ABCD approach) is a method of identifying and treating life threatening events in trauma patients. It is a powerful teaching tool and is taught in different trauma courses and emergency medicine courses for doctors, nurses and paramedics around the world [Carley and Driscoll, 2001].

In the ABCDE approach the doctor or team in charge starts his involvement with the patient by ensuring that a full primary survey is completed. The objectives of the primary survey are to identify and treat any immediately life-threatening event. Generally, after major trauma, depending on their injuries, patients die most rapidly from airway obstruction, followed by breathing problems and then from circulatory failure. Dysfunction of the central nervous system tends to cause death relatively more slowly and may be the result of these problems. Ultimately some injuries may not be revealed until the entire patient is exposed and examined. At the end of the primary survey patients should have a clear airway, have oxygen on and have the cervical spine immobilized. Adequate ventilation must be confirmed. This includes an examination of the chest to clinically exclude or treat immediately life threatening thoracic conditions: tension pneumothorax, open chest wound, massive haemothorax, flail chest or cardiac tamponade. Regarding Circulation and control of haemorrhage any overt bleeding must be controlled by direct pressure. At the same time, the medical team leader must specifically look for clinical evidence of shock using skin colour, clamminess, capillary refill time, heart rate, blood pressure, pulse pressure, conscious level and respiratory rate. If a life threatening event is identified in circulation intravenous access must be established using two wide bore peripheral cannulae and fluids started. Examinations should be started to identify the origin of the problem but (apart from the external haemorrhage) usually that is only possible at hospital. Dysfunction of the central nervous system can be a life threatening event. In our trauma system patients with neurological problems should be transferred to the trauma centre and if the Glasgow coma scale of the patient is bellow 8 control of the airway is also mandatory before transfer.

An Airway life threatening event was considered when an airway obstruction was present. A Breathing life threatening event was considered when there was clinical evidence of tension pneumothorax, open chest wound, massive haemothorax, flail chest or cardiac tamponade. A Circulation life threatening event was considered when there where clinical signs of shock. A Disability problem was considered when there was a GCS inferior to 8.

Time from the incident scene to the trauma centre

Time to trauma centre was defined as time from the accident occurrence to arrival at the level I trauma centre (HGSA). Figure 3 shows the loop of care for the care of trauma patients representing information gathered under the HGSA trauma registry and follow-up registry.

In the outcome studies and when possible separated analyses were done for patients transferred from other hospitals in the trauma system (transfers) and for patients admitted directly in HGSA (primary admissions). Transfers were defined as all trauma patients that were admitted to another hospital or hospitals before arrival to HGSA. Primary admission patients were the trauma patients that arrived at HGSA directly from the incident scene.

Rural and Urban areas

We classified patients according to the residence area using the INE classification, *Tipologia das áreas urbanas, 1998* [INE, 1998]. Patients were divided in three groups according to residence area: R (rural), SU (semi-urban) and U (urban).

1. Urban region: Region that has a population density superior to 500 inhabitants/km^2 or a region that has a place with more than 5000 inhabitants.
2. Semi-urban region: Non Urban region that has a population density superior to 100 inhabitants/km2 or a region that has a place with more than 2000 inhabitants.
3. Rural region: A region not classified as urban or semi-urban.

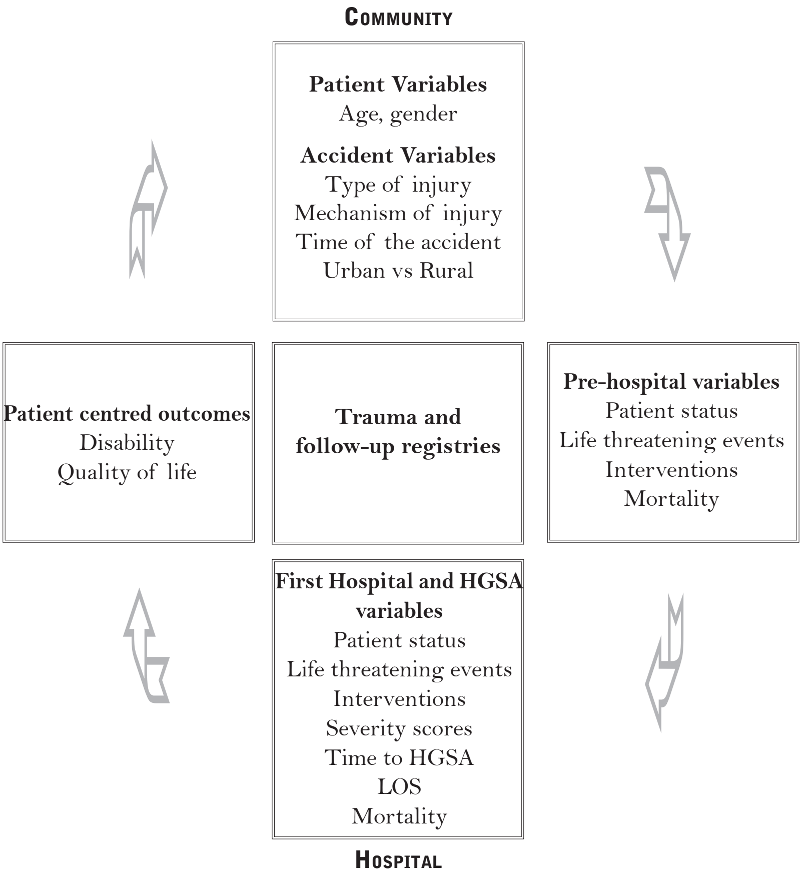

Figura 3 | The loop of care for the care of trauma patients.
Information gathered under HGSA trauma and follow-up registries.

The follow-up clinic

At six months all trauma survivors were contacted to come to a follow-up consultation. In that consultation a structured interview and several outcome measures were applied to identify the outcome status and problems that might need intervention. The instruments used for the purpose of this thesis are discussed below. However this follow-up clinic is meant to observe also all patients that were admitted to intensive care in HGSA and the spectrum of tests and observations is broader than those we present here. In Addenda 5 the data base that collects the information is shown.

Statistical methods

Descriptive analyses of background and severity variables, life threatening events and questionnaire variables were undertaken. Continuous variables were expressed as means ± standard deviations for symmetric variables and medians and inter-quartile range for asymmetric variables. The categorical variables were expressed as absolute and relative frequencies. Pearson Chi Square was used to analyze categorical data. ANOVA and T test were used for variables with symmetric distributions, and Mann Whitney or Kruskall Wallis for asymmetrical data. $P<0.05$ was needed for significance. To assess the predictive effect of different variables on mortality, several logistic regression models were constructed, with mortality as dependent variable and population characteristics and the place of correction of life threatening events as independent variables. Models were built using different independent variables from previous well known prognostic trauma models like TRISS and Probability of Survival 04 variables.[Boyd et al., 1987] [Bouamra et al., 2006] [Perel et al., 2008] Analysis was performed with the statistical software package SPSS 15.0 for Windows. Specific statistical methods are described in detail in each of next chapters.

The mortality distribution with time analyses, were done using the variable time transformed applying a natural logarithm [Gomes et al., 2008a]. A logarithmic scale was used because of its properties and also because of data characteristics. Data showed that mortality was concentrated in the first hours falling quickly subsequently - that is a rather high number of deaths in the first hours followed by few deaths at two weeks post injury. Therefore, the logarithmic scale is more appropriate for describing the frequency distribution with time as it allows more comprehensible representation of the frequency of events. In a logarithmic scale when there are a high number of events the time intervals are shortened showing a better understanding of what is happening; when events are rarer, the time intervals are longer allowing the coverage of a longer range of time values. Consequently, the depiction of events from applying that methodology is more representative and better illustrates death distribution. For mortality distribution the variable *time to death* (in minutes) was transformed using a natural logarithm thus creating a new continuous variable. The next step was to recode the new continuous variable into intervals with the same range (one logarithmic unit). Then to each logarithm unit interval we corresponded a time interval in minutes again. We used the *minute's logarithm* and not *hours* or *days logarithm* because it gave a better representation of our results mainly because of the relatively high number of death events in the first hours and the subsequent clinical implications.

Survival Kaplan Meyer, or survival, curves were used to compare mortality in the different subgroups of patients. These curves are described in detail in specific chapters.

To assess the predictive effect of different variables on mortality, several logistic regression models were constructed, with mortality as dependent variable and population characteristics and the place of correction of life threatening events as independent variables. These models are described in detail in specific chapters.

Ethical Considerations

The publications in this thesis are based on aggregated and anonymized data from HGSA trauma registry and follow-up clinic registry. No additional interventions were made for the studies described herein so this thesis is based on observational data. The HGSA committee for research ethics approved the thesis development. Whenever data from other hospitals was used administrative and/or ethical consent was given before data collection. All information was kept confidential and not disclosed to any persons.

Mortality in Trauma | a population study

BACKGROUND AND AIM

In the *trimodal distribution of deaths* [Trunkey, 1983] trauma mortality is classically grouped into three peaks: immediate, early, and late deaths. The first peak of death occurs at the time of the injury and is related to the severity of the primary injury to major organs or structures such as brain, heart or great vessels. It is stated that only prevention can reduce the incidence of these injuries. The second peak lasts until several hours after the injury has taken place. It is during this time that many causes of morbidity and mortality are preventable by avoidance of a secondary injury due to hypoxia, haemorrhage or any process that leads to inadequate tissue perfusion. The third peak of death occurs days or weeks after the injury and is usually due to sepsis and multiple organ failure. This concept is in part responsible for the genesis of all the modern emergency systems that deal with trauma patients all over the world [Tallon, 2002], [Osterwalder, 2002], [McNicholl, 1994], [Blow et al., 1999]. However the trimodal distribution of trauma deaths is being increasingly challenged both by European and American authors [Demetriades et al., 2005] [Di Bartolomeo et al., 2004; Wyatt et al., 1996]. The basis for the need to confront this concept is the evolution in trauma care over the last decades and the way it might have influenced mortality. Another reason arises because in Europe the pattern and type of trauma, mechanism of injury and design of trauma systems are different from the US, as studied by Trunkey.

The aim of this chapter is to understand the distribution of death in trauma patients using data from a Portuguese trauma system and to determine whether the trimodal distribution of deaths applies to time of death after injury.

Patients and Methods

All trauma deaths occurring between August 2001 and December 2005 in the trauma system area of HGSA were. Trauma patients admitted to HGSA out of the geographical region previously described were excluded. Patients aged less than 13 years of age were also excluded because they are by protocol diverted to a paediatric hospital.

Accident Scene Deaths

A death was classified as being at the scene of the accident when the death occurred at the incident scene or before arrival to hospital. Data concerning scene deaths were recovered from the INE and the RTA prevention registry (Direcção Geral de Viação - Observatório de Segurança Rodoviária).

Hospital Deaths

Data were recovered from the prospective trauma registry in HGSA and through ICD-9-CM (The International Classification of Diseases, 9th Revision, Clinical Modification) [1990] and the Portuguese adaptation of Diagnosis Related Groups (DRGs) [1996] in all other hospitals. The inclusion criteria were the presence of an external cause in the admission diagnosis (ICD9 E800-E999). We excluded all the patients with poisonings and overdoses (ICD9 E850-E869), drowning and suffocation (ICD9 E910--E915), burns (ICD9 E890-E899), iatrogenic accidents (ICD9 E870-E879) and patients that died after hospital discharge. Isolated hip fractures in patients over 65 years of age were also excluded. We also classified hospitals according to the American trauma centres designation levels to be able to compare with other trauma systems [1990].

Time to Death

Time to death was defined as the time between the accident occurrence and death. If the time of the accident was not recorded we estimated it from the location of accident and time of arrival at the first hospital. That estimation used a consensus process to determine time from accident to death that was applied in 31% of all deaths.

The Trunkey Curve

Concerning time to death different time intervals were considered. At first victims were classified into several groups according to time of death to compare with the classical trimodal distribution: death out of hospital (Deaths at scene) death in the first 4 hours in hospital (Deaths < 4 hours) and all deaths after 4 hours (Deaths > 4 hours).

The Natural Logaritm of Time

Then, in order to improve the study of mortality distribution, the variable *time to death* measured in minutes was transformed applying a natural logarithm function. The transformation using the natural logarithm created a new continuous variable. The next step was to recode this new variable into intervals with the same width, i.e. one logarithmic unit. Then, to each logarithm unit interval a time interval expressed in minutes was corresponded thus creating the final time intervals.

MAIN RESULTS

POPULATION CHARACTERISTICS

During the studied period, there were 1811 trauma deaths in the HGSA trauma system. Patients aged less than 13 years (79 deaths) and 296 patients that had more than 65 years of age and had an isolated hip fracture dying of a non traumatic cause were excluded; this resulted in a study of 1436 deaths over a period of 53 months. 752 (52%) patients died at the scene without reaching hospital care. 239 (18%) patients died in the level I trauma centre (HGSA), 287 (21 %) died in a level III trauma centre and the remaining 158 patients (11%) in a level IV/V trauma centre. In hospital deaths happened mostly in the emergency department (52%) with 274 deaths in the emergency room and 82 occurring in the operating room. 207 deaths occurred in the intensive care unit (30%) and 18% in the wards. 76% were male and 24% female with a median age of 43 (25 percentile = 27; 75 percentile = 67). Only 5% of cases were injured by penetrating trauma. In patients injured by blunt trauma the majority were caused by RTA (74%), falls were the cause in 13% and others accounted for 13%. It was not possible to identify the dominant injury in the patients that died at the scene and in the first few hours in hospital (68% of all deaths). From those with an identifiable injury, head injury was the dominant injury in 70% of cases, abdominal trauma was the dominant injury in 31 patients (7%), spinal trauma in 4%, pelvis and extremities in 6% and thoracic trauma in 13% of the patients. When comparing the characteristics of various types of injury we see that deaths due to penetrating trauma occur in younger and predominately male patients ($p<0,001$) and more frequently at the scene of injury ($p=0,003$). When comparing the population characteristics for mechanism of injury we also find significant differences. Patients that die as a result of RTA are younger and more likely to die at the scene ($p<0,001$) than patients who fall or have other mechanisms of injury (Table 2).

Table 2 | Characteristics of trauma deaths

			Type of Injury			Mechanism of Injury		
	Total		Penetrating	Blunt	P*	RTA	Other	P*
	n=1436		n=77	n=1359		n=1059	n=296	
Age, n (%)								
< 60	970	(67)	69(90)	901(66)	**<0.001**	787(75)	104(35)	**<0.001**
> 60	466	(33)	8(10)	458(34)		262(25)	192(65)	
Gender, n (%)								
Male	1089	(76)	75(97)	1014(75)	**<0.001**	801(76)	199(67)	
Female	344	(24)	2(3)	342(25)		246(24)	96(33)	
Time to Death, n (%)								
Death at scene	752	(52)	45(58)	707(52)		699(67)	8(3)	
Death>4 hours	228	(16)	8(11)	220(16)	**0.346**	168(16)	50(17)	**<0.001**
Death>4 hours	456	(32)	24(31)	432(32)		182(17)	238(80)	
Death to hospital, n (%)								
Level I	239	(35)	21(27)	218(17)		121(11)	118(32)	
Level III	287	(42)	9(12)	278(20)	**0.003**	144(14)	138(37)	**<0.001**
Level IV/V	158	(23)	2(3)	156(11)		85(8)	64(17)	
at Scene			45(58)	707(52)		699(67)	53(14)	
Dominant Injury,** n (%)								
Head	305	(70)	20(74)	288(70)		125(70)	180(72)	
Thorax	56	(13)	3(11)	53(13)		27(15)	27(11)	
Abdomen	31	(7)	3(11)	28(7)		17(9)	10(4)	**0.005**
Pelvis/extremities	25	(6)	1(4)	24(6)		95(5)	14(6)	
Spine	20	(4)	0(0)	20(4)		2(1)	18(7)	

*Pearson Chi-Square test; **Dominant Injury was known in 440 patients.

Time to Death

The Trunkey curve

Figure 4 shows the temporal distribution of deaths, using exactly the same time frame that Trunkey used when he developed the trimodal mortality concept in trauma. In our population we found a different distribution but still in three peaks: 52% of the patients died at the scene, only 16% died in the first 4 hours and all the rest (33%) died after that period. The proportion of deaths after one week was only 8%.

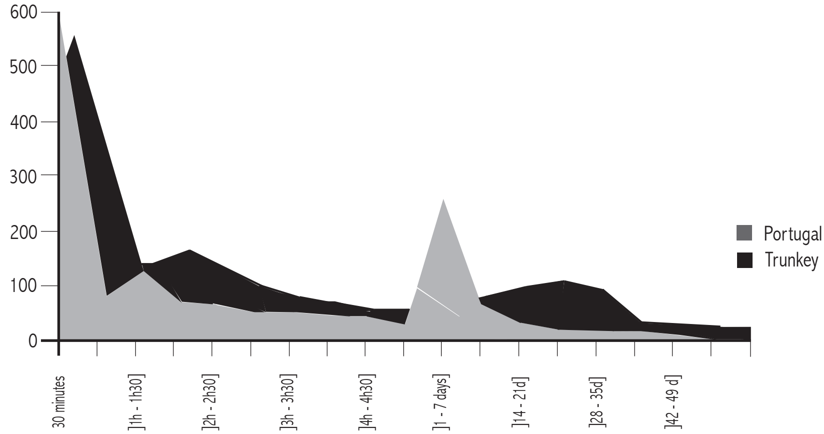

Figura 4 | Comparison with the trimodal concept after Trunkey.
Portugal and Trunkey's number of deaths were normalised per 1000 deaths.

The natural logarithm of time

Figure 5 shows death distribution using a logarithmic scale in minutes where deaths are concentrated in the first 2 days (84%). Using logarithmic transformation 4 peaks appeared and are well identified (deaths at the scene, deaths in the first few hours, deaths in the first two days and finally deaths in the second week) that we named as 2 minutes, 2 hours, 2 days and 2 weeks peak. Table 3 shows differences in background between deaths in the different peaks.

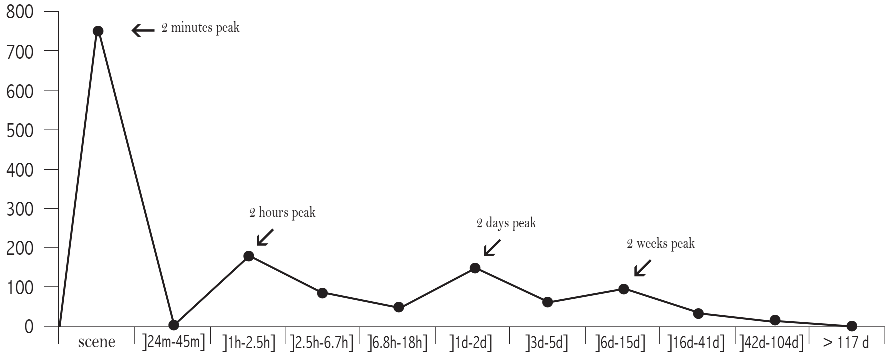

Figura 5 | Death distribution over time in a natural logarithmic scale in minutes. (m = minutes; h = hour; d = day)

Table 3 | Death characteristics concerning time to death

	Time to Death				
	2 minutes (1) n (%)	2 hours (2) n (%)	2 days (3) n (%)	2 weeks (4) n (%)	p*
Age					
< 60	594(79)	205(64)	103(57)	68(37)	**<0.001**
Gender					
Male	587(78)	232(73)	141(78)	127(69)	**0.026**
Mechanism of injury					
Penetrating	45(6)	11(3)	13(7)	8(4)	**0.227**
Death at hospital					
Level I	-	64(20)	87(48)	88(48)	
Level III	-	162(51)	56(31)	69(38)	**<0.001**
Level IV/V	-	93(29)	39(21)	26(14)	
Head Injury**					
No	-	12(19)	0(0)	9(10)	**<0.001**

(1) Death in the place of accident; (2) before 18 hours; (3) between 19 hours and 3 days; (4) after 4 days; *Pearson Chi-Square test; ** Level I trauma centre deaths (n = 239).

Figures 6 and 7 show in a graphic way the differences in age, gender and type of hospital proportion of deaths. The 2 days peak was built upon older patients and head trauma patients that died in ICU hospitals. Previous reports from 2006 also showed that this new peak was dominated by head trauma and older patients [Gomes et al., 2006a].

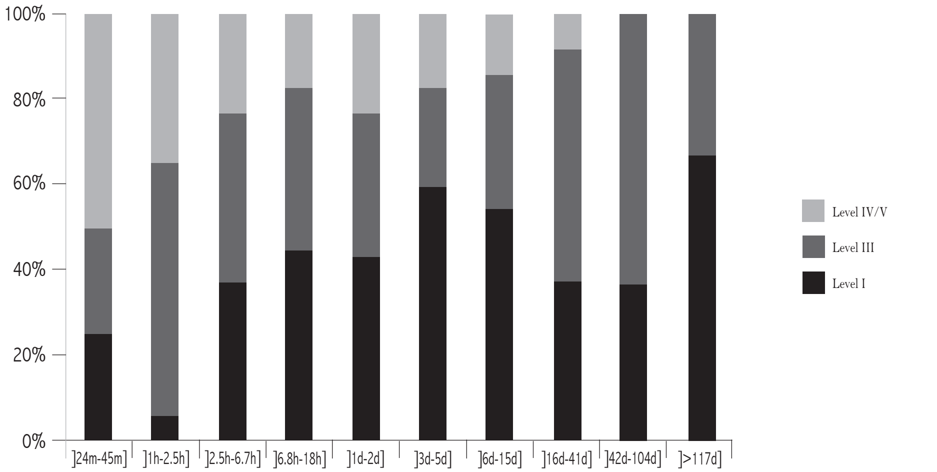

Figura 6 | Comparison of proportion of deaths regarding type of hospital.
Death distribuition over time in a natural logarithmic scale in minutes.

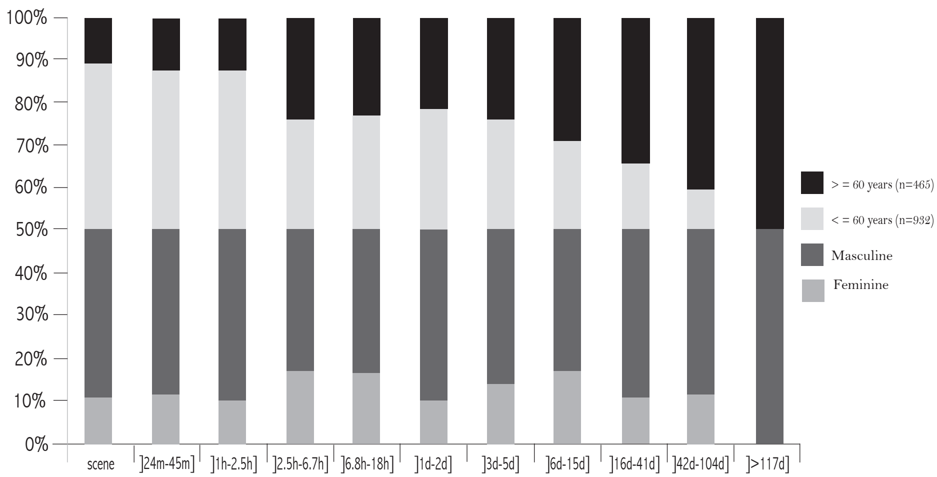

Figura 7 | Comparison of proportion of deaths regarding age and gender.
Death distribuition over time in a natural logarithmic scale in minutes.

Discussion

Limitations

Limitations are discussed in detail in a specific chapter; however some limitations need to be addressed now as they have implications for the comprehension and interpretation of this study. One limitation of this study is that data were collected from several sources. This limited the scope for collecting data concerning dominant injury from the patients who died at the scene, and most of the patients who died in the emergency room in different hospitals (68% of missing data of dominant injury). This meant the analysis of dominant injury was confined to the data collected at the level I trauma centre (HGSA). However it might not create an important bias when we analyse dominant injury in the 2 days and 2 weeks peak because the majority of those deaths happen in the level 1 trauma centre where we have recorded the dominant injury for all deaths. It is not possible to conclude what was the dominant injury for patients dying in the 2 minutes and 2 hours peaks .

Epidemiological variations

Regarding to the type of trauma and the mechanism of injury a specific sample was found that is different from the US but also from other European countries. Penetrating trauma contributes to only 5% of all trauma deaths and that is completely different from the US, where depending on the city, penetrating trauma accounts for 50% of all deaths. Our numbers are similar to what happens in other European countries but even less people die because of penetrating injury. One possible explanation is the fact that Portugal has more RTC than other European countries lowering the proportion of penetrating injuries. In European studies the incidence of penetrating trauma causing death varies from 8% [Wyatt et al., 1996] and 13% [Soreide et al., 2007]. In a previous Portuguese report the incidence of penetrating trauma in a cohort of severe trauma patients was 6% [Santos et al., 2006c]. The characteristics of penetrating trauma deaths are significantly different to those of blunt trauma. It involves younger males and more deaths at the scene. In relation to the mechanism of injury road traffic accidents are the main cause of trauma fatalities and involved mostly young males. Only 13 % of deaths are caused by falls and that 33% of the falls patients that died were more than 60 years of age – this is similar to other European studies [Boto et al., 2006]. It seems that as time passes, deaths are more likely to occur in older people and they occur more in the level I trauma centre, the place for definitive treatment. Again the ageing of the population along with the distribution of levels of care are a possible explanation. Other reports from Europe have highlighted the importance of the aging of population [Aldrian et al., 2007; Di Bartolomeo et al., 2004; Probst et al., 2009] and also reports from around the world talk about its importance [Lee et al., 2006].The differences in type of trauma, mechanism of injury, gender, age and dominant injury can help in understanding our results and serves as a guide to discuss main recommendations.

The Tetramodal Pattern of deaths

Trunkey developed in the early eighties the trimodal concept of mortality distribution [Trunkey, 1983]. As stated previously this is one of the concepts this thesis discusses.

Nevertheless recognizing the importance of the comprehensive graphic Trunkey used to describe trimodal mortality pattern, the same time divisions were used to assess mortality in this trauma system. Several interesting differences were found. The percentage of deaths on scene was similar to Trunkey's (52 %) but this was the only similarity with the trimodal concept. Acute hospital deaths (first 4 hours) accounted for only 15 % of all deaths versus 30% from Trunkey. Late deaths (after the first 4 hours) occurred in 35% of all fatalities versus 20% from Trunkey's description. It was to study these differences in detail and based on our data characteristics that a logarithmic time scale in minutes was used.

It showed 4 distinct peaks that we named after 2 minutes, 2 hours, 2 days and 2 weeks for a more comprehensive analysis.

Analysing the characteristics of our trauma population was paramount to understanding our death distribution. A third peak at 2 days was the main difference compared to the classical trimodal distribution of deaths. Head injury and older patients contribute most for the 2 days peak and these patients died predominantly in ICU. Head injury is the main dominant injury and death distribution along time differs for patients with and without head injury. Head injury patients are the main contributors for the 2 days and 2 weeks peaks. The contribution for the 2 days peak also varied between hospitals with the level I (HGSA) and other hospitals with ICU having most of the cases. A study using authopsy data showed recently that head injury is the main cause of death after 3 hours from the incident scene [Bansal, 2009].

The reason for the manifestation of the 2 days peak could be related also to the improvement of emergency care that reduces the proportion of patients that die early on scene and at 2 hours. This theory is also described by Stocchetti [Stocchetti, 2001] reporting that the quality of the trauma system affects outcome in a negative way because a better trauma system produces lower rates of favourable outcomes. This paradox is owing to the fact that a more efficient pre-hospital system brings to hospital even the most severe cases.

In recent years several authors have also discussed the *trimodal mortality* concept mainly arguing that the distribution was either bimodal or no modality was observed in their reports. The different reports discussing the trimodality distribution of death over time use different scales and intervals, making it difficult to compare to Trunkey's paper and also to compare with the present study [Demetriades et al., 2005; Demetriades et al., 2004; Sauaia et al., 1995]. Pang reports from Australia that no *trimodal mortality* was found. The authors follow a methodology similar to ours but with different time intervals that are not comparable to ours or to Trunkeys. Nevertheless they are able to find a peak in pre-hospital and another in the first 2 days [Pang et al., 2008]. Some European reports also argue against the trimodality of death in trauma. Wyatt reported data from Scotland UK, showing again an exponential decline with time, but again the time frame is not the same [Wyatt et al., 1996] and a linear decrease with time was also reported recently from Norway [Soreide et al., 2007] and from the Netherlands [de Knegt et al., 2008]. Di Bartolomeo also presented epidemiological data from a population-based study in a region from Italy in a graphic way with a time interval similar to Tunkey [Di Bartolomeo et al., 2004]. They showed that the third peak was bigger than expected but they do not try to find a different death distribution. None of the studies mentioned in this paragraph use the same time periods Trunkey used resulting in inability to compare, and being an important limitation. However almost all the studies mentioned use a time continuum scale reporting no pattern in the mortality distribution.

The main advantage of the present study is the ability to compare with Trunkey's time intervals and at the same time identify the need for a common report of deaths over time to avoid misunderstandings and confusions. Another important goal is the proposal of a uniform method to report deaths over time – the used of a logarithm of time scale. The advantages of the logarithm of time have been previously mentioned in this chapter but the most important one is the capability to make the link between data and the clinical problems making easier to explain how death happens with time in trauma. That was also the main advantage of the Trunkey's pattern although he did not use a logarithm scale.

Mortality in Trauma | a trauma centre based study

Background and Aim

In previous chapters the *golden hour* concept has been described and the main reasons why it deserves to be challenged have been raised. In this chapter the *golden hour* paradigm will be discussed in detail. In countries without physicians in the pre-hospital field it makes sense to bring patients to hospital as soon as possible. The same might not be true for most countries in Europe where an EMS with physicians has been developed over decades and where the policy is to bring the physicians to the patient instead of bringing the patient to the physician. However it has been difficult to prove the positive effect of the physician based EMS. In fact it has not been proved till present. It has been advocated that there is a need for randomized controlled trials or studies that maximize the effect of physician based EMS so that the benefit of the physician based EMS can be proved. To ad controversy to that subject ALS in the pre-hospital setting is accomplished by other professionals like trained paramedics depending on the country or trauma system. So it is clearer to talk about ALS vs. BLS (skills based) than physicians vs. paramedic's vs. ambulance man (profession based).

The aim of this chapter is then to challenge the *golden hour* concept using data from a trauma registry. The 2 research questions raised are:

1. Is time to definitive treatment at trauma centre an independent factor contributing to mortality?
2. Does the early treatment of life threatening events have implications for trauma mortality?

Patients and Methods

Setting

HGSA and the EMS in the trauma system have been described in detail in the methods section. The resources are not uniform in the trauma system implying that for the same severity of trauma different approaches are possible. An ALS vehicle staffed with physician and nurse or a BLS Ambulance staffed only by fire-fighters are the two options. ALS vehicles are increasing in number but not enough to cover all regions particularly rural ones. By protocol if a BLS ambulance is dispatched to the scene the patient will be transported to the nearest hospital. Then if the patient needs specialised treatment it will be transported to HGSA. If an ALS physician based vehicle is dispatched to the incident scene the physician in charge makes the transport decision.

Design, patients and definitions

Inclusion and exclusion criteria

All severe trauma patients admitted to the emergency room of HGSA between August 2001 and December 2006 with a life threatening event identified were analysed. We excluded 33 patients without information about life threatening events.

A separated analysis was performed for transfers and primary admissions. Transfers and primary admissions produce different case mix of patients concerning mortality analysis having in consideration the Tetramodal Pattern of mortality in this trauma system. Transfers and primary admissions produce different groups of place of treatment of life threatening events and the junction analysis would not be clear. For the purpose of this study only transfers were analysed so patients arriving via primary transportation to the trauma centre (n=289) were excluded from our subsequent analysis.

Life threatening events

In addition to the trauma registry data, the following information was collected after retrospective review of the patient's clinical notes: type of life threatening event; type of life threatening event treatment and where the treatment was performed (pre-hospital, first hospital or trauma centre) thus identifying the three groups of patients that will be compared from this point on.

To avoid retrospective case definitions of head and severe injury as opposed to what the pre-hospital personnel identifies at the scene (pre-hospital personnel at scene will not always know whether or not the unconscious trauma patient has a head trauma or its real severity) the study of all patients with a life threatening event was performed. Life threatening events were defined as problems in the airway (A), breathing (B), circulation (C) or neurological disability (D) that may endanger life if not immediately identified and controlled as taught in trauma courses. The Airway Breathing Circulation Disability approach (ABCD approach) is a method of identifying and treating life threatening events in trauma patients. It is taught in different trauma courses and emergency medicine courses for doctors, nurses and paramedics around the world [2004; 2004; Lott et al., 2009; Thies et al., 2007]. To be able to identify and treat all life threatening events in the pre-hospital scene implies that a specialized medical team is dispatched to the accident scene in this particular trauma system. In other countries and trauma system designs it has been argued that this objective might be achieved with paramedics. However it is not the purpose of this study to discuss physicians vs. paramedics in the pre-hospital scene and skill based approach will be done (ALS vs. BLS). The treatment of the life threatening events was done either in the pre-hospital scene, in the first hospital to where the patient was transported or only in the trauma centre. The correction of life threatening events was done in pre-hospital when a physician based ALS team was dispatched to the scene.

There is no clinical justification for the transfer of patient with life threatening events from one hospital to HGSA. A Golden Approach (GA) was defined if treatment of life threatening events was done pre-trauma centre. In other words patient had a GA if all life threatening events were corrected in the pre-hospital or first hospital phases. If the required intervention was done later (in the trauma centre), the patient was classified as not having a GA.

When several life threatening events were identified in the same patient, we considered the first one in alphabetic order to be treated, as defined by medical educational principles.

Time to trauma centre
Time to trauma centre was defined as time from the accident occurrence to the arrival at HGSA.

Outcomes
The analysed outcomes were place of treatment of life threatening events and crude hospital mortality, then adjusted for casemix.

Statistical analysis
The descriptive analysis was made using appropriate summary tests. Survival Kaplan Meier curves were done for patients both with and without GA. A test of equality of survival distributions was done using Mantel-Cox regression. To assess the predictive effect of the GA on mortality, several logistic regression models were constructed, with mortality as dependent variable and population characteristics and GA as independent variables. Models were built using different independent variables from previous well know prognostic trauma models [Boyd et al., 1987] [Bouamra et al., 2006] [Perel et al., 2008].

Main Results

Population characteristics

Between 2001 and 2006, 1050 trauma patients were admitted to the emergency room of HGSA and enrolled in the prospective registry. A total of 727 patients were included with a mean age of 44 years (SD=21). The majority were male (78%; n=570) and had sustained injury trough blunt trauma (95%; n=690) with traumatic brain injury (TBI) in 87% of cases. The context of injury was road traffic collision (RTC) in 58% of cases (n=422). All patients had severe trauma with a median Abbreviated Injury Score (AIS) in the head of 4.1 (SD=0.9), a mean Injury Severity Score (ISS) of 26 (SD=11) and Revised Trauma Score (RTS) of 5.8 (SD=1.3). The probability of survival (TRISS) for these patients was 69% and the real survival rate was 72%. Population characteristics are shown in table 4.

Time to trauma centre

Time from accident to trauma centre was also compared. Patients with life threatening events solved in pre-hospital, first hospital and trauma centre phases had respectively a median time from accident to trauma centre of 5 hours and 31 minutes (Interquartile range (IQR) 3:45-9:24), 4 hours and 35 minutes (IQR 2:50-7:02), and 3 hours and 30 minutes (IQR 2:51-6:56).

Life threatening events and their treatment

In accordance with the ABCD assessment and treatment methodology, life threatening events were identified. Not surprisingly most of the patients in this population had “D” problems (n=567; 78%). We assumed that treatment for “D” problems was maintaining an adequate airway (including tracheal intubation in some cases) and aiming for good oxygenation and perfusion followed with early reference to a neurosurgical centre. The second most common life threatening event involved Breathing (n=66; 9%) and it was corrected using a chest drain in 33 cases and mechanical ventilation in 31 patients. Circulation life threatening events were identified in 64 patients (9%) and fluids (6), vasopressors (6) and surgery (52) was the treatment done. Airway life threatening events were identified in 30 patients (4%) and were treated using oxygen (15) intubation (5), a cervical collar (7) and oxygen with basic airway manoeuvres (3). Cervical spinal cord injuries were included in the airway life threatening events as airway assessment and treatment includes cervical spine control. It was assumed that all patients should have had a cervical collar, so if they had a spinal cord injury and no collar that was classified as a life threatening event not corrected. Table 5 lists life threatening events and treatment and Table 4 shows mortality for different life threatening events.

Those patients who had their life threatening events treated in pre-hospital or first hospital (pre-trauma centre) were considered to have had a GA (n=629; 87%). Patients that had their life threatening events solved only in trauma centre did not have a GA. Life threatening events were corrected in the pre-hospital environment in 49 patients (7%), in the first hospital in 580 (80%) and solely in trauma centre in 98 (13%) patients.

Demographic and injury severity characteristics (table 3) of these 3 groups of patients were similar except for age (patients that had a GA with events solved in pre-hospital were younger) and of higher severity. Mortality rates differed across these 3 groups, 20% for patients with life threatening events treated in pre-hospital, 27% for those with events treated in first hospital and 38% for patients with life threatening events solved only in trauma centre (p=0.044).

Table 4 | Patient characteristics concerning place of treatment of life threatening events.

	Life threatening events treatment				
	Total n=727	Pré-hospital n=49	First hospital n=580	Trauma centre n=98	p[1]
Gender, n (%)					
Female	157(22)	11(22)	123(21)	23(24)	0.871
Male	570(78)	38(78)	44(21)	48(22)	
Age, mean (SD)	44(21)	38(19)	44(21)	48(22)	**0.028[2]**
Type of trauma, n (%)					
Blunt	690(95)	48(98)	546(94)	96(98)	-
Penetrating	37(5)	1(3)	34(6)	2(2)	
Rural, n (%)	360(50)	10(20)	320(55)	30(31)	**0.038[2]**
Mechanism injury, n (%)					
Road traffic accident	422(58)	35(71)	331(57)	56(57)	-
Fall	217(30)	8(6)	177(31)	32(33)	
Assault, blunt	5(1)	0(0)	5(1)	0(0)	
Other, blunt	49(7)	5(10)	36(6)	8(8)	
Stabbing	2(0)	0(0)	2(0)	0(0)	
Gunshot	32(4)	1(2)	29(5)	2(2)	
Severity, mean (SD)					
AIS head	4.1(0.9)	4.2(0.9)	4.2(0.9)	4.0(1.1)	0.118[2]
AIS face	1.9(0.7)	2.2(0.8)	1.8(0.6)	2.0(0.8)	0.148[2]
AIS thorax	3.3(1.0)	3.0(1.1)	3.3(1.0)	3.7(0.9)	**0.005[2]**
AIS abdomen	2.7(1.1)	2.4(0.5)	2.5(1.1)	2.9(1.7)	0.155[2]
AIS extremities	2.2(0.9)	2.0(0.7)	2.2(0.8)	2.6(1.0)	**<0.001[2]**
ISS	26(11)	24(13)	26(10)	30(13)	**<0.001[2]**
RTS	5,8(1,3)	5.7(1.3)	5.8(1.3)	6.0(1.3)	0.390[2]
TRISS	0.69(0.28)	0.71(0.31)	0.70(0.27)	0.6(0.32)	**0.011**
Outcome, n (%)					
Died	204(28)	10(20)	157(27)	37(38)	**0.044**
Discharged	523(72)	39(80)	423(73)	61(62)	
Life threatening events, n (%)					
A	30(4)	0(0)	12(2)	4(6)	-
B	66(9)	2(6)	37(7)	12(16)	
C	64(9)	3(8)	13(3)	22(30)	
D	567(78)	31(86)	426(88)	35(48)	

1 - Qui-Square Test; 2 - Independent Sample Test.

Table 5 | Life threatening events and treatment.

Life threatening events	
Airway (A) problem	**30(4)**
Airway obstruction	23(77)
Cervical spine injury	7(23)
Treatment	
Oxygen and basic airway manoeuvres	18(60)
Tracheal intubation	5(16)
Cervical collar	7(24)
Breathing (B) problem	**66(9)**
Pulmonary contusion	24(37)
Massive Haemothorax	17(25)
Tension Pneumothorax	16(25)
Flaid chest	9(13)
Treatment	
Oxygen	66(100)
Ventilation	31(47)
Chest drain	33(49)
Circulation (C) problem	**64(9)**
Clinical signs of shock	64(100)
Treatment	
Surgery	52(81)
Fluids	6(8)
Fluids + vasoconstrictors	6(8)
Disability (D) problem	**567(78)**
GCS < 9	377(66%)
GCS > 8	190(34%)
Treatment	
Tracheal intubation	377(66%)
Referral to Neurosurgery	567(100)

Rural vs Urban

Patients were divided into rural and urban according to the residence area. To do the division we used the *Tipologia das áreas urbanas, 1998* from the Portuguese Instituto Nacional de Estatística [INE, 1998] that defines urban a region with a population density equal or superior to 500 inhabitants/km^2 or if having a place where lived more than 5000 inhabitants.

In this population of transferred trauma, 50% of the patients (n=360) were from a rural area in comparison to a population of primary transportation patients were we found on 18% of patients coming from rural areas (table 4).

Mortality

The univariate analysis of mortality showed that more men than woman survived (26% vs. 37%; p=0.005). Survivors were also younger, predominantly victims of blunt trauma and less severely injured than patients who died. That analysis comparing deaths and survivors is shown in table 6. To detail the analysis to the three groups of patients (pre-hospital, first hospital and trauma centre) Kaplan Meyer curves were also done. Figure 8 shows the survival curves for the 3 groups of patients. Patients were more likely to survive when their life threatening events were corrected in pre-hospital, corresponding to a mortality reduction of almost 50% when compared to those patients whose life threatening events were corrected in trauma centre.

As seen in table 6 patients that had life threatening events corrected in pre-hospital setting were younger and less severe. That is why a multivariate logistic regression was performed to adjust the odds ratio of the Golden Approach to patient characteristics and trauma severity as well as time from accident to trauma centre along with rurality. Logistic regression showed that increases in mortality were associated with female gender and older age, penetrating type of trauma, higher anatomic severity (ISS), higher physiological severity (RTS) and not having a GA (table 7). Time to the trauma centre and rurality were not independent factors of mortality.

Concerning the subgroup of severe head trauma patients a separated analysis was performed concerning general determinants of outcome [Santos et al., 2006c] and the influence of pre-trauma centre approach [Gomes et al., 2007c]. Severe head trauma accounts for 90% of the trauma population of the trauma registry in HGSA. Logistic regression analysis performed for mortality in the head trauma group showed that major determinants were not different from the general population and were: age (OR 1.009), ISS (OR 1.024), penetrating trauma and not having a golden approach (OR1.8).

Table 6 | Univariate analysis comparing survivors with deaths.

	Case Fatality			
	Total n=727	Alive n=49	Dead n=580	p^1 n=98
Gender, n (%)				
Female	157(22)	99(19)	58(28)	**0.005**
Male	570(78)	424(81)	146(72)	
Age, mean (SD)	44(21)	42(21)	48(21)	**<.0001^2**
Type of trauma, n (%)				
Blunt	690(95)	505(97)	185(91)	**0.001**
Penetrating	37(5)	18(3)	19(9)	
Rural, n (%)	360(50)	261(72)	99(28)	-
Severity, mean (SD)				
AIS head	4.1(0.9)	4.0(0.9)	4.7(0.7)	**<0.001^2**
AIS thorax	3.3(1.0)	3.3(1.0)	3.5(1.0)	0.058^2
AIS abdomen	2.7(1.1)	2.6(1.1)	2.8(1.2)	0.536^2
AIS extremities	2.2(0.9)	2.3(0.9)	2.2(0.8)	0.673^2
ISS	26(11)	25(10)	39(11)	**<0.001^2**
RTS	5,8(1,3)	6.1(1.2)	5.3(1.4)	**<0.001^2**
TRISS	0.69(0.28)	0.75(0.25)	0.54(0.29)	**<0.001^2**
Life - threatening events, n (%)				
A	30(4)	25(5)	5(3)	0.479
B	66(9)	49(9)	17(8)	
C	64(9)	47(9)	17(8)	
D	567(78)	402(77)	165(81)	

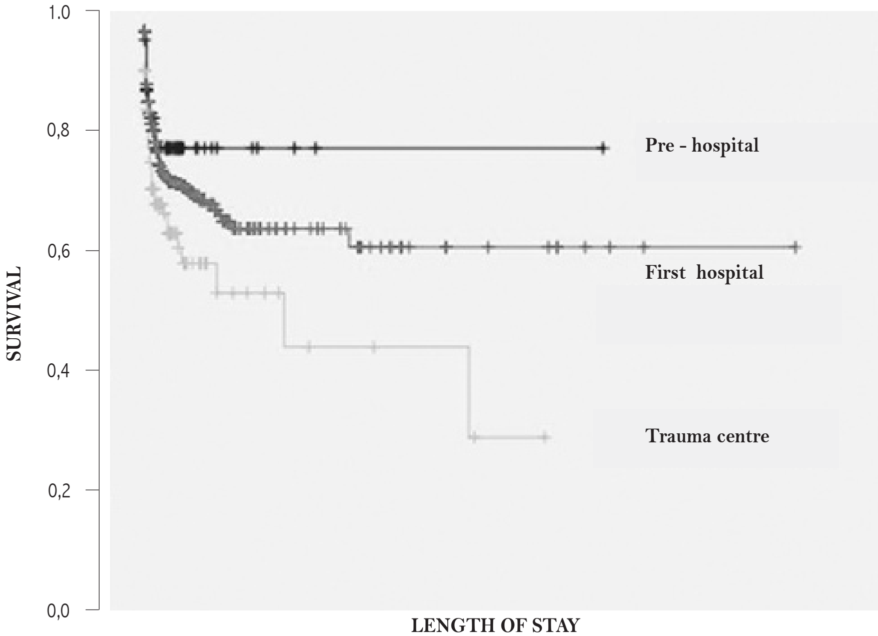

Figura 8 | Survival curves for different places of treatment of life threatening events.

Table 7 | **Regression analysis for mortality.**

	OR	CI 95%	p
Gender			
Male	0.549	0.361-837	**0.005**
Age	1.105	1.006-1.024	**0.001**
ISS	1.044	1.025-1.063	**<0.001**
Type of trauma			
Blunt	1.193	0.087-0.429	**<0.001**
Life threatening events treatment			
Pre hospital	1.000	-	-
First hospital	1.457	0.656-3.233	0.355
Tauma centre	3.256	1.276-8.309	**0.014**
RTS	0.617	0.535-0.713	**<0.001**

Variables in the model: gender, age, ISS, type of trauma, life threatening events treatment (pre hospital, first hospital or trauma centre), RTS and time from accident to trauma centre. Enter method was used.

Discussion

Limitations

Limitations are discussed in detail in a specific chapter afterwards; however some limitations need to be addressed now as they have implications for the comprehension and interpretation of this study. First we did not measure time from the traumatic event to treatment of life threatening events and assumed that patients that had events solved in pre-hospital had them solved earlier than patients that had them solved in primary or secondary hospital or trauma centre. We do not know this with certainty because the registry only records total time from injury till arrival in the trauma centre. However it is unlikely that patients assessed and treated in pre-hospital, by an emergency physician, had their events corrected later than patients that were transported to first hospital and then transferred to trauma centre.

A golden approach is more important to decrease mortality than a golden hour

In this thesis a new concept was developed: the Golden Approach concept. That concept was developed in opposition to the old concept of the *golden hour*. In this thesis, we argue that treatment of life threatening events prior to the arrival at trauma centre – i.e. a Golden Approach concept – may be more relevant to decreasing mortality than shortening the time to definitive care.

In this study we present a different approach to the old discussion on ALS vs. BLS in the pre-hospital scene. One of the problems of previous studies that failed to find improvement in outcome with pre-hospital ALS was the choice of the study population. It will always be difficult to prove the impact of the presence of an ALS team in a trauma scenario where a mix of severe with minor injuries is present some that need an immediate intervention and others whose intervention can be delayed. Assessing the impact of pre-trauma centre treatment of life threatening events and time to trauma centre on mortality was next step. We called a golden approach (GA) the pre-trauma centre treatment of life threatening events. We identified that the presence of a golden approach was associated with a better outcome. A reduction of almost 50% in raw mortality reduction was found for those patients having their life threatening events treated in the pre-hospital environment, when compared with those that had no GA. So the major benefit was observed for those trauma patients who had ALS in the pre-hospital phase. This observed benefit was maintained after adjustment for confounders in logistic regression analysis. As a result we believe that in the context of this report ALS at the scene (and the presence of a medical team with the ability to treat life threatening events) had a positive effect on mortality reduction.

In Europe it was traditional to use a system with pre-hospital physician-manned EMS but it has been difficult to prove its advantages over the use of paramedics and BLS in trauma care as the Americans do. In Portugal EMS physicians are highly skilled in ALS techniques. Admission to the emergency room with physician-manned EMS occurs in about 54% of the cases that arrive to the HGSA of which 70% come directly from the scene of accident and 30% via the referring local hospital [Gomes et al., 2010b (in press)].

Stocchetti and co-workers [Stocchetti, 2001] raised an hypothesis that might also help to understand our results. They found that the quality of the trauma system affects outcome because a better trauma system produces lower rates of favourable outcomes (in his study only deaths). The same result with a increase of early deaths and a decrease of late deaths was also reported recently by McGwin [McGwin et al., 2009]. This before-after study compares deaths distribution before and after a trauma system implementation using authopsy data. Because of this a large number of patients that might not be saved otherwise will survive and possibly with more severe disabilities and worse quality of life. To overcome this possible bias we analysed the subgroup of patients of transferred after we excluded primary transportation and found an important decrease in mortality in the pre-hospital treatment of life threatening events.

Several review papers discuss ALS vs. BLS in the pre-hospital phase. Liberman in a meta-analysis reviews and critiques the literature on ALS and BLS influence on outcome and concludes that it is not possible to demonstrate a clear benefit from on-site ALS in trauma [Liberman et al., 2000]. Bunn at al in another review supported by the WHO identifies only one small randomised study that is in favour of the ALS and concludes on the absence of evidence to support ALS in the pre-hospital setting [Bunn, 2001]. It is possible that different definitions for ALS and BLS, the study of only partial ALS techniques instead of the all concept, small samples and a retrospective methodology are the main reasons for the difficulty in showing a better relationship of ALS with outcome [Roudsari et al., 2007]. Although studies comparing ALS with BLS have been done before as far as we know the comparison was never performed in a well defined cohort where interventions were definitely needed to treat life threatening events. Our study is in accordance with recent papers showing benefit of ALS in the pre-hospital environment [Lossius et al., 2002; Osterwalder, 2002; Osterwalder, 2003] and others that show benefit from pre-hospital ALS only in specific groups of patients namely those with head injury [Coats et al., 1999; Garner et al., 2001; Klemen and Grmec, 2006; Rudehill et al., 2002].

Rurality and time to trauma centre are not independent determinants of mortality

Correcting life threatening events pre-trauma centre increased the total time from the accident to trauma centre. Several studies also found an increase in total pre-hospital time spent if ALS was dispatched to trauma patients [Birk and Henriksen, 2002; Reines et al., 1988; Sampalis et al., 1997]. However in our trauma system time from accident to trauma centre although also higher did not make a measurable difference in the mortality of severe trauma patients. This is in accordance with other European studies showing that long pre-hospital times were not associated with worse outcome [McGuffie et al., 2005; Osterwalder, 2002]. It is possible that the potential disadvantage of spending more time pre-trauma centre might have been diluted by the advantages of delivering good standards of care in the pre-hospital environment correcting life threatening events (GA).

A study from Liberman et al showed no benefit of ALS in urban areas in Canada [Liberman et al., 2003]. To reinforce that idea several other studies showed a benefit of pre-hospital ALS in rural and remote areas [Esposito et al., 1995; Gonzalez et al., 2006; McGuffie et al., 2005]. A possible explanation for our results, that would match these referred studies, would be that patients with a GA were predominantly from a rural area. Data from other studies in this trauma system [Gomes et al., 2010b (in press)] show that patients from rural areas have less access to ALS in the pre-hospital setting compared to trauma patients from urban areas (42% vs. 60%; $P<0.001$) and also that patients from rural areas have most of the time their life threatening problems corrected in the first hospital with only 13% ($P<0.001$) of patients with pre-hospital corrections of events. We show that transferred patients are predominantly from a rural area and take more time to get to the trauma centre. However our results also show that time to trauma centre and rurality are not independent factors for mortality in those trauma patients transferred to a trauma centre.

The ABCD methodology is a valid way to identify and treat life threatening events

Another important result is that this study strongly supports the importance of the ABCD methodology - a structured approach to assess and treat life threatening events in trauma patients. ABCD methodology is currently taught in different trauma courses. This finding is in accordance with other authors like Deakin who found that preventable pre-hospital deaths were related to failure to deliver good solutions to A, B and C life threatening events at the scene [Deakin and Davies, 1994].

Morbidity in Trauma | a six months follow-up study

Background and Aims

Traditionally the focus of trauma outcome was only on mortality but patient centred outcomes like health related quality of life (HRQol) have increasingly been recognised as important [Cameron et al., 2006]. Patient centred outcomes are gaining importance as a substantial proportion of severe trauma patients suffer from long term impairments, disabilities and changes in HRQol that have implications in the return to work and society tasks [Holbrook et al., 1998; Holbrook et al., 1999; MacKenzie et al., 1998; Patel et al., 2005; Vles et al., 2005]. Even patients with mild trauma might survive with moderate or severe disability in almost half of the cases [Thornhill et al., 2000]. Improving the chance of recovery implies that we know what determines it. Several studies have implicated factors as age, gender and injury related factors as determinants of functional outcome and quality of life in severe trauma [Butcher et al., 1996; Holbrook et al., 1998; Holbrook and Hoyt, 2004; Holbrook et al., 2001; Michaels et al., 2000; Murray et al., 2007; van der Sluis et al., 1995; Vles et al., 2005]. Previous studies from this trauma and follow-up registry reported that the main determinants of quality of life after severe trauma are severity (ISS), age, probability of survival (TRISS), LOS and gender [Gomes et al., 2006b; Gomes et al., 2006d; Santos et al., 2006c].

It is however complicated to analyse the consequences of major trauma. If injury characteristics, age and gender are non modifiable factors, process is possibly modifiable. We know that injury severity is a major outcome determinant, along with pre injury conditions and pre morbid state, but there are aspects from the process of care that might influence late outcome like what is done before arrival at the trauma centre. A well performed chain of survival is crucial for this patients starting at the pre-hospital scene and continuing to the place of definitive treatment at the trauma centre. However concerning the choice of the optimal pre-hospital model of care for trauma patients there is no agreement between experts. Several studies show a positive relationship of Advanced Life Support (ALS) in the decrease of mortality in the pre-hospital environment [Abbott et al., 1998; Baxt and Moody, 1987; Bunn, 2001; Celli et al., 1997; Liberman et al., 2000]. Other studies are in favour of the Basic Life Support (BLS) model for the pre-hospital care of trauma patients [Ivatury et al., 1987; Potter et al., 1988; Sampalis et al., 1993; Sampalis et al., 1997; Stiell et al., 2008]. Most of the literature addresses this subject comparing survival and only a few studies deal with late outcome or quality of life.

Previous studies have highlighted the importance of defining specific subgroups of patients that might benefit from pre-hospital ALS as well as the need to address implications on patient centred outcomes. The aims of this study were to assess mortality and late outcome of severe trauma patients admitted to a trauma centre and evaluate the implications of different pre-trauma centre approaches on the outcome. We hypothesise that trauma patients having life threatening events treated in the pre-hospital scene (pre-hospital ALS) will have a better outcome compared to those that were treated later in first hospital or trauma centre.

Patients and Methods

This study setting and data collection has been described in detail in the previous chapters. All trauma patients admitted to the Emergency Room of HGSA between August 2001 and December 2007 were enrolled in this study as they entered the trauma registry and the follow-up registry. Follow-up variables were collected using a web base data base that was accessed by the physician or patient when a self rating questionnaire was the case. For the purpose of this study only data concerning EQ-5D and GOSE will be reported. This are the instruments that have been recommended in a consensus conference to use in trauma patients [Brooks, 1996; Brooks et al., 1991]. The used instruments have been described in detail in the Generic methods section.

First, all trauma patients will be analysed, then specific subpopulations like penetrating trauma and thoracic trauma will be described and finally another analysis will be done to address the objective of relating pre-trauma centre approach to outcome. In the previous chapter only transferred patients were analysed, in this chapter a separated analyses including primary admissions will be done.

Main Results

General Results

First, here is a description of all trauma patients seen in the follow-up clinic. The survivor characteristics are in most aspects similar to the general characteristics of the population as seen in previous chapters. Most of the survivors are young males that suffered blunt trauma and a road traffic accident. Concerning severity however survivors are less severe than the general population but nevertheless with high severity (median ISS of 24). Survivor characteristics are show in table 8. Table 9 concerns GOSE and Table 10 concerns EQ-5D dimensions and summary measures (VAS and Index).

Table 8 | All survivors characteristics

	Survivors (n = 309)
Gender, n (%)	
Male	246(80)
Age, mean (SD)	40(18)
Type of trauma n (%)	
Blunt	290(94)
Mechanism of injury n (%)	
Road traffic accident	187(61)
Fall	85(28)
Stabbing	5(2)
Gunshot	8(3)
Severity, mean (SD)	
ISS	24(11)
RTS	6.3(1.2)
TRISS	81(22)
LOS, median (IQR)	
ICU	8(3-15)
Hospital	18(12-34)

Tables 9 and 10 describe the disabilities and quality of life for this population. We can see that 63% had a favourable outcome with 38% having a good recovery, only 4 patients stayed in persistent vegetative state. Concerning quality of life 52%, 61%, 50% and 45% had no problems in the domains of mobility, self-care, pain/discomfort and anxiety/depression respectively. However concerning return to work only 34% had no problems in this domain. EQ-5D VAS was 60% and Index 67%.

The comparison of outcome, namely morbidity was performed between patients living in rural areas and patients living in urban areas. We were not able to find differences in outcome between the two groups. [Gomes et al., 2010b (in press)] Several other studies were performed in different subpopulations addressing specific research questions all concerning late outcome in this trauma system. A report only in thoracic trauma showed that the main determinants of outcome were ISS, RTS and ICU LOS but not ARDS [Gomes et al., 2007d]. A study performed only in penetrating trauma found that this patients had a reduction on quality of life similar to the blunt trauma survivors [Santos et al., 2006c]. A study addressing determinants of late outcome showed that trauma severity (ISS, RTS, TRISS) along with age were the main determinants of quality of life at 6 months [Gomes et al., 2006b; Gomes et al., 2006d].

Table 9 | All survivors GOSE description

Extended Glasgow Outcome Scale	n (%)
2 | Persistent Vegetative	4(1)
3 | Lower Severe Disability	43(15)
4 | Upper Severe Disability	55(20)
5 | Lower Moderate Disability	13(5)
6 | Upper Moderate Disability	57(20)
7 | Lower Good Recovery	43(15)
8 | Upper Good Recovery	64(23)

Table 10 | All survivors EQ - 5D description

ED - 5D Questionnaire	
Mobility, n (%)	
I have no problems in walking about	144 (52)
I have some problems in walking about	121(43)
I am confined to bed	14(5)
Self - care, n (%)	
I have no problems with self-care	170(61)
I have some problems washing or dressing myself	71(25)
I am unable to wash or dress myself	38(14)
Usual activities, n (%)	
I have no problems with performing my usual activities	94(34)
I have some problems with performing my usual activities	101(36)
I m unable to performing my usual activities	84(30)
Pain / Discomfort, n (%)	
I have no pain or discomfort	139(50)
I have moderate pain or discomfort	123(44)
I have extreme pain or discomfort	17(6)
Anxiety / Depression, n (%)	
I am not anxious or depressed	126(45)
I am moderately anxious or depressed	107(38)
I am extremely anxious or depressed	46(17)
Health state today compared with 12 months ago, n (%)	
Better	53(19)
The same	68(24)
Worse	156(56)
EQ VAS in a 100% scale, median (P25 - P75)	60(50-80)
EQ Index, median (P25 - P75)	67(44-90)

The effect of the golden approach on late outcome

Specific methodology

Life threatening events and treatment

Previous studies have highlighted the importance of defining specific subgroups of patients that might benefit from pre-hospital ALS. We included only trauma patients that had a life threatening event to have a subgroup of patients that would most benefit from ALS in the pre-hospital scene.

Moreover we divided the patients into pre-hospital, first hospital and trauma centre depending on the moment when life threatening events were treated. So the patients in the pre-hospital group had pre-hospital treatment of the life threatening event; patients in the first hospital group didn't have pre-hospital treatment to their life threatening event that was treated in the first hospital; trauma centre group includes patients that arrived at the trauma centre with life threatening events not treated previously. The treatment of life threatening events in the pre-hospital setting implied the availability of an ALS team. Life threatening events were defined as occurrences in the airway (A), breathing (B), circulation (C) or neurological disability (D) that could threaten life. This has been described in detail in the previous chapter. When several life threatening events were identified in the same patient, we considered the first one in alphabetic order to be treated, as defined by medical educational principles. Patients without life threatening events or without sufficient information were excluded form the study (n=77).

Primary admissions vs. transfers

A primary admission was considered when patients arrived directly from the trauma scene. Transfers were considered when the patient arrived transferred from another hospital in the trauma system.

Time to trauma centre

Time to trauma centre was defined as time from the accident occurrence to the arrival at the level I trauma centre (HGSA). Time was measured in minutes.

Rural vs. urban

Patients were divided into rural and urban according to the residence area. To do the division we used the *Tipologia das áreas urbanas, 1998* from the Portuguese Statistics Institute - INE [INE, 1998] that defines urban a region with a population density equal or superior to 500 inhab/km^2 or if having more than 5000 in habitants in a place.

Outcomes

Early outcome measures were Intensive Care (ICU) length of stay (LOS), hospital LOS, HGSA mortality. Late outcome measures were post discharge mortality, Disability and Health Related Quality of life at six months after trauma.

Six months after the injury all the hospital survivors were contacted for a follow-up consultation. At the follow-up clinic they were assessed with a structured interview and several self administered tests. For the purpose of this study only the data concerning quality of life (EQ-5D) and Extended Glasgow Outcome Scale (GOSE) will be reported. Both instruments were previously recommended to measure late outcome in trauma by a panel of experts [Bouillon et al., 2002]. Consent was presumed when the patient attended the consultation.

The EuroQol instrument (EQ-5D) measures Health Related Quality of Life in a generic way and was designed for self-completion [Brooks, 1996]. It is cognitively simple, taking only a few minutes to complete. In this instrument, health is defined along five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension has three levels: no problem, moderate problem or severe problem. In the second part of the instrument, respondents recorded their health status on a visual analogue scale (VAS), between 0 (worst imaginable health state) and 100 (best imaginable health state). An index can be calculated (EQ Index), based on the patients answers to the previous described domains, it also ranges from 0 to 100.

Extended Glasgow Outcome Scale (GOSE) is an eight point scale that classifies the ability of the patient to carry out different aspects of daily activities. It varies from 1 to 8. It classifies the patients into the following categories: death (1), vegetative state (2), lower and upper severe disability (3,4), lower and upper moderate disability (5,6) and lower and upper good recovery (7,8). It is more discriminative than the Glasgow Outcome Scale (GOS) [Jennett and Bond, 1975] for moderate disability and good recovery.

Data analysis

Both EQ-5D and GOSE were categorized to allow analysis. GOSE was dichotomized into favorable outcome (GOSE 5-8 for patients able to live independently) and unfavorable outcome (GOSE 2-4 for patients unable to live an independent life) [McHugh et al., 2007; Murray et al., 2007]. EQ-5D was categorized into three variables per domain (no problems, moderate problems and major problems). For the analysis of the overall outcome, all deaths were included and attributed the score one for the GOSE calculation and set to zero for the EQ-5D index calculation following recommendations from Billingham [Billingham and Abrams, 2002]. Enter method was used.

Specific Results

From January 2003 eight hundred and thirty one patients were enrolled in the prospective trauma registry. 77 patients were excluded from further analysis because of missing data. The analysis from this point on is from 754 patients. Two hundred and fourteen patients died in hospital (28,3%) and mortality after hospital discharge was 4,5%. It was not possible to contact 109 patients (21.5%) because telephone numbers or a valid address was not available in the hospital records. Three hundred and thirty three patients were alive at 6 months and 280 patients (84%) were successfully assessed at 6 months after injury. The overall known follow-up patients were 77%. Concerning non respondents 8 refused the consultation, 5 could not come because were living in an institution, 24 missed the consultation and 16 where still in a hospital ward. In figure 9 a follow-up chart is depicted.

Sample patient characteristics

In table 11 population characteristics along with the differences between primary admissions and transfers can be seen. The majority (78%) of patients were male with a mean age of 44 years (SD ± 20). The most common mechanism of injury was blunt trauma (93%), the majority being road traffic accidents (56%) followed by falls in 30% of the cases. The mean ISS score was 26 (12) mean RTS was 5.9 (1.2) and mean probability of survival (TRISS) was 69%.

Life threatening events and group of treatment are also shown in table 10. Most patients (75%) had life threatening events related to neurological disability (D event) and we found airway events, breathing events and circulation events in 5%, 9% and 11% respectively. Most patients had their problems corrected pre-trauma centre namely in the first hospital (68%). An ALS team was present in the pre-hospital environment and corrected life threatening events in 173 patients (pre-hospital; 23%). The correction of life threate-ning events was delayed till arrival at the trauma centre in 67 (9%) patients. Comparison between transfers and primary admission showed differences only in the type of trauma with penetrating trauma (namely stabbings) predominating in the primary admission group.

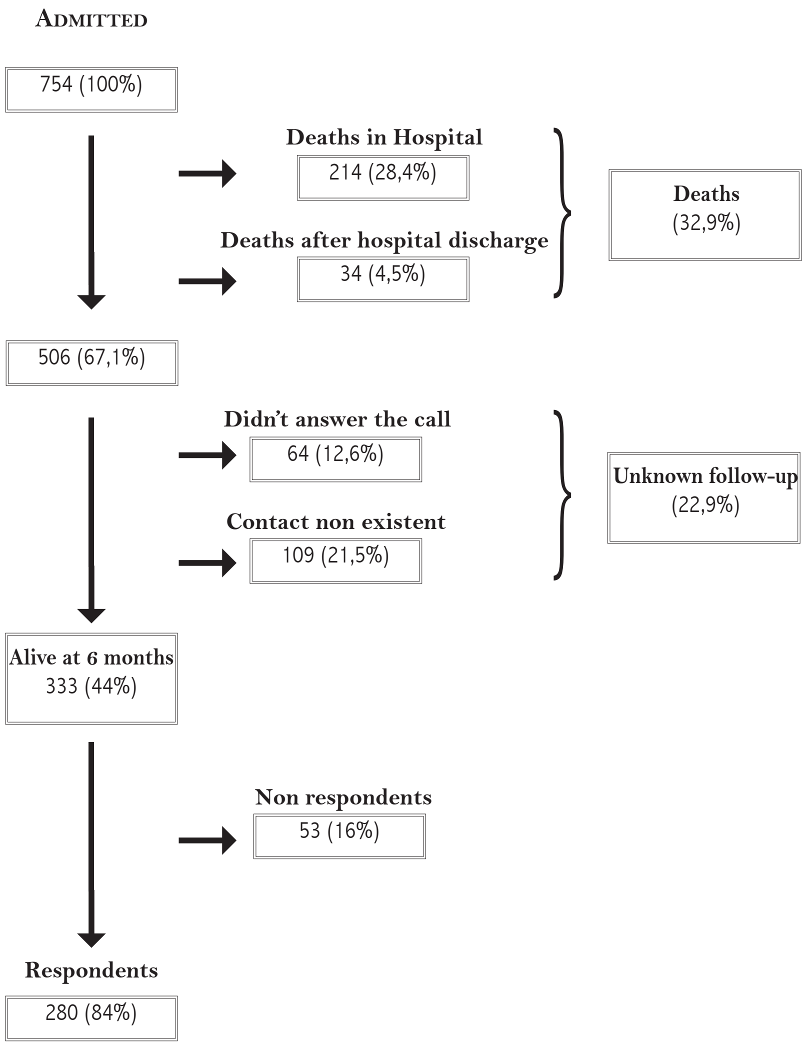

Figura 9 | Follow - up chart.

Comparison between transfers and primary admissions showed significant differences in the type of trauma with penetrating trauma (namely stabbings) predominating in the primary admission group. In primary admission patients life threatening problems were corrected at the pre-hospital scene in 60% of cases whereas for transfers this occurred only in 10%. ($p<0.001$). Median time to trauma centre was one hour for primary admissions and more than four hours for transfers ($p<0.001$). Patients transferred were from rural areas in 48% of cases and primary admissions were from rural areas in 8% of cases only ($p<0.001$).

Mortality

The overall mortality in the studied population was 33%, for transfers 36% and for primary admissions 32%. When the analysis was restricted to the subgroup of patients transferred from other hospitals, we found a significant higher mortality for patients who had had their life threatening events corrected late in trauma centre (46%) compared to the ones who had the life threatening events corrected in pre-hospital setting (18%; $p=0.002$). Different logistic regression models were then built for the all population, primary admissions and transfer patients. It shows that age, ISS and RTS are mortality determinant in all groups. Place of treatment of life threatening events was a determinant only for the transfers group. In that groups having events only corrected in the trauma centre increase the odds of death 3.3 times compared to a correction in the pre-hospital scene (table 12). The introduction of rurality in the regression model did not show an independent relation to mortality.

Table 11 | Sample population characteristics.

	All patients n=754	Primary admissions n=193	Transfers n=561	p
Gender, n (%)				
Male	589(78)	154(79)	435(78)	0.514 [1]
Age, mean (SD)	44(20)	42(20)	45(20)	0.051 [2]
Type of trauma, n (%)				
Blunt	702(93)	168(83)	543(95)	**<0.001**
Mechanism of injury, n (%)				
Road traffic accident	419(56)	107(55)	312(56)	
Fall	228(30)	54(28)	174(31)	
Other, blunt	63(8)	13(7)	50(9)	**<0.001**
Stabbing	12(2)	11(6)	1(0.2)	
Gunshot	32(4)	8(4)	24(4)	
Severity, mean (SD)				
ISS	26(12)	25(13)	26(11)	0,179 [3]
RTS	5.9(1.4)	5.9(1.6)	5.9(1.3)	0,727 [3]
TRISS	69(29)	71(32)	69(28)	0,072 [3]
LOS, median IQR	12(4-25)	12(2-29)	12(5-24)	0,381 [3]
Treatment of life-threatening events, n (%)				
Pre hospital	173(23)	116(60)	56(10)	
First hospital	514(68)	74(40)	442(79)	**<0.001**
Trauma centre	67(9)		61(11)	
Life - threatening events, n (%)				
A, n(%)	36(5)	12(6)	24(4)	
B, n(%)	64(9)	16(8)	48(9)	
C, n(%)	79(11)	20(11)	46(8)	0.053 [1]
D, n(%)	573(75)	145(75)	441(79)	
Time to TC, median IQR	3:34(1:51-5:58)	1:02(0:46-1:40)	4:34(2:54-7:00)	**<0.001**
Rural, n (%)	280(40)	33(12)	247(88)	**<0.001**
Mortality, n (%)	213(28)	65(34)	148(26)	0.052

[1] Chi squares test; [2] Independent sample T test; [3] Mann Withney Test; * Comparison between primary admissions and transfers.

Table 12 | Regression analysis for mortality in the sample population.

	All patients OR	p	Transfers OR	p	Primary admissions OR	p
Gender						
Male	0.074	0.704	0.622	0.059	1.386	0.518
Age	1.017	**<0.001**	1.016	**0.003**	1.024	**0.017**
RTS	0.524	**<0.001**	0.572	**<0.001**	0.396	**<0.001**
ISS	1.042	**<0.001**	1.041	**<0.001**	1.042	**0.009**
Blunt trauma	0.331	**0.001**	0.236	**0.002**	0.670	0.504
Life threatening event treatment						
First hospital	1.043	0.792	1.668	0.219		
Trauma centre	1.827	0.097	3.376	0.016	1.76	0.201
C Statistic	0.793		0.770		0.850	

Logistic regression model using the Enter method. Total number of deaths n = 248 and survivors n= 333 were analysed. First hospital and trauma treatment in comparison with pre hospital treatment of life threatening events (Pre hospital ALS).

<u>Patient centred outcomes</u>

Table 13 shows characteristics of the survivors evaluated at 6 months compared to the non responders. Comparison between responders and non responders showed no differences namely concerning treatment of life threatening events. Survivors were male (80%) with a mean age of 40 years (SD ± 18). The most common mechanism of injury was blunt trauma (95%), the majority being road traffic accidents (61%) followed by falls in 27% of the cases. The mean ISS score was 25 (11.2) mean RTS was 6.3 (1.2) and mean TRISS was 79% (23%).

A comparison between respondents and patients without contact was also done. That comparison showed that patients not contacted were younger and less severely injured. It is possible that we show the worst scenario achievable.

In table 14 a detailed characterization of disability and quality of life is depicted. At 6 months 54% of patients could walk without any problem, 61% had no problem at all in the self-care domain, 34% of patients had no problems with their usual activities, 55% had no problem in the pain and discomfort domain. Anxiety and Depression problems were present in 50% of patients. When we asked patients to compare their actual level of health with the six months previous to trauma 58% of them found they felt worse. When asked to graduate their health state in a visual analogue scale (VAS), the mean classification was 62% (IQR 50%-80%), and the result for the EQ-5D Index (a summary measure) was 0.66 (IQR 0.46-0.91). There were no significant differences in quality of life measured using EQ-5D and place of treatment of life threatening events (Figure 11).

Table 13 | Comparison between respondents and non respondents.

	Respondents (n=280)	**Non Respondents** (n=53)	**p**
Gender, n (%)			
Female	57(20)	11(21)	0.948[1]
Male	223(80)	42(79)	
Age, mean (SD)	40(18)	46(18)	0.069[2]
Type of trauma, n (%)			
Penetrating	15(5)	4(7)	0.519[1]
Blunt	265(95)	49(93)	
Mechanism of injury, n (%)			
Road traffic accident	171(61)	29(55)	
Fall	77(27)	15(28)	-
Other, blunt	21(8)	6(11)	
Stabbing	5(2)	0	
Gunshot	6(2)	3(5)	
Severity, n (%)			
ISS	25(11)	26(12)	0.585[3]
RTS	6.3(1.2)	6.3(1.3)	0.795[3]
TRISS	79(23)	75(25)	0.151[3]
Length of Stay, n (%)			
ICU	9(4-16)	10(6-18)	0.366[3]
Hospital	19(12-35)	18(9-33)	0.210[3]
Treatment of life-threatening events, n (%)			
Pre hospital	70(25)	13(25)	0.845[1]
First hospital	188(68)	35(66)	
Trauma centre	20(7)	5(9)	

[1] Chi squares test; [2] Independent sample T test; [3] Mann Withney Test.

Table 14 | Late outcome measured using EQ - 5D and GOSE

EQ-5D domains	Total (n=280)	Pre hospital (n=71)	First hospital (n=189)	Trauma centre (n=20)	p
Mobility, n (%)					
No problems	151(54)	37(53)	100(53)	14(70)	
Moderate problems	113(40)	29(40)	79(42)	5(25)	-
Severe problems	16(6)	5(7)	10(5)	1(5)	
Self - care, n (%)					
No problems	172(61)	41(58)	116(61)	15(75)	
Moderate problems	64(23)	18(25)	43(23)	3(15)	-
Severe problems	44(16)	12(17)	30(16)	2(10)	
Usual activities, n (%)					
No problems	95(34)	22(31)	62(33)	11(55)	
Moderate problems	92(33)	26(37)	62(33)	4(20)	0.322[1]
Severe problems	93(33)	23(32)	65(34)	5(25)	
Pain / Discomfort, n (%)					
No problems	155(55)	41(58)	102(54)	12(60)	
Moderate problems	113(40)	29(41)	77(41)	7(35)	-
Severe problems	12(4)	1(1)	10(5)	1(5)	
Anxiety / Depression, mean (SD)					
No problems	139(50)	40(56)	87(46)	12(60)	
Moderate problems	102(36)	19(27)	79(42)	4(20)	0.100[1]
Severe problems	39(14)	12(17)	23(12)	4(20)	

EQ-5D summary	Total (n=280)	Pre hospital (n=71)	First hospital (n=189)	Trauma centre (n=20)	p
Index, median IQR	66(47-91)	62(50-91)	67(44-85)	85(61-91)	**0.023[3]**
VAS, median IQR	60(50-80)	60(50-80)	60(50-80)	70(50-90)	0.721[3]

GOSE	Total (n=280)	Pre hospital (n=71)	First hospital (n=189)	Trauma centre (n=20)	p
Favorable n(%)	181(65)	45(63)	121(64)	15(75)	0.600[1]
Unfavorable n(%)	99(35)	26(37)	68(36)	5(25)	

[1] Chi squares test; [2] Independent sample T test; [3] Kruskall Wallis Test.

Resuming normal occupation and social activities (Good recovery – GOSE=7-8) was possible for 39% of survivors while 25% were disabled but independent (GOSE=5-6) and 34% were dependent (GOSE=4-3). Only 1% was in vegetative state (GOSE=2). A favourable outcome (GOSE of 5, 6, 7 and 8) was then possible for 65% of the patients. There were no significant differences in disability measured using GOSE and place of treatment of life threatening events (Figure 10).

Figura 10 | Disability in the survivors of severe trauma.
% of patients with a favourable outcome in the three subgroup (p= 0.600).

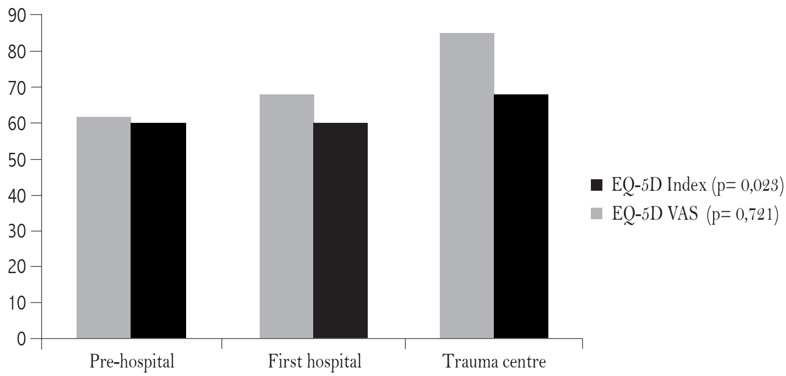

Figura 11 | Quality of life in the survivors of severe trauma.

Several logistic regression models were also built using EQ-5D Index and GOSE as dependent variables and age, gender, type of trauma, ISS, RTS, rurality and pre-trauma centre approach as dependent predictors; for all population, primary admissions and transfers (table 15 and 16). These models shoed that age, RTS and ISS (main determinants of survival) are also determinants of disability and quality of life but that pre-trauma centre approach did not affect either disability or quality of life of survivors. Rurality *per se* was not a determinant of mortality or patient centred outcomes.

Table 15 | Regression analysis for unfavourable outcome (GOSE 1-4).

	All patients OR	p	Transfers OR	p	Primary admissions OR	p
Gender						
Male	0.581	0.047	0.544	0.052	0.571	0.369
Age	1.040	**<0.001**	1.045	**<0.001**	1.027	**0.019**
RTS	0.577	**<0.001**	0.572	**<0.001**	0.601	**0.001**
ISS	1.039	**<0.001**	1.037	**0.003**	1.047	**0.016**
Blunt trauma	0.555	0.169	0.251	0.054	1,230	0,726
Life threatening event treatment						
First hospital	1.057	0.831	1.983	0.103		
Trauma centre	1.368	0.486	2.626	0.095	0.810	0.650
C Statistic	0.785		0.795		0.773	

Logistic regression model using the Enter method. Total number of deaths n = 248 and respondents n= 280 were analysed. First hospital and trauma centre treatment in comparison with pre hospital treatment of life threatening events (Pre hospital ALS).

Overall outcome

A more integrated view of outcome including deaths and disabilities or quality of life in the same analysis is possible using the GOSE test computing deaths as 1 and using the EQ-5D test attributing to deaths zero punctuation in the summary measure. Mean EQ-5D index was 35.1 (37.5) and mean GOSE was 3.5 (2.7) and there were no significant differences for pre-hospital, first hospital or trauma centre correction of life threatening events.

Table 16 | Regression analysis for EQ-5D Index.

	All patients OR	p	Transfers OR	p	Primary admissions OR	p
Gender						
Male	0.073	0.205	0.062	0.355	0.084	0.474
Age	-0.297	**<0.001**	-0.303	**<0.001**	-0.293	**0.015**
RTS	0.062	0.287	0.037	0.590	0.092	0.426
ISS	-0.178	**0.002**	-0.183	**0.007**	-0.188	0.098
Blunt trauma	-0.087	0.128	0.035	0.603	-0.241	**0.036**
First hospital	0.036	0.570	0.001	0.933		
Trauma centre	0.087	0.168	0.067	0.440	0.179	0.123

Linear regression model using the Enter method. EQ-5D index was used as a continuos variable. First hospital and trauma centre tratment in comparsion with pre-hospital treatment of life threating events (Pre hospital ALS). n=280 survivors.

Discussion

Limitations

The present study has limitations and the results must be comprehended under their knowledge. As this is not a population based study we cannot comment or generalize on the implications of the different pre-trauma centre approaches on pre-trauma centre mortality. However what we can say is transfer patients able to arrive at the trauma centre had lower mortality if their life threatening events were corrected in the pre-hospital scene by an ALS team.

We focused on outcome at 6 months which is a common period to assess outcome in polytrauma and head trauma patients. However adaptation and evolution continues after 6 months and it is possible that another result would be found if we measure outcome later. Nevertheless and again the scenario we present in this study is probably the worst possible as disabilities and quality of life tend to improve or at least stabilize over time.

Finally the number of patients with life threatening events treated in the pre-hospital scene and in trauma centre was relatively small compared to the proportion of patients whose problems were corrected in a first hospital. That result reflects our trauma system design where pre-hospital ALS is not generalized and where most of the patients are derived to a first hospital before being transferred to trauma centres. However we think those differences in case mix do not limit the generalization of our conclusions and that they even permit to access different pre-trauma centre approaches that would be almost impossible without randomised controlled studies.

Implications of early correction of life threatening events

The central message of this manuscript is that treating life threatening events early in the pre-hospital setting decreased mortality at the trauma centre for the transfer subgroup of patients and did not seam to play a determinant role in disability or quality of life of survivors. In other words pre-hospital ALS decreased mortality in patients that had the injury in a geographical area where had to be admitted to a first hospital before the trauma centre. However, for primary admissions that advantage was not observed either in mortality or patient centre outcomes.

In this study we present a different approach to the old discussion on ALS vs. BLS in the pre-hospital scene. One of the problems of previous studies that failed to find improvement in outcome with pre-hospital ALS was the choice of the study population. It will always be difficult to prove the impact of the presence of an ALS team in a trauma scenario where a mix of severe with minor injuries is present some that need an immediate intervention and others whose intervention can be delayed. That is why in this study only trauma patients that had a life threatening event (aiming at increasing the chances to detect any advantage of pre-hospital ALS) were included and divided in 3 groups concerning the treatment: pre-hospital, first hospital or trauma centre. Our interpretation of findings is that for patients in primary admission, predominantly from urban areas and that arrive at the trauma centre in less than one hour, the pre-hospital correction of life threatening events does not make a measurable impact on mortality or morbidity. For patients transferred, predominantly from rural areas and that take in median four hours to arrive at the trauma centre, the correction of life threatening events in pre-hospital scene decreases mortality measured at the trauma centre.

There are not many studies addressing ALS vs. BLS in the pre-hospital scene for trauma patients mainly if we are looking for outcomes other than mortality. It is not the purpose of this study to revise the literature on the subject but there are some studies that deserve a discussion. Coats and co-authors in a paper published in JAMA [Coats et al., 1999] discussed the outcomes after traumatic brain injury using GOS to describe outcome of patients treated by a trauma system with ALS in the pre-hospital scene. They concluded that there was no increment of unfavourable outcomes and showed an overall favourable outcome (deaths were taken into account) in 34% of the patients. We report a similar favourable outcome in our patients. Our study is also consistent with a study from Di Bartolomeo [Di Bartolomeo et al., 2004] that compared outcome using GOS and mortality in an Italian trauma system, with different ALS or BLS approaches and found no differences in mortality or in late outcome. Some studies were able to show a better late outcome for patients treated with ALS [Garner et al., 2001; Klemen and Grmec, 2006] and others a worse [Baxt and Moody, 1987; Nicholl et al., 1995] illustrating the need for randomised controlled studies and the study of specific subgroups of patients where ALS might have a higher impact.

A recent before-after controlled clinical trial study from Canada [Stiell et al., 2008] shows an increase in mortality with ALS implementation and no change in late outcome measured using Functional Independence Measure (FIM). Comparison with our report is difficult as the Canadian study compares ALS done by trained paramedics in urban scenarios. In our study ALS means the presence of a doctor that identifies and corrects the life threatening events that each patient had in either rural or urban scenarios. Nevertheless the subgroup of patients admitted directly from the scene would be the ones to compare with this study. We didn't confirm an increase in mortality with pre-hospital ALS but we were not able to show a benefit as we did for the transfer patients.

Concerning the measure of health related quality of life in this ALS vs. BLS controversy, literature is even scarcer. We found only one study that uses EQ-5D as we did. Oppe [Oppe and De Charro, 2001] studies the effect of a specific ALS team (helicopter critical care team) in the outcome of trauma patients using EQ-5D and was not able to find differences between the groups. Our results were similar.

Stocchetti and co-workers[Stocchetti, 2001] raised an hypothesis that might also help to understand our results. They found that the quality of the trauma system affects outcome because a better trauma system produces lower rates of favourable outcomes (in is study only deaths). This paradox is owing to the fact that a more efficient pre-hospital system brings to hospital even the most severe cases. Because of this a large number of patients that might not be saved otherwise will survive and possibly with more severe disabilities and worst quality of life. To overcome this possible bias we analysed separately transfers and primary admissions.

Patient centred outcomes

Another important message from this report is that severe trauma was associated with important limitations in most aspects of everyday life measured either by EQ-5D or GOSE. This is in accordance with the literature [Gabbe et al., 2006; Holtslag et al., 2007; Marmarou et al., 2007; McHugh et al., 2007; Meerding et al., 2004; Mushkudiani et al., 2007; Myburgh et al., 2008; Vles et al., 2005].

There is a growing body of evidence on the determinants of outcome after trauma but not many studies that, like we do, report disability using GOSE and quality of life using EQ-5D test, making comparisons difficult. Similar to our results Myburgh [Myburgh et al., 2008] report 60% of favourable outcomes in severe trauma patients. Murray and Mushkudiani in reports from the IMPACT study [Murray et al., 2007; Mushkudiani et al., 2007] use GOS as an outcome measure and like us found age but not gender as determinants of disability. Vles [Vles et al., 2005] using EQ-5D and GOSE find gender (woman worse), ISS and body areas affected (brain and spine are worse) the main determinants of outcome. A report from the Trauma Recovery Project [Holbrook and Hoyt, 2004] also shows that quality of life is worse in women than in men but EQ-5D is not used to measure quality of life. We were in fact also able to relate gender to outcome in the all population of patients also with woman having a worse outcome. However that difference was not evident when we divided the patients into primary admissions and transfers. Magnotti found in more than 36 thousand patients no gender differences in determining mortality [Magnotti et al., 2008]. This is similar to what we reported. However in contrast to our study they also report that male gender was associated with increased morbidity. It is important to say however that they do not analyse late outcome using a measure of disability or quality if life. Meerding used EQ-5D in a population based study from the Netherlands and shows also age, gender, type of injury, LOS, ICU admission, spine and extremities as determinants of late functional outcome [Meerding et al., 2004]. Holtslag and colleges also found specific body areas affected (head, TVM, extremities) as determinants of disability using GOS and EQ-5D [Holtslag et al., 2007]. They did not find age, gender or severity as determinants of GOS or quality of life. The difference to our report is that these authors studied also other factors that in the end were more important to morbidity - education and co-morbidities.

Discussion

Main Limitations

The previous three chapters resumed the work done to answer the research questions and are the core for this thesis. At this point it is important to make a summary of common limitations and main findings from the entire study.

Identifying weaknesses is the first step towards improving research methodology and formulating new questions. It is also vital in validation and extrapolation of results. That is why limitations for each of the studies were discussed in the proper place in each chapter. Limitations that are common to the entire thesis will be discussed here.

Confounding variables

First, this is a retrospective analysis based on data collected prospectively in a trauma centre registry. The fact that the collection of data was not directly linked to the research questions could raise some threats to internal validity of the studies. The presence of confounding variables (it is possible that other variables not measured in the study could have influenced the outcome) is one of the threats. Hospital mortality, overall mortality and late outcome (disabilities and quality of life) may have been influenced also by the quality of HGSA care and possible differences in patient handling after reaching the trauma centre. That was not measured in this study. However as late mortality (2 days and 2 weeks peaks) accounts for only 25% of cases we believe that the influence of the process of care at the trauma centre is limited compared to the influence of pre-hospital or first hospital care. Another point is that restrictive inclusion and exclusion criteria were used to maximize the internal and external validity of this study. Because primary trauma transportations and secondary transfers occur in different types of trauma patient these groups were always analysed separately to prevent either exposure introducing bias and/or confounding results.

Hospital based vs. population based registry

Second, the discussion of the *golden hour* concept included only severe trauma patients that were admitted to a trauma centre. As this was not a population based study we cannot comment or generalize on the implications of the different pre-trauma centre approaches on pre-trauma centre mortality. However what we can say is that patients able to arrive at the trauma centre had lower mortality if their life threatening events were corrected in the pre-hospital scene by an ALS team. Due to the Tetramodal Pattern of death in trauma previously described, it is possible and even probable that the impact on early mortality would be even higher in that context.

Information bias

Information bias may occur if data are missing or unobtainable for certain cases. That is what happened partially in the late outcome analysis. A known outcome in at least 70% of patients is recommended by McLellan [McLellan et al., 1996] as the minimum standard for outcome evaluation. Concerning late outcome investigation, we have 22.9% of unknown outcomes (most of them because of incorrect contacts in the hospital records) witch is perfectly acceptable for that kind of study. Unknown outcomes could include deaths after discharge and survivors that have completely recovered and don't have any symptom or those who have extreme symptoms. Either could have influence the results of late outcome. On the other hand the extensive unknown follow-up population study (responders vs. non responders vs. contacts not known) showed that these patients were the less severe ones. It is therefore likely that the numbers of unknown of late deaths are small. The severity measured by ISS and ICU LOS was lower for the unknown outcome group of patients making us consider also that the scenario we describe is the worst possible and if the non responders would come to the consultation the overall outcome in this study would be better.

Timing of follow-up

The focus on outcome at 6 months is a common period to assess outcome in polytrauma and head trauma patients. However adaptation and evolution continues after 6 months and it is possible that another result would be found if we measure outcome later. Nevertheless and again the scenario we present in this study is probably the worst possible as disabilities and quality of life tend to improve or at least stabilize over time.

Number of events

Finally, the number of patients with life threatening events treated in the pre-hospital scene and in trauma centre was relatively small compared to the proportion of patients whose problems were corrected in a first hospital. That derived from the fact that this is an observational study and that events were not distributed evenly. This is also prone to bias such as selection and information bias. That result reflects our trauma system design where pre-hospital ALS is not generalized and where most of the patients are transported to a first hospital before being transferred to trauma centres. However we think those differences in case mix do not limit the generalization of our conclusions and that they even permit to access different pre-trauma centre approaches that would be almost impossible without randomised controlled studies.

Summary of main findings

The main findings have been discussed in detail in each one of the three previous chapters. However, and because next step is to highlight new paradigms and make recommendations, it is important at this stage to make a summary of main findings rose by this study. They are as follow:

1 Mortality distribution in our trauma system as a Tetramodal pattern.

2 A Golden Approach – treating life threatening event prior to transfer to trauma centre – is more important to decrease mortality than a *golden hour.*

3 Treating life threatening events early in the pre-hospital setting (pre-hospital ALS) decreased the mortality of severe trauma patients transferred to the trauma centre but had no measurable effect on disability or quality of life.

4 ALS in the pre-hospital setting did not have a measurable benefit in mortality, disability or the quality of life of severe trauma patients directly admitted to the trauma centre.

5 Rurality and time to trauma centre had no independent impact on trauma outcomes measured at the trauma centre.

6 Trauma related disabilities and compromises in quality of life are still important at 6 months after injury.

Further investigation

Uniform report of trauma is of paramount importance specifically the report of trauma deaths over time and patient centred outcomes. Only in that way will be possible to analyse larger data bases and produce recommendations for the future development of trauma systems. European health authorities should support the implementation of a European trauma registry.

In particular the research in this area in Portugal deserves further developments. The lack of research and quality data in Portugal is often a major barrier, as we tend to undermine the importance of the problem, even thought it is a major public health issue. The investigation project financed by the FCT I am involved in: Trauma grave - implicações da mortalidade e morbilidade na prática clínica [PIC/IC/83120/2007] will hopefully in the future contribute to these needs. Portuguese health authorities should implement or support the implementation of a national trauma registry.

This study has documented several epidemiological dimensions of trauma in Portugal, revealing the enormity of the local problem. This understanding should lead to more research and influence policies. Efforts will be amply rewarded if more focus is laid on strengthening research and placing trauma on the public health agenda of our governments. Unless systematic efforts are made in Portugal towards prevention, management and rehabilitation, many more individuals will continue to die or sustain disabilities and this will be a costly waste to our society.

New paradigms and main recommendations

In the previous chapters consequences of severe trauma were discussed. This outcome study has implications in the different areas of the patient care loop. The information on the outcome of major trauma should allow us to provide patients and relatives with better prognostic information. The treatment evaluation should help physicians to assess current strategies and to make well-grounded decisions for the future. Finally in relation to prevention and policy, data on the consequences of major trauma can be used to develop preventive measures or can be used to determine policies about national health care.

Following the discussion in the previous chapter two new paradigms can be put forward and recommendations made for the clinical practice and trauma system design.

Tetramodal mortality pattern

The trauma mortality distribution pattern is diverting from the traditional trimodal concept to include a fourth peak in the distribution corresponding to severe head trauma and older patients. Four peaks are now described: two minutes peak; two hours peak; two days peak and two weeks peak.

Recommendations:

1 **Special attention should be paid to prevention**: To decrease deaths at the incident scene (the 2 minutes peak – 53% of deaths) injury prevention initiatives are the most important ones as deaths happening at the scene are generally impossible to treat.

2 **The development of an effective trauma system is paramount**: To reduce the second peak of death (the 2 hours peak – 22%) we must

continue to support the development of pre-hospital EMS and in-hospital emergency room care, the development of trauma teams and trauma education, along with efforts on trauma system development to improve initial stabilization and expedite pathways of transfer to definitive care for those who need.

3 **Special attention should be drawn to ICU availability**: Concerning the 2 days peak of mortality (13%), ICU treatment is of paramount importance because mortality is increased due to severe head injury and aging of the population. In the last decades we observed enormous advances in resuscitation strategies, acceptance of *damage control* and improvement in diagnostic technology. Now we must put more effort into researching the optimal management of head injuries and old patients in the ICU environment. That recommendation is also important to deal with the latest 2 weeks peak of mortality (12%) paramount to prevent infection and multiple organ dysfunctions.

The Golden Approach paradigm

Trauma patients that arrive at the trauma centre with the life threatening events already treated (either in pre-hospital or first hospital) – *golden approach* – have a better outcome.

Recommendations:

4 The design of trauma systems should reinforce the ALS medically based pre-hospital team mainly in areas where the trauma centre is a long distance away. The pre-hospital presence of an ALS team that is able to treat life threatening events improves transferred patient mortality even if this prolonged time to trauma centre.

5 It is paramount to establish patient, family and society awareness about the burden of trauma. Rehabilitation strategies that link the other elements of the trauma system would be essential to close the loop of care for trauma patients.

6 A national trauma registry should be implemented. Only in that way further investigation on this or other subjects is possible.

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Addenda

Addenda 1 shows the published paper: *Mortality distribution in a trauma system: from data to health policy recommendations.*

Addenda 2 shows the published paper: *The importance of pre-trauma centre treatment of life-threatening events on the mortality of patients transferred with severe trauma.*

Addenda 3 shows the published paper: *O doente politraumatizado grave: implicações da ruralidade na mortalidade, incapacidade e qualidade de vida.*

Addenda 4 shows the trauma registry data base

Addenda 5 shows the follow-up registry data base

Addenda 6 shows the Euroqol questionnaire

Addenda 7 shows the Extended Glasgow Outcome Scale

Addenda 1

Mortality Distribution in a Trauma System: From Data to Health Policy Recommendations

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Abstract

Introduction: Trimodal distribution of deaths and the golden hour concepts are in part responsible for the genesis of all modern trauma systems but these concepts have been challenged recently. Our aim was to describe distribution of death in trauma using data from a trauma system and discuss what could be done from the organizational point of view to improve outcome.

Methods: We included all traumatic deaths occurring between 2001 and 2005 in a trauma system. Data on age, gender, time and place of injury, time of first and second hospital arrival, cause of trauma and type of accident, hospital characteristics, dominant injury and time of death were collected for this study. For mortality distribution the variable time was transformed applying a natural logarithm.

Results: A total of 1,436 deaths occurred over a period of 53 months; 52% at the scene, 18% in the level I trauma center, 21% in level III trauma center and the remaining in level IV/V trauma center. Death distribution using a logarithmic scale in minutes showed four peaks: deaths at the scene, deaths in the first hours, deaths in the first 2 days and finally, deaths in the second week that we referred as 2 min, 2 h, 2 days and 2 weeks peak. We found statistically significant differences in age and dominant injury concerning timing of death.

Conclusions: A tetramodal pattern of death distribution could be described. Our data support the need to focus on the treatment of severe head injuries namely in the intensive care environment.

Key Words

Trauma · Mortality distribution · Trauma system · Epidemiology

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Introduction

Trauma is a major cause of death in the world and the leading one from 5 to 44 years of age. Road traffic accidents (RTA), working accidents, self-inflicted injuries and interpersonal violence are the main causes for it. According to the World Health Organization more than 1.2 million people die in RTA every year and as many as 50 million people are injured or disabled. It is estimated that for the year 2020 trauma will be the 3rd cause of death in the world. In Europe, the problem is similar with trauma as the first cause of death up to 44 years of age [1].

Portugal is on the top of the list among European countries concerning trauma occurrence and mortality [2]. Data from the Portuguese Statistics National Department (INE) show that in the year 2004, the total number of RTA was 63.668 and 53.144 was the number of victims with 1,135 fatalities in place. Statistics show that the number of victims of trauma in 2004 was 109 per 100,000 inhabitants [3, 4]. Data concerning only head trauma patients showed an incidence of 137/

100,000 inhabitants in 1997 with a mortality rate of 17/100,000 inhabitants [5].

It is universally accepted that victims of trauma must be treated promptly using trained and experienced personnel along with adequate referral for the most appropriate hospital to continue the treatment. This is the "golden hour" concept. Despite the broad consensus regarding this concept and its usefulness as a training concept there is not much evidence to support it [6]. Another concept that is closely linked to this, is the "trimodal distribution" of deaths [7]. In this concept, trauma mortality is classically grouped into three peaks: immediate, early, and late deaths [8] where the first peak of death occurs at the time of the injury and is related to the severity of the primary injury to major organs or structures such as brain, heart or great vessels. It is stated that only prevention can reduce the incidence of these injuries. The second peak lasts until several hours after the injury has taken place. It is during this time that many causes of morbidity and mortality are preventable by avoidance of a secondary injury due to hypoxia, hemorrhage or any process that leads to inadequate tissue perfusion. The third peak of death occurs days or weeks after the injury and is usually due to sepsis and multiple organ failure.

These two concepts are in part responsible for the genesis of all the modern emergency systems that deal with trauma patients all over the world [9–12]. However, the trimodal distribution of trauma deaths is being increasingly challenged both by European and American authors [13–15].

Evaluation of the time and place of trauma deaths in a European setting along with the characterization of specific groups may help to resolve this issue and may provide valuable assessment of a trauma system and trauma centers identifying the areas that might benefit from prevention, education, research and allocation of resources.

Aim

Our aim was to understand the distribution of death in trauma patients using data from a Portuguese trauma system and to find clues from the organizational point of view to improve outcome.

Objectives

To analyze time and place of death in a trauma system, describing mortality distribution over time.

To compare distribution of deaths concerning age, gender, mechanism and type of injury, dominant injury and characteristics of hospital.

To compare mortality distribution in this trauma system, matching it with the classical "trimodal" distribution of deaths.

Materials and Methods

This study includes all trauma deaths occurring between August 2001 and December 2005 in the trauma system area of Hospital Geral de Santo António (HGSA). HGSA is a 600 bedded all-specialty university hospital, the level I trauma center for the city of Porto and a part of the north of Portugal. HGSA has about 150,000 emergency department cases per year with about 1,800 trauma patients [16]. This trauma system includes four districts of the north of Portugal (Bragança, Vila Real, Aveiro (partial) and Porto (partial)). The trauma system includes several small hospitals (corresponding to level IV/V trauma center) and only three hospitals with intensive care units (corresponding to level III trauma center). None of the hospitals in the trauma system have neurosurgery emergency coverage except HGSA. Hospital de Santo António covers a geographical area of 157,619 square kilometers with a population of 2,530,987 people, from whom almost 50% live in the major urban center, Porto [4]. The Emergency Medical System (EMS) within this region consists of a dispatch center that answers to all the emergency calls (112 calls) and sends the most appropriate response available, including medical involvement with five fast vehicles and one helicopter available in a 24 h basis [17]. By protocol all severe trauma patients will be admitted to the nearest hospital and then transferred to HGSA for continuation of care. The exceptions are death or presence of intensive care unit in the first hospital. In this situation if the patient does not need specific specialized trauma care, like vascular surgery, neurosurgical expertise or thoracic surgery, the patient can stay in the first hospital.

Trauma patients admitted to HGSA out of the geographical region previously described were excluded. Patients aged less than 13 years were also excluded because they are by protocol diverted to a pediatric hospital.

Data were recovered from the prospective trauma registry in HGSA and through ICD-9-CM (The International Classification of Diseases, 9th Revision, Clinical Modification) [18] and the Portuguese adaptation of Diagnosis Related Groups (DRGs) [19] in all other hospitals. The inclusion criteria were the presence of an external cause in the admission diagnosis (ICD9 E800-E999). We excluded all the patients with poisonings and overdoses (ICD9 E850-E869), drowning and suffocation (ICD9 E910-E915), burns (ICD9 E890-E899), iatrogenic accidents (ICD9 E870-E879) and patients who died after hospital discharge. Isolated hip fractures in patients over 65 years of age were also excluded.

Data concerning deaths in place were recovered from the INE and the RTA prevention registry (Direcção Geral de Viação – Observatório de Segurança Rodoviária).

Because of the heterogeneity and multiplicity of sources used for data collection the investigators used a consensus process to determine time from accident to death that was applied in 31% of all deaths. If the time of the accident was not recorded we estimated it from the location of accident and time of arrival at the first hospital.

The following data were collected for this study: age, gender, time and place of injury, time of first hospital arrival, time of second hospital arrival, cause of trauma and type of accident, hospital characteristics, dominant injury and time of death.

Concerning time of death we considered different time interval. At first victims were classified into several groups according to time of death to compare with the classical trimodal distribution: death out of hospital (Deaths at scene), death in the first 4 h in hospital (Deaths < 4 h) and all deaths after 4 h (Deaths > 4 h). Then, in order to improve the study of mortality distribution, the variable "time to death" measured in minutes was transformed applying a natural logarithm function. That transformation using the natural logarithm created a new continuous variable. The next step was to recode this new variable into intervals with the same width, i.e. one logarithmic unit. Then, to each logarithm unit interval a time interval expressed in minutes was corresponded thus creating the final time intervals used in Figures 2, 3 and 4 (for example, the interval between 3 and 4 of the logarithmic scale corresponds to the time interval between 24 and 45 min). The option to use the natural logarithm came from its properties that well apply to the nature of our data. In a logarithmic scale when there are a high number of events the time intervals are shortened showing a better understanding of what is happening; when events are rarer, the time intervals are longer allowing the coverage of a longer range of time values.

We also classified hospitals according to the American trauma centres designation levels to be able to compare with other trauma systems [20].

The study received the approval of the ethics committees or local administration approval where they didn't exist.

The descriptive analysis was made using appropriated summary tests. Categorical variables were described using absolute and relative (%) frequencies and the continuous variables analyzed using median as central tendency and standard deviation as dispersion measurement. When appropriated Qui-Square test was applied to test hypothesis related to categorical variables (p was considered significant when inferior to 0.05). Statistical analysis was performed using SPSS® v.14.0 (Statistical package for the Social Sciences).

Results

Population Characteristics

During the study period, there were 1,811 trauma deaths in the HGSA trauma system. We excluded 79 deaths in patients aged less than 13 years and 296 patients who were more than 65 years, had an isolated hip fracture and died of a non-traumatic cause. Considering the aforementioned exclusions we ended up with 1,436 deaths over a period of 53 months; 752 (52%) patients died at the scene without reaching hospital care; 239 (18%) patients died in the level I trauma center (HGSA); 287 (21%) died in a level III trauma center and the remaining 158 patients (11%) in a level IV/V trauma center; where 76% were male and 24% female with a median age of 43 (25 percentile = 27; 75 percentile = 67). Age distribution had 2 peaks, one in the 30s and the other in the 70s and ranged from 13 to 100. When considering the type of injury only 5% was penetrating trauma (10 stabbings and 59 gunshot assault). For the blunt trauma the majority is caused by RTA (74%), falls were the cause in 13% and other accounted for 13%. It was not possible to identify the dominant injury in the patients who died at the scene and in the first few hours in hospital (68% of all deaths). From those with an identifiable injury, head injury was the dominant injury in 70% of cases, abdominal trauma was the dominant injury in 31 patients (7%), spinal trauma in 4%, pelvis and extremities in 6% and thoracic trauma in 13% of the patients (Table 1).

In hospital, deaths happened mostly in the emergency department (52%) with 274 deaths in the emergency room and 82 occurring in the operating room; 207 deaths occurred in the intensive care unit (30%) and 18% in the wards.

When comparing the population characteristics for type of injury we see that deaths due to penetrating trauma occur in younger and male patients ($p < 0.001$) and at the scene at a bigger proportion ($p = 0.003$). When comparing the population characteristics for mechanism of injury we also find significant differences. Patients who die because of RTA are younger ($p < 0.001$) and more frequently male ($p < 0.001$) than patients who fall or have other mechanisms of injury.

Table 1. Characteristics of trauma deaths (n = 1436).

	Total (n = 1436)		Type of injury			Mechanism of injury		
			Penetrating (n = 77)	Blunt (n = 1359)	p*	RTA (n = 1,059)	Other n (n = 296)	p*
Age, n (%)								
< 60	970	(67)	69 (90)	901 (66)	< 0.001	787 (75)	104 (35)	< 0.001
≥ 60	466	(33)	8 (10)	458 (34)		262 (25)	192 (65)	
Gender, n (%)								
Male	1,089	(76)	75 (97)	1,014 (75)	< 0.001	801 (76)	199 (67)	
Female	344	(24)	2 (3)	342 (25)		246 (24)	96 (33)	
Time to death, n (%)								
Death at scene	752	(52)	45 (58)	707 (52)	0.346	699 (67)	8 (3)	< 0.001
Death ≥ 4 h	228	(16)	8 (11)	220 (16)		168 (16)	50 (17)	
Death > 4 h	456	(32)	24 (31)	432 (32)		182 (17)	238 (80)	
Death at hospital, n (%)								
Level I	239	(35)	21 (27)	218 (17)	0.003	121 (11)	118 (32)	< 0.001
Level III	287	(42)	9 (12)	278 (20)		144 (14)	138 (37)	
Level IV/V	158	(23)	2 (3)	156 (11)		85 (8)	64 (17)	
At scene			45 (58)	707 (52)		699 (67)	53 (14)	
Dominant injury[a], n (%)								
Head	305	(70)	20 (74)	288 (70)	–	125 (70)	180 (72)	0.005
Thorax	56	(13)	3 (11)	53 (13)		27 (15)	27 (11)	
Abdomen	31	(7)	3 (11)	28 (7)		17 (9)	10 (4)	
Pelvis and extremities	25	(6)	1 (4)	24 (6)		95 (5)	14 (6)	
Spine	20	(4)	0 (0)	20 (4)		2 (1)	18 (7)	

*Pearson Chi-Square test
[a]Dominant injury was known in 440 patients

Patients dying at the scene are predominantly RTA victims and those who die after more than 4 h have more frequently other mechanism of injury ($p < 0.001$). Victims of blunt trauma from other mechanism than RTA are more probable to die in level III or IV/V trauma centres ($p < 0.001$). Looking at the dominant injury, RTA results more frequently in abdominal, spine and thoracic trauma than other mechanisms of injury ($p = 0.005$). Patients' characteristics concerning type and mechanism of injury are resumed in Table 1.

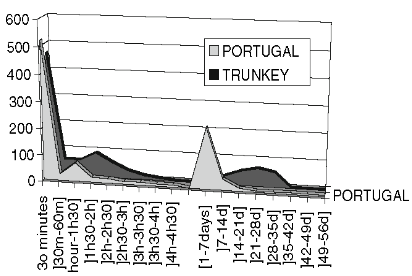

Figure 1. Distribution of deaths; comparison with the trimodal concept after Trunkey (Portugal and Trunkey's number of deaths were normalized per 1,000 deaths).

Mortality Distribution

Figure 1 shows the temporal distribution of deaths, using exactly the same time frame that Trunkey used when he developed the trimodal mortality concept in trauma. In our population, we found a different distribution but still in three peaks: 52% of the patients died at the scene, only 16% died in the first 4 h and all the rest (33%) died after that period. The proportion of deaths after 1 week was only 8%.

To better understand what was happening in the latest peak we decided to apply the natural logarithm because of its properties previously described. Figure 2 shows death distribution using a logarithmic scale in minutes where we can see that deaths are concentrated in the first 2 days (84%). Using logarithm transformation four peaks appeared and are well identified (deaths at the scene, deaths in the first few hours,

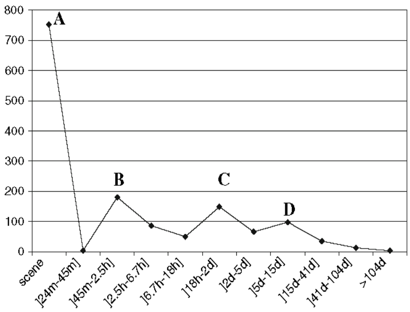

Figure 2. Death distribution over time in a natural logarithmic scale in minutes. (m = minutes; h = hour; d = day); A) 2 min; B) 2 h, C) 2 days; D) 2 weeks.

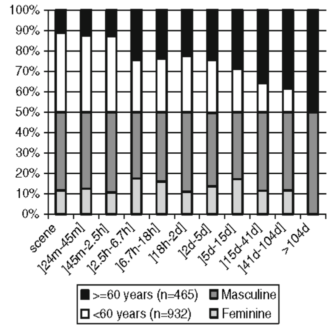

Figure 3. Distribution of deaths over time concerning age and gender. (m = minutes; h = hour; d = day).

deaths in the first 2 days and finally, deaths in the second week) that we named as 2 min, 2 h, 2 days and 2 weeks peak.

Figure 3 shows the proportional distribution curves for gender and age. Age distribution is not uniform with the proportion of older people increasing with time. Woman account for only 25% of deaths but their curve parallels the curve for men.

Mortality distribution in the logarithmic time scale in minutes for the head injury versus non-head injury deaths in the level I trauma center is shown in Figure 4. We analyzed only deaths from HGSA and used only the abbreviated injury scale (AIS) coded patients. It shows that patients without head injury die in a different way, more uniformly through the time without evident peaks. These figures are complemented by Table 2 that shows statistically significant differences in patient characteristics (age, gender, type of hospital and head injury) concerning timing of death in the previously described four peaks.

Discussion

Population Characteristics

This study is believed to be the first in Portugal with this magnitude, to incorporate contributions from both hospital and out of hospital data on trauma deaths in an entire trauma system.

Figure 4. Distribution of deaths over time with and without head trauma in HGSA (n = 239).

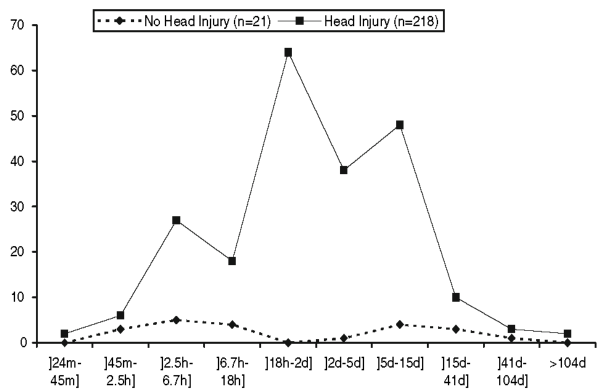

Table 2. Death characteristics concerning time to death.

	Time of death				
	2 min[a] n (%)	2 h[b] n (%)	2 day[c] n (%)	2 weeks[d] n (%)	p*
Age					
< 60	594 (79)	205 (64)	103 (57)	68 (37)	< 0.001
≥ 60	158 (21)	114 (36)	79 (43)	115 (63)	
Gender					
Male	587 (78)	232 (73)	141 (78)	127 (69)	0.026
Female	161 (22)	87 (27)	40 (22)	56 (31)	
Mechanism of injury					
Penetrating	45 (6)	11 (3)	13 (7)	8 (4)	0.227
Blunt	707 (94)	308 (97)	169 (93)	175 (96)	
Death at hospital					
Level I	–	64 (20)	87 (48)	88 (48)	< 0.001
Level III	–	162 (51)	56 (31)	69 (38)	
Level IV/V	–	93 (29)	39 (21)	26 (14)	
Head injury[e]					
No	–	12 (19)	0 (0)	9 (10)	< 0.001
Yes	–	52 (81)	87 (100)	79 (90)	

*Pearson Chi-Square test
[a]Death in the place of accident
[b]Before 18 h
[c]Between 19 h and 3 days
[d]After 4 days
[e]Level I trauma centre deaths (n = 239)

There are several aspects that deserve to be underlined:

(1) penetrating trauma contributes to only 5% of all trauma deaths and that is similar to what happens in other European countries. Death characteristics of the penetrating trauma are significantly different from blunt trauma. It involves younger males and more deaths at the scene. Road traffic accidents are the main cause of trauma fatalities and involved mostly young males.
(2) it is interesting to see that 13% of deaths are caused by falls and that 33% of the patients that died were more than 60 years. It seems that as time passes, deaths are more probable to be from older people and they occur more in the level I trauma center. Again the ageing of the population along with distribution of levels of care are a possible explanation.
(3) head injury is the main dominant injury and death distribution along time differs for patients with and without head injury. Head injury patients are the main contributors for the 2 days and 2 weeks peaks.
(4) only 18% of all deaths are in the level I trauma centre. The majority of hospital deaths happen in the emergency room or theatre, followed by the Intensive Care Unit's deaths.
(5) one limitation of this study is that data were collected from several sources. It was not possible to collect data concerning dominant injury from the patients who died at the scene and most of the patients who died in the emergency room (in total, 68%). That limited the analysis of dominant injury to the data collected on the level I trauma center. However, in our opinion it does not create an important bias when we analyze dominant injury in the 2 days and 2 weeks peak because the majority of those deaths happen in the level 1 trauma center where we have recorded the dominant injury for all deaths.

Mortality Distribution

Several authors have discussed before the epidemiology of injury and proposed that time from injury to death can provide guidance to policymakers in the process of seeking interventions that could reduce morbidity and mortality [21, 22]. Data regarding rate, causes and timing of death and also trends along time are widely available in US literature. Trunkey developed in the early 1980s the trimodal concept of mortality distribution [7] following the analysis of the pattern of death in a data base from San Francisco General Hospital and a paper of Baker et al. in 1980 [8]. In Trunkey's original paper, the graph is diagrammatic, introducing a concept rather than data. He grouped the different causes of death and discussed ways to prevent and minimize them. This approach has shown invaluable pedagogical advantages and along other merits contributed to the design of a landmark in the organization of the care for the trauma patients all over the world: the trauma system. This approach to the delivery of trauma care is widely accepted as an effective strategy to reduce mortality due to injury. Recently Mackenzie et al. presented a national evaluation of the effect of trauma centers on mortality in the United States. They concluded that the risk of death was lower when care was provided in a trauma center compared to another kind of hospital [23]. In the last 3 decades many changes took place in the care of the injured patient in the occidental world namely the development of trauma systems, trauma centers, prevention programs, emergency medicine, pre-hospital medicine, medical involvement in the field and intensive care development.

In recent years, several authors have discussed the trimodal concept. Demetriades et al. challenged the trimodal concept for trauma mortality based on the fact that fewer patients are dying after 1 week. They hypothesize that the improvement in clinical care and the development of trauma systems reduces late deaths to the minimum and concludes that the classical trimodal distribution of deaths does not apply to their trauma system. He presents an analysis of 4,151 deaths over a 3-year period in a trauma system in the USA. Looking in detail to the data, we can observe that deaths concentrate in the first week and mainly in the first 3 days. The first peak has not changed, the third peak disappeared, so the second peak became larger. This issue is not discussed by the authors and they do not use the same time intervals as the original's Trunkey description making it difficult to compare data [13, 24].

Meislin et al. report 766 deaths from an Arizona trauma system [25]. He described a trimodal distribution with a shift towards earlier deaths (79% dying in the first 2 days after admission) concluding that the distribution is bimodal. In his interpretation changes in the trauma system with the development of the EMS system and the enormous number of head injured patients and other blunt trauma patients along with the aging of the population were the main causes for this difference. Again he does not use the same time intervals as Trunkey did.

Sauaia et al. reassessed the epidemiology of trauma deaths in a trauma system in Denver city and county [26], reporting a similar bimodal behavior of trauma deaths curve discussing that explanations for the differences with Trunkey's curve were due to differences in injury mechanism (49% of penetrating trauma), increasing proportion of head injury and the prolonging survival of some unsalvageable patients admitted in ICU for organ donation. Several other authors discussed the mortality pattern namely Stewart in 2003 [22], Peng et al. in 1998 [27] and Acosta et al. in 1998 [28] presenting graphics of death distribution without the trimodal pattern, representing mainly an exponential decrease of death with time. Again in all these papers time distribution uses different scales and intervals.

In Europe, Wyatt reported data from Scotland UK, showing again an exponential decline with time rather than a trimodal distribution [14]. He concludes that the improvement of care in Scotland could abolish the second and third peaks and that the potential to save lives with improvement in treatment is reduced. The authors point out that the mechanism of injury were different from the USA with less than 6% of penetrating trauma. The time scale used was in hours after injury, again not the same used by Trunkey. From Italy, Di Bartolomeo et al. [15] presents epidemiological data from a population-based study. When presenting trauma mortality data the authors plot data in a graphic with a time interval similar to Tunkey. They showed that the third peak was bigger than expected (almost 30% against 20% from Trunkey) and the trimodal concept was again discussed. They discussed the role of improvement of care namely pre-hospital care and prevention.

Recognizing the importance of the comprehensive graphic Trunkey used to describe trimodal mortality pattern, first we used the same methodology to assess mortality curve in our trauma system. When analyzing the temporal distribution of deaths we found several interesting differences. The percentage of deaths on scene is similar (52%) but the only similarity with the trimodal concept. Acute hospital deaths (first 4 h) account for only 15% of all deaths versus 30% from Trunkey. Late deaths (after the first 4 h) account for 35% of all fatalities versus 20% from Trunkey description (Figure 2). If we plot the data in a graphic in that way, we can still see a trimodal distribution of trauma deaths. It is then obvious that in our population the biggest in-hospital peak is between 4 h and 3 days and that is a big difference with Trunkey.

To study these differences in detail we used a logarithmic time scale in minutes that showed four distinct peaks that we named after 2 min, 2 h, 2 days and 2 weeks for a more comprehensive analysis finding a tetramodal distribution (Figure 2). Compared to Turnkey the main difference is the peak at 2 days. Head injury and older patients contribute most for it and these patients die predominantly in the Intensive Care Units of level I trauma centers (Table 2). The reason for the appearance of the 2 days peak could be related to the improvement of emergency care reducing the proportion of patients who die early on and also to the huge amount of head injury patients who die in the intensive care units after some days of support, along with the aging of the population.

Our data showed a rather high number of deaths in the few first hours followed by a rather low number of deaths after a couple of weeks. Therefore, a logarithmic scale is in our opinion much more appropriate to describe the distribution of deaths with time as it allows more comprehensible representation of the frequency of events.

In the interpretation of that data distribution we have to keep in mind that the location of the peaks as well as the number of peaks found is dependent on the choice of the classes' width and limits and that other peaks could be found with a different logarithm. With the method applied in this paper, we found a tetramodal distribution and our opinion was reinforced by the clinical and organizational implications of such a model.

The interventions that can prevent death in the different four peaks of mortality described in this paper are different, just as the causes of death differ in the four peaks:

(1) for the 2 min peak, we must pursue injury prevention initiatives as deaths happening at incident scene are mostly impossible to treat.
(2) to reduce the 2 h peak we must continue to support the development of pre-hospital and in-hospital emergency room care, the development of trauma teams and trauma education, along with efforts on trauma system development to improve initial stabilization and expedite pathways to transfer to definitive care.
(3) concerning the 2 days peak, Intensive Care treatment is of paramount importance; here mortality is increased due to head injury and less because of exsanguination. In the last decades we observed enormous advances in resuscitation strategies, acceptance of "damage control" and improvement in diagnostic technology. Now we must put more effort into researching the optimal management of CNS injuries in the Intensive Care environment.
(4) to deal with the latest 2 weeks peak, we must prevent infection and multiple organ dysfunctions with the emphasis putted on the late beneficial consequences of previous and early diagnosis and interventions, like trauma system development to bring people safer to hospital, development of trauma teams to deal with the patients in the first few hours and intensive care development.

Conclusion

In summary, we investigated the epidemiology of trauma deaths in a large and demographically diverse area where RTA is a major cause of death in young males.

We described a tetramodal pattern of death distribution in our trauma system where deaths occur in four peaks: 2 min, 2 h, 2 days and 2 weeks. This peak at 2 days could be explained by improvements in care, differences in the type of trauma and aging of the population and should focus more attention into intensive care environment, namely head injury treatment.

Uniform report of trauma is of paramount importance specifically the report of trauma deaths over time. Only in that way will be possible to analyze larger data bases and produce recommendations for the future development of trauma systems.

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Addenda 2

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Clinical paper

The importance of pre-trauma centre treatment of life-threatening events on the mortality of patients transferred with severe trauma☆

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A B S T R A C T

Aim: The benefit of a well organised trauma system is acknowledged but doubts remain concerning the optimal pre-hospital trauma care model. We hypothesise that the treatment of life-threatening events before arrival at trauma centre – either pre-hospital or first hospital – may be more relevant to decreasing mortality than shortening the time to trauma centre.
Methods: A cohort of 727 trauma patients with life-threatening events – identified as airway, breathing, circulation or neurological disability – requiring transfer to a trauma centre were studied. Data on patient's characteristics, trauma features, and mortality were taken from a trauma registry. Patients were divided into 3 groups depending on the place of treatment of life-threatening events: pre-hospital, first hospital or trauma centre. Survival Kaplan–Meier curves and logistic regression were used to assess the effect of place of treatment of life-threatening events on mortality.
Results: Patients from the pre-hospital and first hospital groups had 20% and 27% mortality respectively, compared to 38% among those whose life-threatening events were corrected only at the trauma centre. Logistic regression showed that patients whose life-threatening events were corrected only at the trauma centre had an odds of death 3.3 times greater than those from the pre-hospital group, adjusted for patient and trauma characteristics and time to trauma centre.
Conclusion: In trauma patients requiring transfer to a trauma centre, pre-hospital interventions to treat life-threatening events may significantly decrease mortality when compared to similar interventions performed later at the trauma centre.

1. Introduction

The benefit of a well organised trauma system with specialized trauma centres is fully acknowledged,[1–4] but doubts still remain concerning what could be considered as the optimal pre-hospital trauma care. Several authors have studied the effect of pre-hospital *advanced* life support (ALS) in comparison with pre-hospital *basic* life support (BLS) approaches on trauma mortality and other outcomes.[5–9] However, there are no large or controlled studies on that subject and the controversy is far from being resolved. Even studies that address the effect of specialized trauma teams and helicopters on trauma patients' outcome showed conflicting results.[10–12]

Moreover, studies that compare pre-hospital ALS and BLS approaches often have different definitions for ALS and BLS, study only partial ALS attitudes or techniques – instead of the whole concept – and above all do not study and compare ALS and BLS in a population of trauma patients with life-threatening events needing treatment.[13]

Traumatic life-threatening events were defined in the medical literature as events that endanger life and that should be corrected during the primary survey of treatment of trauma patients. By definition life-threatening events should be treated urgently. The methodology to identify and treat life-threatening events is also known as ABCD methodology and is taught in different trauma courses around the world namely European Trauma Course[14] and ATLS.[15]

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Our aim was to estimate the effect on mortality of treating the life-threatening events prior to arrival at the trauma centre (either in the pre-hospital scene or in the first hospital) in comparison with treatment of life-threatening events only at the trauma centre. We considered two hypotheses: (1) The early treatment of life-threatening events in trauma patients decreases the risk of death. (2) Time from accident to definitive treatment at trauma centre is an independent factor contributing to mortality.

2. Methods

2.1. Setting

We analysed data from a trauma registry that includes all patients admitted to a neurosurgical centre in the North of Portugal (Hospital de Santo António—HGSA). HGSA is a 700 bedded University acute central hospital with neurosurgical cover and intensive care facilities. No other hospital within this trauma system has emergency neurosurgical coverage. HGSA serves Northeast Portugal (a mixed urban/rural area) with a catchment area of approximately 2,500,000 inhabitants. The Emergency Medical System (EMS) within this region consists of a dispatch centre that answers all emergency calls (112) and sends the most appropriate resource available. One helicopter and 10 fast vehicles with trained medical doctors are available for this response.[16] The decision whether or not to dispatch a physician to the field is reached on the basis of the information received on the phone and the available resources. As the resources are not uniform for the same severity of trauma, different approaches are possible from an ALS vehicle with doctor and nurse to an BLS Ambulance staffed only by fire-fighters with basic skills. If an ALS resource is not available BLS ambulances attend the scene and transport the patient to the nearest hospital with an emergency department (ED). Such ALS teams with medical involvement are only available in urban areas. As a consequence the level of trauma care in the designated area is not uniform. In Portugal the trauma centre levels, according to the American College of Surgeons,[17] are not used for accreditation; most first hospitals with ED are comparable to level III trauma centres and if a neurosurgical and/or intensive care is needed the patient is transferred to HGSA, the level I trauma centre for this region.

2.2. Study design, patients and definitions

A trauma registry at HGSA has been prospectively maintained using Trauma Injury Severity Score methodology (TRISS) for severity coding.[18] For the purpose of this study we analysed data between August 2001 and December 2006. In addition the following information was collected after retrospective review of the patient's clinical notes: type of life-threatening event; type of life-threatening event treatment and location where the treatment was performed (pre-hospital, first hospital or trauma centre).

2.2.1. Patients

We included in this study all trauma patients admitted to the emergency room of HGSA that were transferred from another hospital in the trauma system, corresponding to 72% of the severe trauma patients admitted to this trauma centre.

2.2.2. Life-threatening events

Life-threatening events were defined as problems in the airway (A), breathing (B), circulation (C) or neurological disability (D) that may endanger life if not immediately identified and controlled as taught in trauma courses. The airway breathing circulation disability approach (ABCD approach) is a method of identifying and treating life-threatening events in trauma patients. It is taught in different trauma courses and emergency medicine courses for doctors, nurses and paramedics around the world.[14,15,19] At the end of the primary survey patients should have a patent airway, have oxygen on and have the cervical spine immobilized. Adequate ventilation must be confirmed afterwards. This includes an examination of the chest to clinically exclude or treat immediately life-threatening thoracic conditions. Tension pneumothorax, open chest wound, massive haemothorax, flail chest or cardiac tamponade are the thoracic life-threatening events. Regarding circulation any overt bleeding must be controlled by direct pressure. If a life-threatening event is identified in circulation (clinical evidence of shock using skin colour, clamminess, capillary refill time, heart rate, blood pressure, pulse pressure, conscious level and respiratory rate) intravenous access must be established and fluids started. Examinations should identify the origin of the problem but (apart from the external haemorrhage that should be controlled using direct pressure) usually that is only possible at hospital. Dysfunction of the central nervous system can be a life-threatening event. In our trauma system patients with D problems must be transferred to the trauma centre, and if the Glasgow coma scale of the patient is bellow 8, control of the airway is mandatory. When several life-threatening events were identified in the same patient, we considered the first one in alphabetic order to be treated, as defined by medical educational principles.

To avoid retrospective case definitions of head and severe injury as opposed to what the pre-hospital personnel identifies at the scene (paramedics or physicians at scene will not always know whether or not the unconscious trauma patient has a head trauma or degree of severity) we studied only patients with a life-threatening event identified (regardless of subsequent injury diagnoses).

Patients were divided into 3 groups related to the place of treatment of life-threatening events: pre-hospital, first hospital or trauma centre. Life-threatening events and treatments are described in Table 1.

2.2.3. Time to trauma centre

Time to trauma centre was defined as time from the accident occurrence to the arrival at the level I trauma centre (HGSA).

The primary outcome measure used was trauma centre mortality. The descriptive analysis was made using appropriate summary tests. Categorical variables were described using absolute and relative (%) frequencies, continuous variables were analysed using mean as central tendency and standard deviation as a dispersion measurement and non-continuous variables using median as central tendency and inter-quartile range (IQR) as a dispersion measurement. When appropriate Chi-Square testing and Fisher's exact testing were applied to test hypothesis related to categorical variables. Survival Kaplan–Meier curves were done for patients in the 3 groups (pre-hospital, first hospital and trauma centre treatment of life-threatening events). Test of equality of survival distributions were done using Cox regression. To assess the predictive effect of the place of treatment of life-threatening events on mortality, several logistic regression models were constructed, with mortality as dependent variable and population characteristics as independent variables. Models were built using different independent variables from previous well know prognostic trauma models.[18,20,21] Statistical significance was set at the 0.05 level. SPSS® 15.0 was used for statistical analysis.

3. Results

3.1. Population characteristics

Between 1st January 2001 and 31st December 2006, 1050 trauma patients were admitted to the emergency room of HGSA

Table 1
Patients' variables according to mortality and place of treatment of life-threatening events.

	Total (n = 727)	Case fatality		p[a]	Life-threatening events treatment			p[a]
		Alive (n = 523)	Dead (n = 204)		Pre-hospital (n = 49)	First hospital (n = 580)	Trauma centre (n = 98)	
Gender, n (%)								
Female	157 (22)	99 (19)	58 (28)	0.005	11 (22)	123 (21)	23 (24)	0.871
Male	570 (78)	424 (81)	146 (72)		38 (78)	457 (79)	75 (77)	
Age, mean (SD)	44 (21)	42 (21)	48 (21)	<0.001[b]	38 (19)	44 (21)	48 (22)	0.028[b]
Type of trauma n (%)								
Blunt	690 (95)	505 (97)	185 (91)	0.001	48 (98)	546 (94)	96 (98)	–
Penetrating	37 (5)	18 (3)	19 (9)		1 (3)	34 (6)	2 (2)	
Mechanism of injury n (%)								
Road traffic collision	422 (58)	331 (63)	91 (44)	–	35 (71)	331 (57)	56 (57)	–
Fall	217 (30)	141 (27)	76 (37)		8 (6)	177 (31)	32 (33)	
Assault, blunt	5 (1)	4 (1)	1 (1)		0 (0)	5 (1)	0 (0)	
Other, blunt	49 (7)	32 (6)	17 (8)		5 (10)	36 (6)	8 (8)	
Stabbing	2 (0)	2 (0)	0 (0)		0 (0)	2 (0)	0 (0)	
Gunshot	32 (4)	13 (3)	19 (9)		1 (2)	29 (5)	2 (2)	
AIS, *mean* (SD)								
Head	4.1 (0.9)	4.0 (0.9)	4.7 (0.7)	<0.001[b]	4.2 (0.9)	4.2 (0.9)	4.0 (1.1)	0.118[b]
Face	1.9 (0.7)	1.9 (0.7)	1.8 (0.6)	0.324[b]	2.2 (0.8)	1.8 (0.6)	2.0 (0.8)	0.148[b]
Thorax	3.3 (1.0)	3.3 (1.0)	3.5 (1.0)	0.058[b]	3.0 (1.1)	3.3 (1.0)	3.7 (0.9)	0.005[b]
Abdomen	2.7 (1.1)	2.6 (1.1)	2.8 (1.2)	0.536[b]	2.4 (0.5)	2.5 (1.1)	2.9 (1.7)	0.155[b]
Extremities	2.2 (0.9)	2.3 (0.9)	2.2 (0.8)	0.673[b]	2.0 (0.7)	2.2 (0.8)	2.6 (1.0)	<0.001[b]
ISS, median (IQR)	25 (18–32)	25 (17–30)	25 (25–34)	<0.001[c]	22 (16–32)	25 (18–29)	29 (24–38)	0.001[d]
RTS, median (IQR)	5.9 (5–6.9)	5.9 (5–6.9)	5.0 (4–5.9)	<0.001[c]	5.9 (4–6.9)	5.9 (5–6.9)	5.9 (5–7.1)	0.238[d]
Probability of survival, *mean* (SD)	0.69 (0.28)	0.75 (0.25)	0.54 (0.29)	<0.001[b]	0.71 (0.31)	0.70 (0.27)	0.6 (0.32)	0.011
Outcome n (%)								
Died	204 (28)	–	–		10 (20)	157 (27)	37 (38)	0.044
Discharged	523 (72)	–	–		39 (80)	423 (73)	61 (62)	
Life-threatening events								
A	30 (4)	25 (5)	5 (3)	0.479	0 (0)	12 (2)	4 (6)	–
B	66 (9)	49 (9)	17 (8)		2 (6)	37 (7)	12 (16)	
C	64 (9)	47 (9)	17 (8)		3 (8)	13 (3)	22 (30)	
D	567 (78)	402 (77)	165 (81)		31 (86)	426 (88)	35 (48)	

[a] Qui-Square test.
[b] Independent sample test.
[c] Mann–Whitney.
[d] Kuskall–Wallis; IQR: inter-quartile range.

and enrolled in the prospective registry. We included in this study 761 trauma patients transferred from another hospital. Twenty-five patients who had no life-threatening events identified were excluded from subsequent analyses. We also excluded 8 patients with missing data related to the presence or the treatment of life-threatening events.

Patients included had a mean age of 44 years (*SD* = 21). The majority were male (78%; $n = 570$) and had sustained injury through blunt trauma (95%; $n = 690$) with traumatic brain injury (TBI) in 87% of cases. The context of injury was road traffic collision (RTC) in 58% of cases ($n = 422$). All patients had severe trauma with a mean Abbreviated Injury Score (AIS) in the head of 4.1, a median Injury Severity Score (ISS) of 25 (IQR 18–32) and a median Revised Trauma Score (RTS) of 5.97 (IQR 5–6.9). The probability of survival (TRISS) for these patients was 69% and the real survival rate was 72% (Table 1).

3.2. Life-threatening events

In accordance with the ABCD assessment and treatment methodology, life-threatening events were identified. Not surprisingly most of the patients in this population had "D" problems ($n = 567$; 78%). We assumed that treatment for "D" problems was maintaining an adequate airway (including tracheal intubation if the GCS was less than 8 points) and aiming for good oxygenation and perfusion followed with early reference to a neurosurgical centre. For example: if a patient arrived at the first hospital with a possible head injury identified, a GCS less than 8 identified and the protection of the airway was performed in first hospital prior to transfer, then that patient was assumed to be part of the first hospital group (life-threatening event corrected in first hospital). If the identification and treatment of D problem was performed in pre-hospital before arrival at the first hospital then that patient was part of the pre-hospital group (life-threatening event corrected in the pre-hospital scene). If the same patient arrived at the trauma centre without intubation (and the need was present before arrival) then that patient would be part of the trauma centre group. The second most common life-threatening event involved breathing ($n = 66$; 9%) and it was corrected using a chest drain in 33 cases and mechanical ventilation in 31 patients. The same methodology described above was used to decide in which group each patient would be. Circulation life-threatening events were identified in 64 patients (9%) and fluids (6), vasopressors (6) and surgery (52) were the treatments performed. Airway life-threatening events were identified in 30 patients (4%) and were treated using oxygen (15) intubation (5), a cervical collar (7) and oxygen with basic airway manoeuvres (3). Cervical spinal cord injuries were included in the airway life-threatening events as airway assessment and treatment includes cervical spine control. It was assumed that all patients should have had a cervical collar, so if they had a spinal cord injury and no collar that was classified as a life-threatening event not corrected.

Whenever it was not possible to understand retrospectively if the life-threatening event was present before arrival at the first hospital or trauma centre or if it developed only during transportation to the trauma centre, that patient was excluded because of missing data. Table 2 lists life-threatening events and treatment and Table 1 shows mortality for different life-threatening events.

3.3. Place of treatment of life-threatening events and outcome

Most of the patients had their life-threatening events treated in pre-hospital or first hospital (pre-trauma centre) ($n = 629$; 87%). Life-threatening events were corrected in the pre-hospital environment in 49 patients (7%), in the first hospital in 580 (80%) and solely in trauma centre in 98 (13%) patients. Demographic and injury severity characteristics (Table 1) of these 3 groups of patients were similar except for age and ISS (patients who had life-threatening events treated in the pre-hospital phase were younger and less severely injured). Mortality rates differed across these 3 groups, 20% for patients with life-threatening events treated in the pre-hospital environment, 27% for those with events treated in first hospital and 38% for patients with life-threatening events solved only in the trauma centre ($p = 0.044$).

Fig. 1 shows the survival curves for the 3 groups of patients. Patients were more likely to survive when their life-threatening events were corrected in the pre-hospital phase, corresponding to a mortality reduction of almost 50% when compared to those patients whose life-threatening events were corrected later in trauma centre.

Table 2
Life-threatening events and treatments.

Life-threatening events	
Airway (A) problem	30 (4)
Airway obstruction	23 (77)
Cervical spine injury	7 (23)
Treatment	
Oxygen and Basic airway manoeuvres	18 (60)
Tracheal intubation	5 (16)
Cervical collar	7 (24)
Breathing (B) problem	66 (9)
Pulmonary contusion	24 (37)
Massive Haemothorax	17 (25)
Tension Pneumothorax	16 (25)
Flail chest	9 (13)
Treatment	
Oxygen	66 (100)
Ventilation	31 (47)
Chest drain	33 (49)
Circulation (C) problem	64 (9)
Clinical signs of shock	64 (100)
Treatment	
Surgery	52 (81)
Fluids	6 (8)
Fluids + Vasoconstrictors	6 (8)
Disability (D) problem	567 (78)
GCS < 9	377 (66%)
GCS > 8	190 (34%)
Treatment	
Tracheal intubation	377 (66%)
Referral to Neurosurgery	567 (100)

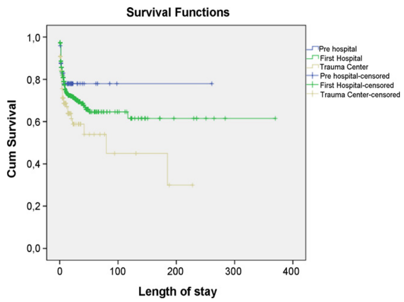

Fig. 1. Survival curves for patients with life-threatening events treated in pre-hospital, first hospital or trauma centre. Length of stay is depicted in days.

Table 3
Regression analysis for mortality.

	OR	CI 95%	p
Gender			
Female	1.000	–	
Male	0.549	0.361–.837	0.005
Age	1.015	1.006–1.024	0.001
ISS	1.044	1.025–1.063	<0.001
Type of trauma			
Penetrating	1.000	–	
Blunt	0.193	0.087–0.429	<0.001
Place of treatment of life-threatening events			
Pre-Hospital	1.000	–	
First Hospital	1.457	0.656–3.233	0.355
Trauma Centre	3.256	1.276–8.309	0.014
RTS	0.617	0.535–0.713	<0.001
Time to trauma centre	1.000	0.999–1.001	0.568
C Statistic	0.757		

Variables in the model: gender, age, ISS, RTS, type of trauma, place of treatment of life-threatening events and time to trauma centre. Enter method was used.

Time from accident to trauma centre (including pre-hospital and first hospital times) was also compared. Patients with life-threatening events solved in pre-hospital, first hospital and trauma centre phases had respectively a median time from accident to trauma centre of 5 h and 31 min (IQR 3:45–9:24), 4 h and 35 min (IQR 2:50–7:02), and 3 h and 30 min (IQR 2:51–6:56).

As the univariate analyses showed that patients whose life-threatening events where treated in the pre-hospital environment had lower mortality but at the same time were younger and less severely injured, a multivariate logistic regression was performed to adjust the odds of death to patient characteristics and trauma severity as well as time from accident to trauma centre. Logistic regression showed that increases in mortality were associated with female gender and older age, penetrating type of trauma, higher anatomic severity (ISS), higher physiological severity (RTS) and having the life-threatening events corrected only at the trauma centre (Table 3). Different models using TRISS and other severity model variables and categories were constructed but did not show a better performance in this population and are not shown.

4. Discussion

Our main finding was that the treatment of life-threatening events in the pre-hospital scene (compared to the treatment of life-threatening events only at first hospital or the trauma centre) decreased the mortality of severe trauma patients transferred to a trauma centre. A reduction of almost 50% in crude mortality was found for those patients having their life-threatening events treated in the pre-hospital phase. This observed benefit was maintained after adjustment for confounders in logistic regression analysis. As a result we believe that in the context of this report pre-hospital ALS and the ability to treat life-threatening events had a positive effect on mortality reduction. We accepted our first hypothesis.

In the literature not many studies support a positive relationship of ALS with outcome but most are able to show an increase of on-scene time when ALS is performed. Several important reviews summarise well the results of relevant studies. Liberman in a meta-analysis reviews and critiques the literature on ALS and BLS influence on outcome. He reviews 174 papers, recovers only 15 that permit an outcome analysis, was unable to find any large randomised prospective study, and concludes that "...the aggregated data from the literature have failed to demonstrate a clear benefit from on-site ALS in trauma".[10] Bunn et al. in a review supported by the World Health Organisation identifies only one small randomised study that is in favour of the ALS and concludes on the absence of evidence of the effectiveness of ALS in the pre-hospital setting.[12] However, different definitions for what is called ALS and BLS, the study of partial ALS attitudes or techniques instead of the all concept analyses, small study samples, studies not controlled nor randomised and a retrospective methodology are probably the main reasons for the difficulty in showing a better relationship of ALS with outcome, along with differences between trauma systems.[13] The future of ALS pre-hospital trauma care depends on finding the groups of patients who benefit definitely from it. We believe that this study contributes to this debate as it shows that trauma patients transferred to a trauma centre benefit from ALS in the pre-hospital phase. Although studies comparing ALS with BLS have been done before as far as we know the comparison was never performed in a well-defined cohort where interventions were definitely needed to treat life-threatening events, as was the case in this study. Our study is in accordance with recent papers showing benefit of ALS in the pre-hospital environment[9,22,23] and others that show benefit from pre-hospital ALS only in specific groups of patients namely those with TBI.[24–27]

A recent before-after controlled clinical trial study from Canada[28] shows an increase in mortality with ALS implementation. Comparison with our report is difficult as the Canadian study compares ALS done by trained paramedics in urban scenarios. In our study ALS means the presence of a doctor that identifies and corrects the life-threatening events that each patient had in either rural or urban scenarios. Moreover they study only patients admitted directly from the scene and we are studying transferred patients.

Another important result is that this study strongly supports the importance of the ABCD methodology—a structured approach to assess and treat life-threatening events in trauma patients. ABCD methodology is currently taught in trauma courses like ATLS[15] and European Trauma Course.[29] This finding is in accordance with other authors like Deakin who found that preventable pre-hospital deaths were related to failure to deliver good solutions to A, B and C life-threatening events at the scene.[30]

We also report that correcting life-threatening events pre-trauma centre (pre-hospital and first hospital) increases the total time from the accident to trauma centre. The mean times we report were very long mainly not only because we are analysing only transferred trauma patients but also because the trauma system we are analysing has hospitals that are more than three driving hours away from the trauma centre. Several studies also found an increase in total pre-hospital time spent if ALS was dispatched to trauma patients.[31–33] Moreover some studies even reported a worse outcome if the time to trauma centre was prolonged.[5,6] However in our trauma system time from accident to trauma centre although also higher did not make a measurable difference in the mortality of severe trauma patients making us reject our second hypothesis. This is in accordance with other European studies from Scotland and Switzerland showing that long pre-hospital times were not associated with worse outcome.[7,23] We believe that the potential disadvantage of spending more time pre-trauma centre might have been diluted by the advantages of delivering good standards of care in the pre-hospital environment or first hospital correcting life-threatening events prior to transfer to the trauma centre.

4.1. Study strengths and weaknesses

Our study's strengths lie in the well described cohort of patients; the prospective evaluation of a single trauma system with all patients transferred and afterwards treated in the same trauma centre; the use of the TRISS methodology for severity analysis and the use of a regression modelling to adjust mortality for case mix.[34]

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There are however a number of potential limitations in this study that must be taken into consideration. First, hospital mortality (more precisely trauma centre mortality), the dependent variable used, is a crude measure of effectiveness and may be heavily influenced by the quality of primary hospital care and possible differences in patient handling after reaching the trauma centre. Second we did not measure time from the traumatic event to treatment of life-threatening events and assumed that patients who had events solved in pre-hospital care had them solved earlier than patients who had them solved in primary or secondary hospital or trauma centre. We do not know this with certainty because the registry only records total time from injury till arrival in the trauma centre. However it is unlikely that patients assessed and treated in the pre-hospital phase, by an emergency physician, had their events corrected later than patients who were transported to first hospital and then transferred to trauma centre. Third we did not collect data on urban versus rural geography in our trauma system. A study from Liberman et al. showed no benefit of ALS in urban areas in Canada.[35] Other studies suggest benefit from pre-hospital ALS in rural and remote areas.[7,36,37] One possible explanation for our results would be that patients with life-threatening events corrected pre-trauma centre were predominantly from a rural area. Fourth we cannot make conclusions regarding the influence of pre-trauma centre correction of life-threatening events on pre-trauma centre mortality as this is a study based only on a trauma centre registry and not a population based study.

4.2. Conclusions and future research

Interventions able to treat life-threatening events (especially if made early by pre-hospital ALS teams) decreased transferred trauma patient mortality even if this prolonged time to trauma centre. Further research should indicate whether this conclusion can be generalised to different trauma systems.

Conflict of interest

All authors' deny any conflicts of interest.

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Addenda 3

ACTA MÉDICA PORTUGUESA, 2010 (in press)

1 - Título:

O doente politraumatizado grave – implicações da ruralidade na mortalidade, incapacidade e qualidade de vida.

Does rurality affect the outcome of trauma patients?

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5 – Resumo em português e em inglês com palavras-chave e key-words

O doente politraumatizado grave – implicações da ruralidade na mortalidade, incapacidade e qualidade de vida.

<u>Objectivos</u>: Determinar no doente politraumatizado o impacto da ruralidade na epidemiologia, gravidade e mortalidade dos doentes politraumatizados graves, bem como na incapacidade e qualidade de vida após a alta.

<u>Métodos</u>: Foi feita análise do registo prospectivo de todos os politraumatizados admitidos na Sala de Emergência do Hospital de Santo António entre 2001 e 2007 para a obtenção de dados epidemiológicos, de gravidade e de resultado precoce. Foram analisados os registos prospectivos da Consulta de Follow-Up realizada aos seis meses pós acidente para colheita de dados acerca de incapacidade e qualidade de vida. Os doentes foram divididos em três grupos: R (rural), SU (semi-urbano) e U (urbano), de acordo com a área de residência. Foram estudadas diversas variáveis com o objectivo de demonstrar relação com a área de residência: sexo, idade, tipo de trauma e mecanismo de lesão, dias de internamento (hospitalar e em Unidade de Cuidados Intensivos), gravidade anatómica por segmento (AIS), gravidade do politrauma (ISS), gravidade fisiológica (RTS), probabilidade de sobrevida (TRISS), existência de cuidados pré-hospitalares médicos (VMER), admissão prévia noutro hospital, existência de internamento em Cuidados Intensivos, mortalidade, qualidade de vida medida pelo Euroqol (EQ-5D) e incapacidade medida pelo Extended Glasgow Outcome Scale (GOSE).

<u>Resultados</u>: Entre 2001 e 2007 foram admitidos à SE do HGSA 1311 doentes. 161 doentes foram excluídos por ausência de informação relativa à área de residência. Foram estudados 1150 doentes (214 rurais, 219 semi-urbanos, 717 urbanos). Existe uma relação estatisticamente significativa entre a área de residência e a existência de cuidados pré-hospitalares médicos (VMER) (Grupo R: 12,2%; Grupo SU: 17,7%; Grupo U: 70,1%, com $p<0,001$), a admissão prévia noutro hospital (Grupo R: 89,2%; Grupo SU: 85,8%; Grupo U: 61,9%, com $p<0,001$), e de internamento em Cuidados Intensivos (Grupo R: 82,2%; Grupo SU: 78,5%; Grupo U: 72,4%, com $p<0,006$). Não

houve diferenças estatisticamente significativas entre os três grupos de doentes relativamente às outras variáveis epidemiológicas, de gravidade ou de resultado em termos de mortalidade, incapacidades ou qualidade de vida.

Conclusões: Os politraumatizados que residem em zonas rurais são semelhantes aos das zonas urbanas em termos epidemiológicos e de gravidade. Apesar de os doentes provenientes de zonas rurais não terem abordagem medicalizada no pré-hospitalar com a mesma frequência que os doentes que provêm de zonas urbanas e passarem com mais frequência por um primeiro hospital, isso não se traduziu em maior mortalidade avaliada no centro de trauma ou em menor qualidade de vida.

Palavras-chave:

Trauma; rural; urbano; mortalidade; incapacidades; qualidade de vida; GOSE; EQ-5D

Does rurality affect the outcome of trauma patients?

Objectives: To determine the impact of rurality in epidemiology, injury severity, health care facilities, length of stay, mortality, functional outcome and quality of life in severe trauma patients.

Methods: All trauma patients admitted in our Emergency Room between 2001 and 2007. Data was collected from the prospective Trauma Registry and Follow-Up Registry 6 months after the accident. Patients were divided in three groups according to residence area: R (rural), SU (semi-urban) and U (urban). Sex, age, type of injury, length of stay in hospital and intensive care, anatomic severity (AIS), politrauma severity (ISS), physiologic severity (RTS), surveillance probability (TRISS index), pre-hospital care, previous admission in other hospital, intensive care admission, Euroqol and Extended Glasgow Outcome scale and mortality were studied in order to find a relation with rurality.

Results: 1150 patients were analyzed (214 rural, 219 semi-urban, 717 urban). We found a statistical significant relation between rurality and pre-hospital care with rural patients having less medical approach in pre-hospital (R group: 12,2%; SU group: 17,7%; U group: 70,1%, $p<0{,}001$), previous admission in other hospital with rural patients being more often admitted in another hospital before transfer to the trauma centre (R group: 89,2%; SU group: 85,8%; U group: 61,9%, $p<0{,}001$) and intensive care admission (R group: 82,2%; SU group: 78,5%; U group: 72,4%, com $p<0{,}006$). We did not find any significant relation between other variables studied namely severity and early or late outcome.

Conclusions: Living in rural areas does not seam to give more burden of disease to severe trauma patients. Rural patients are similar to those that live in urban areas concerning epidemiology, injury severity and outcome. Despite lack of medical pre-hospital care and higher previous admission in other hospital in rural patients, mortality between groups didn't differ in our trauma centre.

Key-words:

Trauma; Rural; Urban; outcome; Mortality; disability; quality of life; EQ-5D; GOSE

Introdução:

O trauma é a principal causa de morte e incapacidade em indivíduos jovens em todo o mundo [1]. Os acidentes de viação e de trabalho, as quedas, as tentativas de suicídio e a violência interpessoal são os factores etiológicos mais importantes no trauma. De acordo com a Organização Mundial de Saúde (OMS), mais de 1.2 milhões de pessoas morrem por acidentes de viação anualmente e cerca de 50 milhões sofrem lesões ou ficam incapacitados. O trauma é a primeira causa de morte em indivíduos entre os 5 e os 44 anos e estima-se que no ano 2020 passe a ser a 3ª causa de morte. A nível Europeu, o trauma também é a primeira causa de morte até aos 44 anos e Portugal lidera a lista de países europeus em termos de incidência de trauma e mortalidade. Em Portugal, os acidentes de viação são a principal causa de trauma, seguindo-se os acidentes de trabalho, violência interpessoal e tentativas de suicídio [2]. Dados do Instituto Nacional de Estatística (INE) mostram que, no ano 2004, o número total de acidentes de viação foi de 63668 com 53144 vítimas. Este número inclui 1135 mortes, 4190 feridos graves e 47819 feridos ligeiros [3]. A mortalidade hospitalar por causa externa, obtida a partir do ICD-9, esteve relacionada com trauma em 10964 casos. Dados mais pormenorizados, nomeadamente de admissões hospitalares, são difíceis de obter, mas o número total de vítimas por trauma em 2004 em Portugal pode ter sido aproximadamente de 100 por 100000 habitantes.

A literatura tem estudado diversas variáveis e a sua influência no resultado de doentes politraumatizados, sendo a maior parte delas relacionadas com a gravidade da lesão sabendo-se pouco acerca do impacto das condições geográficas, nomeadamente da ruralidade nesse resultado [4]. Alguns estudos demonstram que o trauma rural é substancialmente diferente do urbano em termos de causas, população envolvida, tipo de lesões e resultado clínicos [4, 5]. Na tentativa de explicar este facto têm sido avançados dados acerca da menor acessibilidade das áreas rurais a cuidados médicos e da necessidade de muitos destes doentes serem transportados para centros especializados, em áreas urbanas. No entanto, outros estudos não mostram diferenças em termos de severidade do trauma e mortalidade entre politraumatizados de áreas urbanas e rurais [5-7], assim como em termos de resultado funcional destes doentes [4, 8]. Para contribuir para este debate é nosso objectivo determinar o impacto da ruralidade na epidemiologia, gravidade do trauma, tipo de circuito hospitalar, tempo de internamento e mortalidade dos doentes politraumatizados graves admitidos a um centro de trauma, bem como no resultado funcional e qualidade de vida destes doentes.

Material e métodos:

1 - Descrição do sistema de trauma e os cuidados no pré-hospitalar

A primeira abordagem das vítimas de trauma é, em geral, feita pelo INEM (Instituto Nacional de Emergência Médica). A coordenação de todos os doentes críticos é efectuada pelo CODU (centro de orientação de doentes urgentes) que responde a todas as chamadas de emergência (112) e envia os recursos mais apropriados disponíveis. Como os recursos não são uniformes para a mesma gravidade de trauma, diferentes abordagens são possíveis, desde uma VMER até uma ambulância com bombeiros apenas com conhecimentos básicos. Se uma VMER não está disponível, as ambulâncias com bombeiros assistem o doente no local e transportam-no para o hospital com serviço de urgência mais próximo. Se uma VMER é enviada ao local, o médico decide para onde o doente é transportado, podendo transportar directamente para o HGSA, sem passar pelo hospital mais próximo [9, 10].

Relativamente à área de referenciação, este sistema de trauma tem no HGSA o seu epicentro e inclui 4 distritos do norte de Portugal (Bragança, Vila Real, Aveiro (parcial) e Porto (parcial)). Os doentes com traumatismo craneo-encefálico da área do Hospital Pedro Hispano também são referenciados para o HGSA. A área geográfica de drenagem dos traumatizados graves para o HGSA está ilustrada na figura 1. O HGSA também recebe politraumatizados fora da sua área de referenciação pela escassez ou ausência de vagas de CI noutros hospitais. O HGSA é um hospital universitário com 600 camas e é o correspondente ao centro de trauma nível I para a cidade do Porto e para parte do norte de Portugal. Tem cerca de 130.000 casos por ano no Serviço de Urgência, sendo 1800 referentes a vítimas de trauma [11]. Cobre uma área geográfica de 15.761,9 Km2 com uma população de mais de 2 milhões de pessoas, no entanto, quase 50% desta população reside no centro urbano (cidade do Porto). O HGSA não tem as valências de Cirurgia Cardio-torácica ou Cirurgia Pediátrica, nem tem Serviço de Urgência Pediátrico. Doentes com menos de 16 anos e doentes que necessitam de Cirurgia Cardio-torácica são, através de um protocolo, orientados para outro hospital.

2 – Medição da gravidade

Existem escalas que visam quantificar o grau de gravidade da lesão do politraumatizado. Basicamente, estes sistemas definem a extensão da lesão, predizem a morbi-mortalidade e servem como base de comparação entre doentes e instituições. O RTS (Revised Trauma Score) é uma das escalas fisiológicas mais comuns que utiliza 3 parâmetros específicos: Escala de Coma de Glasgow (GCS), a pressão arterial sistémica (SBP) e a frequência respiratória (RR). O RTS codificada tem valores entre 0 e 7,84 [12]. O AIS (Abbreviated Injury Scale) é uma escala anatómica formulada num consenso baseando-se num sistema de classificação de vários níveis de gravidade da lesão, com valores de 1 (lesão menor) a 6 (lesão letal) [13]. A escala ISS [14, 15] define-se como a soma da pontuação máxima obtida na escala de AIS nas três regiões mais afectadas ao quadrado. O intervalo de valores da escala de ISS situa-se entre 1 e 75. Um trauma grave define-se po um ISS ≥ 16. A metodologia TRISS (trauma and injury severity score), usa uma equação de regressão que determina a probabilidade de sobrevivência (Ps) de um paciente aplicando uma fórmula onde são pesados o ISS, RTS a idade do doente e o tipo de trauma [16].

3 – Classificação das regiões em rural, semiurbana e urbana

Para classificar os nossos doentes de acordo com a sua área de residência, usamos a classificação "Tipologia das áreas urbanas, 1998" do Instituto Nacional de Estatística [17], que define a freguesias nacionais da seguinte forma: a) Freguesias urbanas: freguesias que possuam densidade populacional superior a 500hab/km2 ou que integrem um Lugar com população residente superior ou igual a 5000 habitantes. b) Freguesias semi-urbanas: freguesias não urbanas que possuam densidade populacional superior a 100hab/km^2 e inferior ou igual a 500 habitantes/km^2 ou que integrem um Lugar com população residente superior ou igual a 2000 habitantes e inferior a 5000 habitantes. c) Freguesias rurais: não classificadas nem como urbanas nem como semi-urbanas. Deste modo, os nossos doentes foram divididos em 3 grupos: Grupo R (grupo rural), Grupo SU (semi-urbano) e Grupo U (urbano).

4 – Medição do resultado

O resultado precoce foi medido através do tempo de internamento nos CI e no hospital e pela mortalidade. Dividimos a mortalidade em precoce (nas primeiras 48 horas) e tardia (> 48h) conforme a distribuição da mortalidade no trauma [10].

Seis meses após o acidente todos os doentes que tiveram alta do HGSA foram contactados por telefone ou carta para virem à consulta de follow-up. Para avaliar o resultado, foram analisados os dados de vários testes efectuados na consulta de Follow-Up: para a avaliação da qualidade de vida usamos o Euroqol (EQ-5D) e para a avaliação funcional, o Extended Glasgow Outcome Scale (GOSE).

O GOSE [18] é uma escala numérica que mede o resultado tardio desde a morte passando pelas diferentes incapacidades e deficiências e terminando no indivíduo que ficou sem qualquer sequela. Esta escala necessita de uma entrevista estruturada para ser aplicada. As 8 categorias da escala de GOSE são: Morte (1), Estado Vegetativo (2), Incapacidade Severa Baixa (3), Incapacidade Severa Alta (4), Incapacidade Moderada Baixa (5), Incapacidade Moderada Alta (6), Boa Recuperação Baixa (7) e Boa Recuperação Alta (8).

O *EQ-5D* [19, 20] é um instrumento *standard* utilizado como medida genérica de saúde aplicável a uma grande variedade de estados de saúde e doença que fornece um perfil descritivo simples e um único índice para cada indivíduo. O *EQ-5D* é cognitivamente simples, sendo necessários cerca de 2 minutos para o seu preenchimento. O actual questionário de *EQ-5D* tem um formato de 3 níveis e 5 dimensões, isto é, o conceito saúde é definido em 5 dimensões: mobilidade, auto-cuidado, actividades da vida diária, dor / desconforto e ansiedade / depressão. Cada dimensão apresenta 3 níveis: sem problema, problema moderado e problema grave. Na segunda parte do *EuroQol*, os pacientes são questionados pelo estado de saúde através da Escala Visual Analógica, em que zero significa o pior estado de saúde imaginável e cem o melhor estado de saúde.

5 – Tratamento estatístico

Para a análise descritiva da amostra foram aplicadas estatísticas de sumário apropriadas.

(%), as variáveis contínuas foram descritas utilizando como medida de tendência central a mediana e de dispersão os percentis 25 e 75. Foram testadas hipóteses sobre a distribuição de variáveis contínuas com distribuição não normal, através da utilização dos testes não paramétricos de Kruskall Wallis ou Teste Anova para distribuições normais. Para testar hipóteses sobre a independência de variáveis categóricas foram aplicados o teste de Qui-quadrado de independência ou o teste exacto de Fisher, conforme apropriado. Foi considerado um nível de significância de 0,05. A análise foi efectuada utilizando o programa de análise estatística SPSS® v.16.0 (Statistical Package for the Social Sciences). O EQ-5D e o GOSE foram divididos em categorias para permitir a análise.

Resultados:

1 – Caracterização da população

A caracterização da população pode ser vista na tabela 1 nomeadamente no que diz respeito á comparação entre os três subgrupos de doentes. 1311 doentes foram admitidos à sala de emergência no período considerado. A nossa amostra é constituída por 1150 doentes, dos quais 79% dos doentes eram do sexo masculino, com mediana de idades de 41 (25-60) anos. 214 doentes residiam em área rural (18,6%), 219 em área semi-urbana (19%) e 717 em área urbana (62,3%). Os traumatismos foram causados por acidentes de viação em 56,8% dos casos. A mediana do índice ISS, RTS e TRISS foram respectivamente de 25 (16-29), 5,97 (5,03-6,90) e de 83,27 (56,42-95,65).

Foram prestados cuidados médicos no pré-hospitalar (VMER) em 53,6% dos doentes. Dos doentes admitidos na sala de emergência do HGSA, 71,6% foram transferidos de outros hospitais. A mediana do intervalo de tempo entre a ocorrência do acidente e a chegada ao HGSA foi de 3h18minutos (10minutos-55h01minuto). Entre os doentes estudados, 75,4% necessitaram de internamento em cuidados intensivos. A mediana de dias de internamento hospitalar foi de 12 dias e de internamento em unidade de cuidados intensivos de 5 dias. A mortalidade hospitalar foi de 28,4% (14,1% dos nossos doentes morreram nas primeiras 48h) Não houve diferenças estatisticamente significativas entre os 3 grupos de doentes relativamente ao sexo, idade, incidência de lesão penetrante ou fechada, causa da lesão, dias de internamento hospitalar e em Unidade de Cuidados Intensivos, gravidade anatómica por segmento (AIS), gravidade do politrauma (índice ISS), gravidade fisiológica (RTS), probabilidade de sobrevida (TRISS), mortalidade, mortalidade precoce (<48h) e mortalidade tardia (>48h).

Os doentes residentes em áreas urbanas receberam cuidados médicos pré hospitalares com maior frequência (Grupo R: 12,2%; Grupo SU: 17,7%; Grupo U: 70,1%), com $p<0,001$. Os doentes residentes em áreas rurais e semi-urbanas foram admitidos com maior frequência num outro hospital antes do internamento no Hospital de Santo António (Grupo R: 89,2%; Grupo SU: 85,8%; Grupo U: 61,9%), com $p<0,001$. A mediana do intervalo de tempo entre a ocorrência do acidente e a chegada ao HGSA foi maior nos doentes residentes em áreas rurais e semi-urbanas (Grupo R: 5h22minutos; Grupo SU: 4h20minutos; Grupo U: 2h26minutos), com $p<0,001$. Os doentes residentes em áreas rurais e semi-urbanas foram admitidos com maior frequência em Unidade de Cuidados Intensivos (Grupo R: 82,2%; Grupo SU: 78,5%; Grupo U: 72,4%), com $p<0,006$.

2 – Resultado tardio (tabelas 2 e 3)

Para a avaliação do resultado aos 6 meses incluimos apenas doentes desde a implementação da consulta de follow-up em 2003. Dos 437 doentes elegiveis para follow-up apenas foram avaliados na consulta 323 correspondendo a uma taxa de respondentes de 74%. A Figura 2 mostra o fluxograma de seguimento dos doentes detalhando as exclusões.

Relativamente ao EQ-5D, 51,7% dos doentes não tinha problemas com a mobilidade, 60,1% não tinham problemas com os cuidados pessoais, 32,5% não tinham problemas com as actividades pessoais, 52,9% diziam não ter problemas relativamente a dor e mal-estar e 47,8% afirmavam não ter problemas relacionados com ansiedade e depressão. Não houve diferenças estatisticamente significativas entre os 3 grupos de doentes relativamente às medidas de sumário (índex) e na escala analógica visual (VAS).

Relativamente ao resultado funcional, 63,2% dos doentes apresentavam resultado favorável na escala de GOSE (GOSE=5+6+7+8). Não houve diferenças estatisticamente significativas entre os 3 grupos de doentes relativamente ao GOSE.

Discussão:

a) Principal resultado e sua discussão

O resultado principal deste artigo é que os doentes traumatizados graves residentes em zonas rurais de Portugal não tiveram maior mortalidade tardia nem mais incapacidades ou pior qualidade de vida que o mesmo tipo de doentes residentes em áreas urbanas. No entanto, é necessário interpretar estes resultados com cuidado e à luz de algumas limitações que descrevemos a seguir.

Residir em áreas rurais implica, em geral, um menor acesso a meios de socorro imediato podendo daí resultar uma maior mortalidade e mais incapacidades a longo prazo traduzindo-se em pior qualidade de vida. A contribuir para mais incapacidades e pior qualidade de vida poderá estar também o menor acesso a meios de reabilitação por parte de residentes em áreas rurais. É este o racional que motivou múltiplos estudos sem que no entanto esteja encerrada a controvérsia. Foi com o objectivo de tentar ultrapassar algumas das limitações de estudos anteriores e contribuir para este debate que realizámos este estudo.

O nosso estudo confirma que os doentes residentes em áreas rurais têm menos acesso a cuidados médicos no pré-hospitalar sem que no entanto fôssemos capazes de mostrar que se traduz também numa maior mortalidade medida no HGSA. O nosso estudo também mostra que em relação ao resultado tardio, medindo as incapacidades e a qualidade de vida, não há diferenças entre habitantes rurais e urbanos, tendo em conta que nos estamos a referir somente a doentes que chegaram ao HGSA.

Levantamos duas hipóteses para explicar os nossos resultados:

1 - O impacto da ruralidade estará provavelmente a montante do HGSA – no local e no primeiro hospital – traduzindo-se potencialmente em maior mortalidade precoce mas os sobreviventes que conseguem chegar ao centro de trauma têm a mesma mortalidade e vivem com o mesmo tipo de incapacidades e a mesma qualidade de vida que os seus congéneres da cidade. Só com um estudo populacional baseado num Registo Nacional de Trauma será possível confirmar ou rejeitar esta hipótese.

2 – O método que utilizámos para comparar as populações rurais e urbanas – classificação que usa a densidade populacional – é redutora e não mede a acessibilidade a recursos de saúde de forma adequada. Só com um estudo populacional baseado num Registo Nacional de Trauma será possível confirmar ou rejeitar esta hipótese.

b) Comparação com a literatura

Vários estudos relacionam a ruralidade com o aumento do tempo de resposta das equipas de emergência e maior tempo de chegada até ao tratamento definitivo, alguns não mostram qualquer impacto da ruralidade na mortalidade como um realizado em van, estudo populacional e de desenho antes-depois que mostra o impacto de várias idas de prevenção na incidência de trauma nomeadamente TCE mas não confirma a iencia da ruralidade na mortalidade [6]. Um estudo do impacto do heli-transporte no ma em ambiente rural e urbano também mostra que depois da implementação do transporte não se verificam diferenças de mortalidade entre vitimas de trauma sportadas de áreas rurais *vs.* urbanas [7]. Um estudo de Harradine e colaboradores estuda doentes com TCE grave em múltiplas unidades de reabilitação e compara os ltados tardios da população residente nas áreas rural e urbana em New South Wales, tralia. Neste estudo como no nosso não há diferenças no resultado tardio (qualidade ida e resultado funcional) entre os residentes de áreas rurais ou urbanas. Também a valorização da mortalidade tem que ser feita com cuidado mas os resultados do ltado tardio são generalizáveis. Um estudo escocês de McGuffie e colaboradores [5] bém compara residentes rurais e urbanos num estudo populacional, concluindo que mpo até ao centro de trauma e a necessidade de CI é maior nos doentes matizados provenientes de zonas rurais assemelhando-se aos resultados que nós ntrámos. Neste estudo também não são encontradas diferenças na mortalidade e no o de internamento, apesar do carácter populacional do mesmo. Contrariamente ao o este estudo não inclui o resultado tardio. Outro estudo, este dos Estados Unidos compara resultados tardios em traumatizados rurais e urbanos concluindo que a área esidência não era factor independente determinante do status funcional. Neste do a medição do status funcional é feita usando o Disability Rating Scale (DRS) e o do é realizado apenas em TCE limitando a comparação com o nosso estudo. Outra ise efectuada numa unidade de reabilitação com o objectivo de encontrar determinantes de dependência em TCE também não encontra relação com a ruralidade encontrando como principais determinantes a gravidade inicial do trauma e a idade [8]. Há no entanto estudos que mostram maiores incapacidades nos sobreviventes de trauma residentes em áreas rurais sugerindo barreiras até agora pouco estudadas [25-29]. Um estudo de Schootman e colaboradores revela maiores dependências e pior estado de saúde em residentes de áreas rurais com menos de 100 residentes por milha quadrada [25]. No entanto a principal diferença em relação ao nosso estudo reside no facto de estes autores incluírem muitos traumatizados menos graves o que se traduz num resultado com independência completa em 73% dos doentes contra 63% no nosso estudo. Outra diferença importante reside no facto de a definição de ruralidade neste artigo ser diferente da nossa implicando ainda uma menor densidade populacional.

Um estudo recente analisa dados do registo de trauma do HGSA e compara diferentes abordagens no pré-hospitalar [30] São analisados apenas doentes em transporte secundário, ou seja, doentes que demoram mais de 3 horas até ao centro de trauma. Este estudo conclui que a presença da VMER e a capacidade de corrigir precocemente no local os problemas que ameaçam a vida dos politraumatizados diminuiu a mortalidade medida no centro de trauma de forma significativa e independente e foi mais importante do que reduzir o tempo total gasto até ao HGSA. Ou seja, a presença de VMER será fundamental para a sobrevivência dos traumatizados que têm o acidente a mais de 3 horas do centro de trauma. É possível que estes doentes que demoram mais de 3 horas a chegar ao HGSA sejam predominantemente de zonas rurais, o que nos leva a pensar que a presença ou ausência de VMER nas zonas rurais pode também ter influenciado os nossos resultados e contribuído para a redução das diferenças encontradas.

c) Limitações

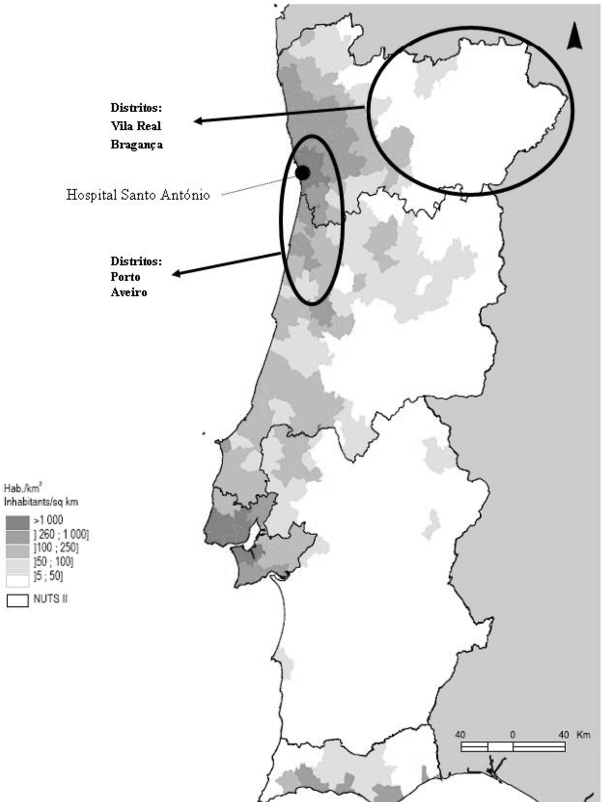
Os resultados e conclusões deste estudo têm de ser lidos à luz de três limitações: 1) Este estudo não é um estudo populacional, que só seria possível se houvesse um registo nacional de trauma, mas sim um estudo de resultado num centro de trauma. Esta limitação tem principalmente importância na análise da mortalidade. Conforme literatura recente parece apontar a mortalidade no trauma acontece principalmente nos 2 primeiros dias (80%) e dentro desta mortalidade precoce cerca de 50% morrem no local do acidente e 30% depois disso com um pico por volta das 2 horas. [10] Este estudo não inclui a mortalidade no local nem a mortalidade nas primeiras horas quando o doente passa por um outro hospital que não o HGSA. Assim a mortalidade no local pode ter sido maior nos grupos rurais devido ao atraso no reconhecimento do acidente e na prestação de cuidados pré-hospitalares mas não temos dados que o suportem. Além disso, nos grupos com maior ruralidade, a admissão noutro hospital foi mais frequente e todos os doentes que morreram no hospital de referência e que não chegaram a ser admitidos na sala de emergência do HGSA também não estão incluídos no estudo. Apesar do que atrás descrevemos podemos concluir que a mortalidade no centro de trauma não foi afectada pela ruralidade no nosso estudo. Esta limitação que descrevemos para a valorização das diferenças na mortalidade não é verdade para o estudo da morbilidade pois recebemos todos os sobreviventes graves no nosso centro de trauma sendo o resultado da morbilidade generalizável a toda a população de politraumatizados graves. 2) No nosso estudo quando definimos os grupos: rural, urbano e semi-urbano, fizemo-lo pelo local da residência. Se em relação à morbilidade estes critérios são os mais importantes (nomeadamente relacionados com a acessibilidade a meios de reabilitação), em relação à mortalidade seria mais adequado ter o local de ocorrência do acidente. No entanto múltiplos estudos mostram concordância entre a área da residência e o local do acidente [26, 28]. Além disso os resultados do nosso estudo apontam para uma menor utilização do pre-hospitalar medicalizado nos doentes rurais apoiando esta concordância do local de residência e da ocorrência do acidente. 3) Medir o nível de urbanidade ou ruralidade pela densidade populacional tem as limitações decorrentes da própria classificação. Assumir acessibilidade de meios de emergência ou de reabilitação associados a esta classificação pode não ser totalmente verdade. Esta limitação não é no entanto fácil de ultrapassar mas poderia ser complementada com um inquérito acerca dos meios disponíveis em cada região. Para tentar ultrapassar este tipo de limitação da classificação de ruralidade pela densidade populacional isolada, Gontkovsky e colaboradores [8] utilizaram outro método para definir urbanidade considerando a população dos três maiores aglomerados populacionais em cada região. Mesmo assim não encontraram como nós qualquer diferença no resultado tardio.

Conclusões:

É urgente a implementação de um Registo Nacional de Trauma que permita estudos populacionais que tenham como objectivo caracterizar o trauma e estudar as suas consequências, nomeadamente no que diz respeito às diferenças entre os habitantes rurais e urbanos.

Neste estudo, os politraumatizados de zonas rurais foram semelhantes aos das zonas urbanas em termos epidemiológicos, de gravidade e do resultado tardio.

Figura 1: Densidade populacional por município e sinalização da área de referenciação do HGSA para o trauma grave



Fonte: INE, I.P., Estimativas provisórias de população residente e Instituto Geográfico Português (IGP), a partir da Série Cartográfica Nacional à escala 1: 50 000 (IGP) e Carta Administrativa Oficial de Portugal de Março de 2008 (CAOP 2008.0) (IGP).

Figura 2: Fluxograma de seguimento dos doentes detalhando as exclusões.

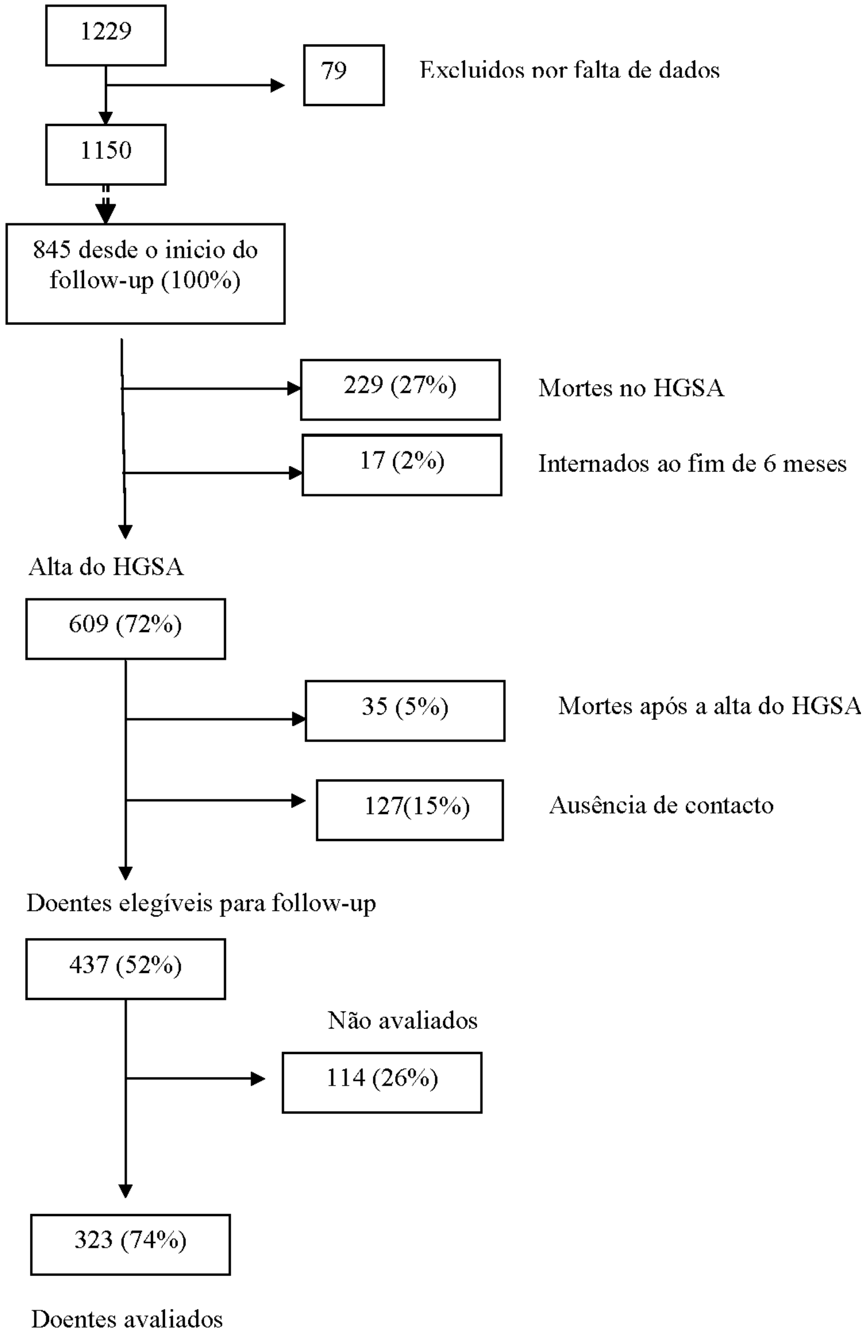


Tabela I: Características da população

	Total (n=1150)	Local de residência Rural (n=214)	Semi-Urbano (n=219)	Urbano (n=717)	p
Sexo n (%)					
Masculino	909 (79,0)	176 (82,2)	181 (82,6)	552 (77,0)	0,088*
Feminino	241 (21,0)	38 (17,8)	38 (17,4)	165 (23,0)	
Idade, média (dp)	44 (20)	45 (20)	43 (20)	44 (21)	0,641**
ISS, mediana e IQR	25 (16-29)	25 (17-29)	25(16-30)	25(16-32)	0,846***
RTS, mediana e IQR	5,97 (5,03-6,90)	5,97 (5,03-6,90)	5,97 (5,03-6,90)	5,97 (5,03-7,11)	0,722***
TRISS, mediana e IQR	83,27 (56,42-95,65)	83,53 (61,21-94,62)	81,38 (56,42-95,65)	83,50 (55,65-95,66)	0,890***
AIS, mediana e IQR					
Cabeça	4,00 (3,00-5,00)	4,00 (4,00-5,00)	4,00 (3,00-5,00)	4,00 (3,00-5,00)	0,601***
Face	2,00 (1,00-2,00)	2,00 (2,00-2,00)	2,00 (1,00-2,00)	2,00 (1,00-2,00)	0,399***
Tórax	3,00 (3,00-4,00)	3,00 (3,00-4,00)	4,00 (3,00-4,00)	3,00 (3,00-4,00)	0,398***
Abdómen	2,00 (2,00-3,00)	3,00 (2,00-4,00)	2,00 (2,00-3,00)	2,00 (2,00-3,00)	0,154***
Extremidades	2,00 (2,00-3,00)	2,00 (2,00-3,00)	2,00 (2,00-3,00)	2,00 (2,00-3,00)	**0,050***
Tipo de lesão, n (%)					
Penetrante	74 (6,4)	13 (6,1)	12 (5,5)	49 (6,8)	0,753*
Fechada	1076 (93,6)	201 (93,9)	207(94,5)	668 (93,2)	
Causa da lesão, n (%)					
Acidentes Viação	651 (56,8)	111 (51,9)	126 (57,8)	414 (58,0)	
Quedas	339 (29,6)	68 (31,8)	64 (29,4)	207 (29,0)	
Arma branca	15 (1,3)	1 (0,5)	1 (0,5)	13 (1,8)	0,403*
Arma de fogo	47 (4,1)	11 (5,1)	9 (4,1)	27 (3,8)	
Outras,	94 (8,2)	23 (10,7)	18 (8,3)	53 (7,4)	
Tempo (horas:minutos) até ao HGSA, mediana e IQR	3:18 (0:10-55:01)	5:22 (0:20-41:30)	4:20 (0:20-32:30)	2:26 (0:10-55:01)	**<0,001***
Cuidados pré-hospitalares, n (%)	616 (54)	75 (35,0)	109 (49,8)	432 (60,2)	**<0,001***
Admissão prévia noutro hospital, n (%)	82 (72)	191(89,2)	188(85,8)	444 (61,9)	**<0,001***
Admissão em UCI, n (%)	867 (75)	176 (82,2)	172 (78,5)	519 (72,4%)	**0,006***
Dias internamento hospitalar, mediana e IQR	12 (4-24)	13 (4-26)	12 (4-26)	12 (3-24)	0,527***
Dias internamento em UCI, mediana e IQR	5 (1-11)	6 (2-11)	4 (1-10)	5 (0-11)	0,213***
Mortalidade precoce, n (%)	162 (14)	25 (11,7)	36 (16,4)	101 (14,1)	0,364*
Mortalidade total, n (%)	327 (28)	57 (26,6)	62 (28,3)	208 (29,0)	0,795*

*Teste qui quadrado de Pearson, ** ANOVA *** Teste de Kruskall Wallis. IQR – Inter Quartil Range

Tabela II – Descrição do teste EQ-5D comparando os diferentes locais de residência

	Total (n=323)	Local de residência Rural (n=59)	Semi-Urbano (n=74)	Urbano (n=190)	p
Mobilidade n (%)					
Sem problemas	167 (51,7)	32 (54,2)	40 (54,1)	95 (50,0)	
Problemas moderados	136 (42,1)	26 (44,1)	28 (37,8)	82 (43,2)	-
Problemas Extremos	20 (6,2)	1 (1,7)	6 (8,1)	13 (6,8)	
Cuidados Pessoais n (%)					
Sem problemas	194 (60,1)	30 (50,8)	42 (56,8)	122 (64,2)	
Problemas moderados	77 (23,8)	14 (23,7)	19 (25,7)	44 (23,2)	0,197*
Problemas Extremos	52 (16,1)	15 (25,4)	13 (17,6)	24 (12,6)	
Actividades Habituais n (%)					
Sem problemas	105 (32,5)	18 (30,5)	23 (31,1)	64 (33,7)	
Problemas moderados	106 (32,8)	18 (30,5)	26 (35,1)	62 (32,6)	0,938*
Problemas Extremos	112 (34,7)	23 (39,0)	25 (33,8)	64 (33,7)	
Dor/Mau Estar n (%)					
Sem problemas	171 (52,9)	29 (49,2)	41 (55,4)	101 (53,2)	-
Problemas moderados	135 (41,8)	27 (45,8)	29 (39,2)	79 (41,6)	
Problemas Extremos	17 (5,3)	3 (5,1)	4 (5,4)	10 (5,3)	
Ansiedade/Depressão, n (%)					
Sem problemas	154 (47,8)	30 (50,8)	37 (50,0)	87 (46,0)	0,601*
Problemas moderados	120 (37,3)	24 (40,7)	26 (35,1)	70 (37,0)	
Problemas Extremos	48 (14,9)	5 (8,5)	11 (14,9)	32 (16,9)	
Index Total, mediana (IQR)	63,68 (23,09-100,00)	61,43 (23,09-100,00)	68,61 (22,88-100,00)	66,80 (23,09-100,00)	0,987**
VAS, mediana (IQR)	60 (20-90)	60 (20-90)	55 (20-100)	60 (30-90)	0,467**

*Teste Qui quadrado de Pearson, ** Teste Kruskal Wallis

Tabela III – Descrição do teste GOSE comparando os diferentes locais de residência

	Total (n=323)	Local de residência Rural (n=59)	Semi-Urbano (n=74)	Urbano (n=190)	p*
GOSE, n (%)					
2-Estado Vegetativo	5 (1,5)	0 (0)	2 (2,7)	3 (1,6)	
3-Disfunção grave inferior	55 (17,0)	11 (18,6)	14 (18,9)	30 (15,8)	
4-Disfunção grave superior	59 (18,3)	10 (16,9)	15 (25,4)	34 (57,6)	
5-Disfunção moderada inferior	24 (7,4)	2 (3,4)	5 (6,8)	17 (8,9)	0,582
6-Disfunção moderada superior	59 (18,3)	13 (22,0)	14 (23,7)	32 (54,2)	
7-Disfunção ligeira inferior	50 (15,5)	5 (8,5)	10 (13,5)	35 (18,4)	
8-Boa recuperação superior	71 (22,0)	18 (30,5)	14 (18,9)	39 (20,5)	
Outcome favorável (5+6+7+8), n (%)	204 (63,2)	38 (64,4)	43 (58,1)	123 (64,7)	0,590

*-Teste Qui – quadrado de Pearson

8 – Bibliografia

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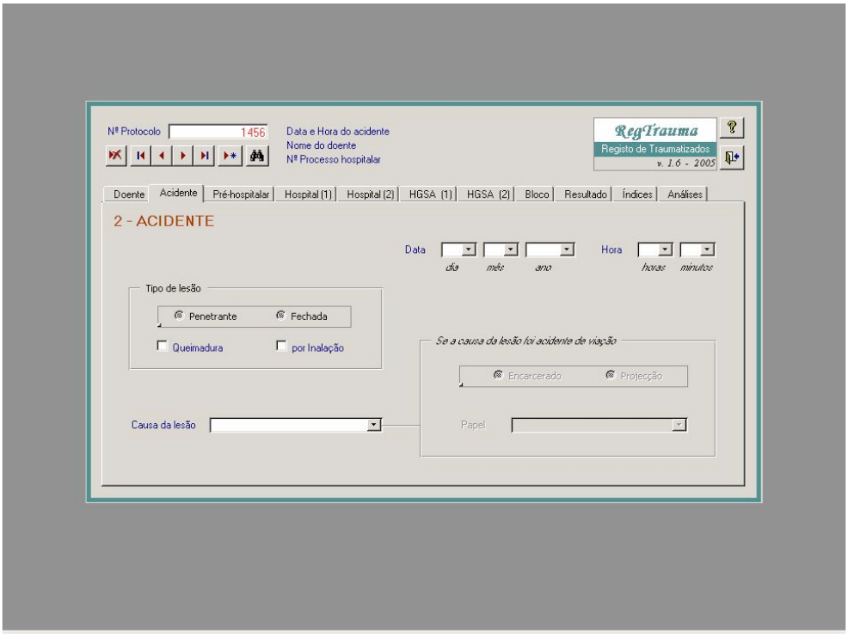
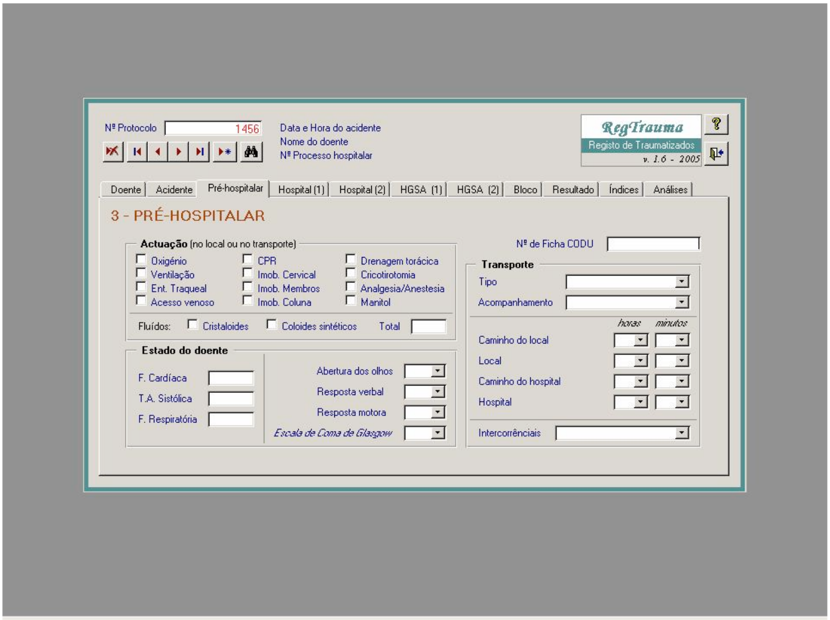
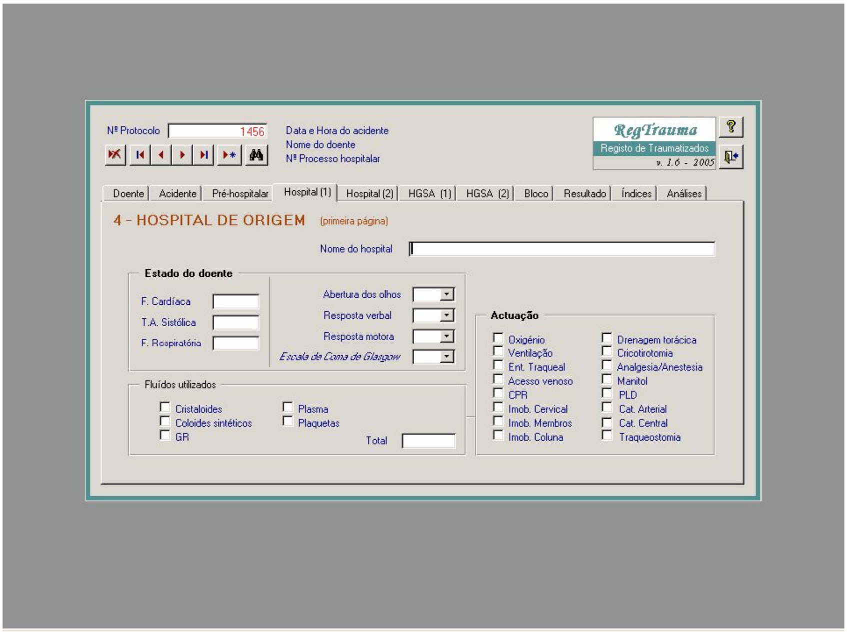
Addenda 4

BASE DE DADOS DO REGISTO PROSPECTIVO DE TRAUMA



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1456
Data e Hora do acidente
Nome do doente
Nº Processo hospitalar
RegTrauma
Registo de Traumatizados
v. 1.6 - 2005
Doente
Acidente
Pré-hospitalar
Hospital (1)
Hospital (2)
HGSA (1)
HGSA (2)
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T.A. Sistólica
F. Respiratória
Abertura dos olhos
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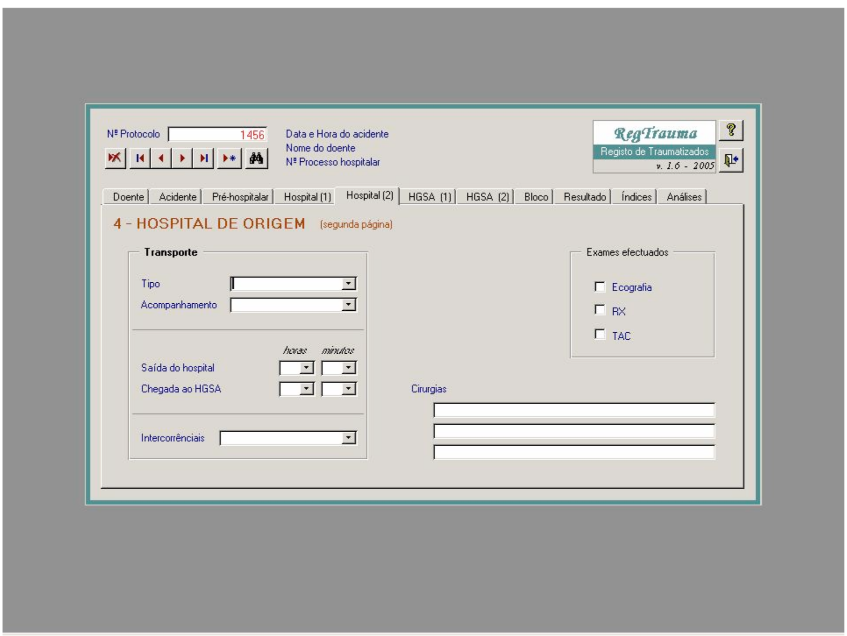
Resposta motora
Escala de Coma de Glasgow
Fluídos utilizados
Cristaloides
Coloides sintéticos
GR
Plasma
Plaquetas
Total
Actuação
Oxigénio
Ventilação
Ent. Traqueal
Acesso venoso
CPR
Imob. Cervical
Imob. Membros
Imob. Coluna
Drenagem torácica
Cricotirotomia
Analgesia/Anestesia
Manitol
PLD
Cat. Arterial
Cat. Central
Traqueostomia


Nº Protocolo
1456
Data e Hora do acidente
Nome do doente
Nº Processo hospitalar
RegTrauma
Registo de Traumatizados
v. 1.6 - 2005
Doente
Acidente
Pré-hospitalar
Hospital (1)
Hospital (2)
HGSA (1)
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Bloco
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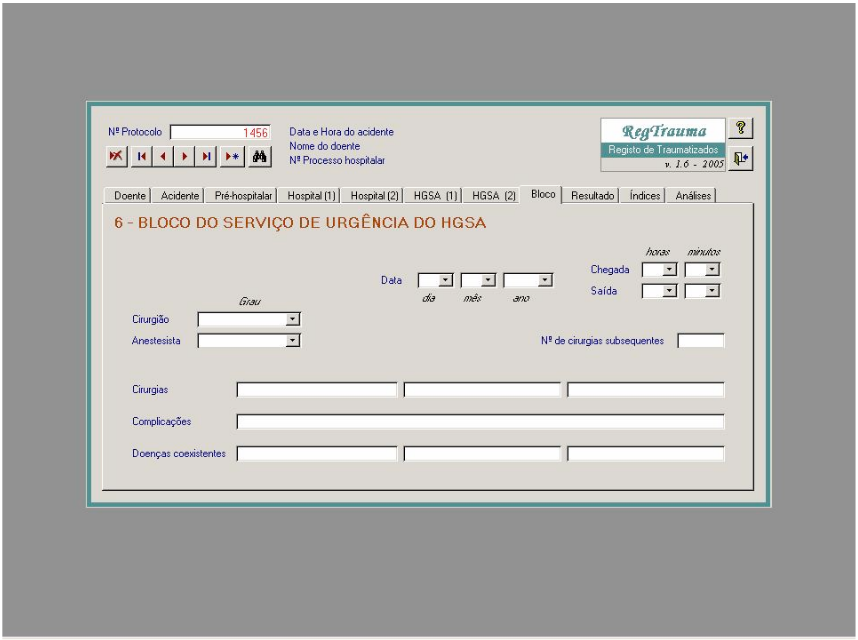
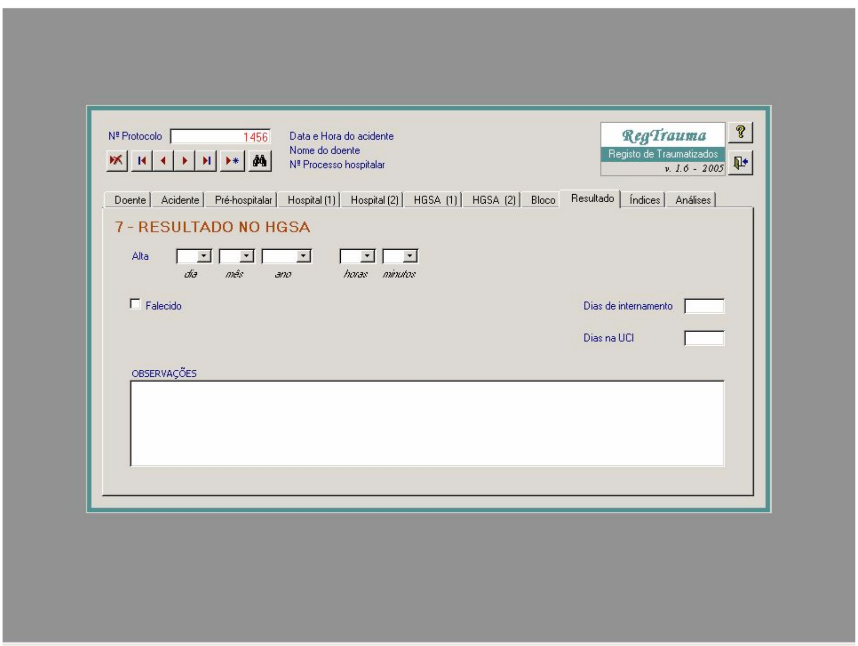
Tipo
Acompanhamento
horas
minutos
Saída do hospital
Chegada ao HGSA
Intercorrênciais
Exames efectuados
Ecografia
RX
TAC
Cirurgias

Nº Protocolo 1456
Data e Hora do acidente
Nome do doente
Nº Processo hospitalar
RegTrauma
Registo de Traumatizados
v. 1.6 - 2005
Doente | Acidente | Pré-hospitalar | Hospital (1) | Hospital (2) | HGSA (1) | HGSA (2) | Bloco | Resultado | Índices | Análises
5 - HOSPITAL G. DE ST. ANTÓNIO (primeira página)
Estado do doente
Abertura dos olhos
Resposta verbal
Resposta motora
Escala de Coma de Glasgow
F. Cardíaca
T.A. Sistólica
F. Respiratória
dia mês ano horas minutos
Entrada no HGSA
Entrada na Sala Emergência
Saída da Sala Emergência
Destino
Actuação
Oxigénio
Ventilação
Ent. Traqueal
Acesso venoso
CPR
Imob. Cervical
Imob. Membros
Imob. Coluna
Drenagem torácica
Cricotirotomia
PL Peritoneal
Algaliação
Sonda gástrica
Cat. Central
Cat. Arterial
Via intraóssea
Fluídos
Cristaloides
Coloides sintéticos
GR
Plasma
Plaquetas
Total

Nº Protocolo 1456
Data e Hora do acidente
Nome do doente
Nº Processo hospitalar
RegTrauma
Registo de Traumatizados
v. 1.6 - 2005
Doente | Acidente | Pré-hospitalar | Hospital (1) | Hospital (2) | HGSA (1) | HGSA (2) | Bloco | Resultado | Índices | Análises
5 - HOSPITAL G. DE ST. ANTÓNIO (segunda página)
Médicos que vêm o doente
Horas Minutos Especialidade Grau CAT SAVP Nome Nº mecanog.
Exames
Horas Minutos Cabeça Coluna Bacia Membros Abdomen Tórax Pelve
RX
TAC
ECO


Nº Protocolo
1456
Data e Hora do acidente
Nome do doente
Nº Processo hospitalar
RegTrauma
Registo de Traumatizados
v. 1.6 - 2005
Doente
Acidente
Pré-hospitalar
Hospital (1)
Hospital (2)
HGSA (1)
HGSA (2)
Bloco
Resultado
Índices
Análises
6 - BLOCO DO SERVIÇO DE URGÊNCIA DO HGSA
horas
minutos
Chegada
Saída
Data
dia
mês
ano
Grau
Cirurgião
Anestesista
Nº de cirurgias subsequentes
Cirurgias
Complicações
Doenças coexistentes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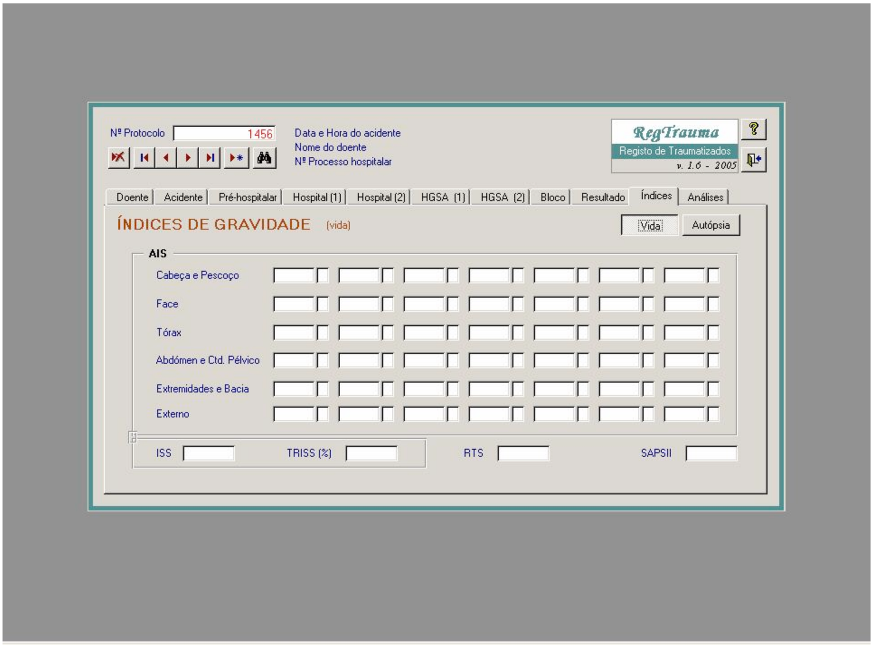
1456
Data e Hora do acidente
Nome do doente
Nº Processo hospitalar
RegTrauma
Registo de Traumatizados
v. 1.6 - 2005
Doente
Acidente
Pré-hospitalar
Hospital (1)
Hospital (2)
HGSA (1)
HGSA (2)
Bloco
Resultado
Índices
Análises
7 - RESULTADO NO HGSA
Alta
dia
mês
ano
horas
minutos
Falecido
Dias de internamento
Dias na UCI
OBSERVAÇÕES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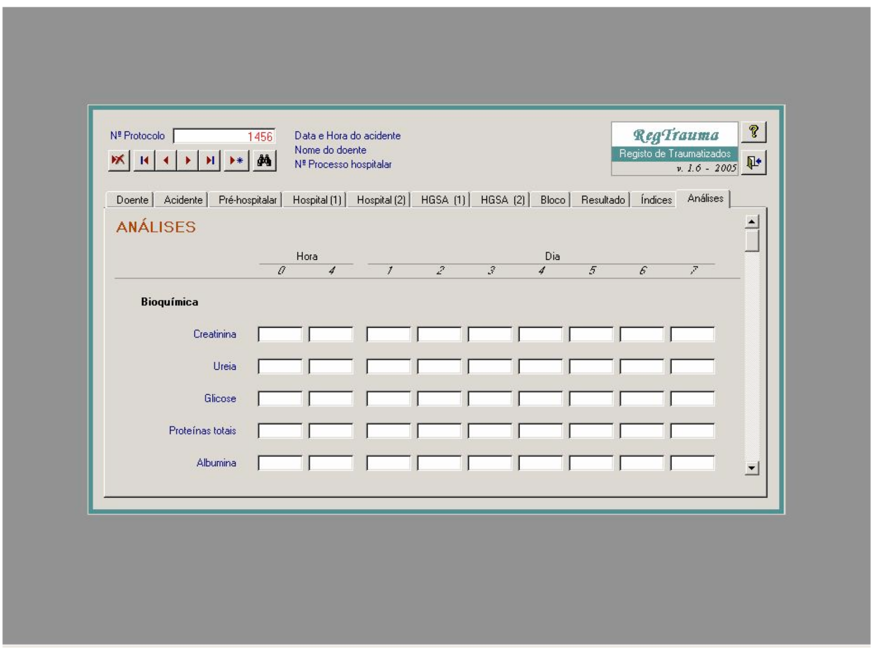
1456
Data e Hora do acidente
Nome do doente
Nº Processo hospitalar
RegTrauma
Registo de Traumatizados
v. 1.6 - 2005
Doente
Acidente
Pré-hospitalar
Hospital (1)
Hospital (2)
HGSA (1)
HGSA (2)
Bloco
Resultado
Índices
Análises
ÍNDICES DE GRAVIDADE
(vida)
Vida
Autópsia
AIS
Cabeça e Pescoço
Face
Tórax
Abdómen e Ctd. Pélvico
Extremidades e Bacia
Externo
ISS
TRISS (%)
RTS
SAPSII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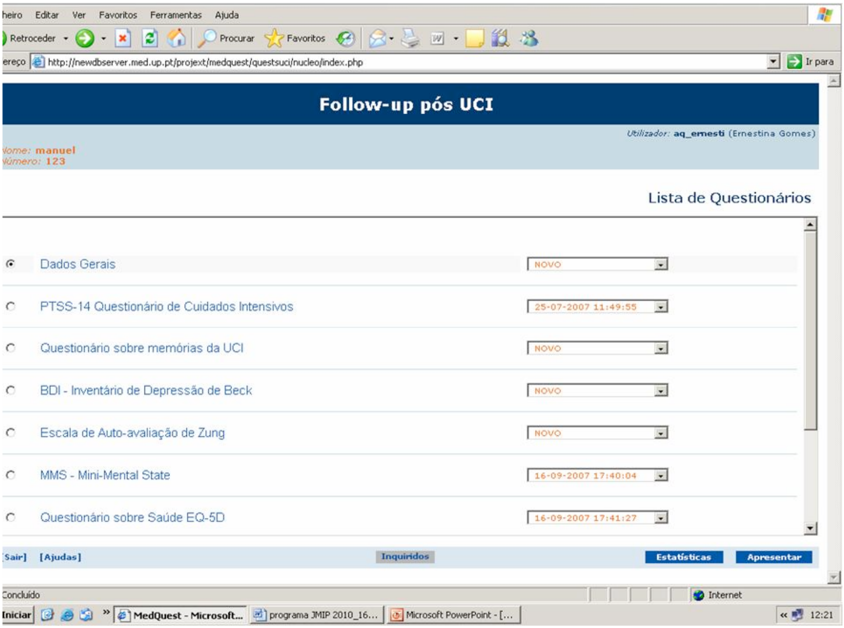
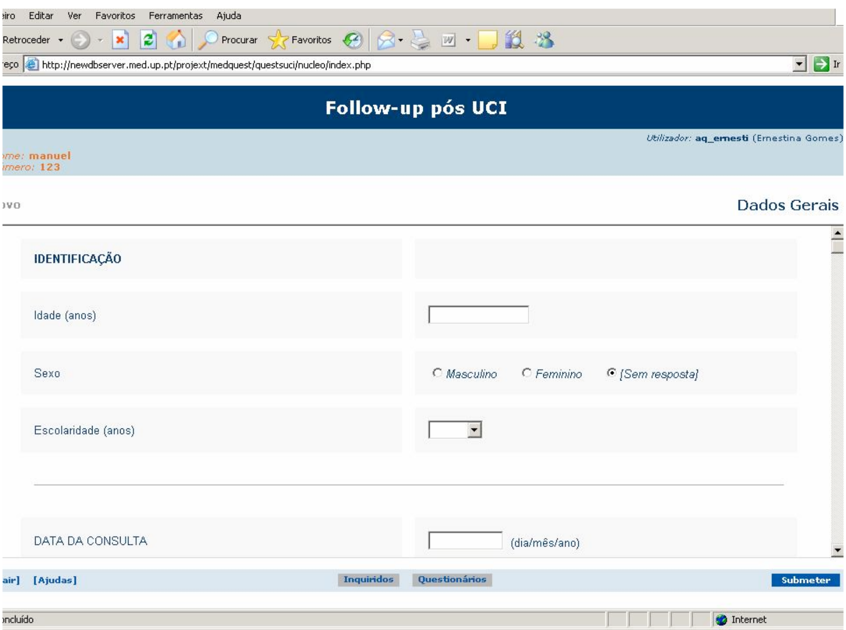
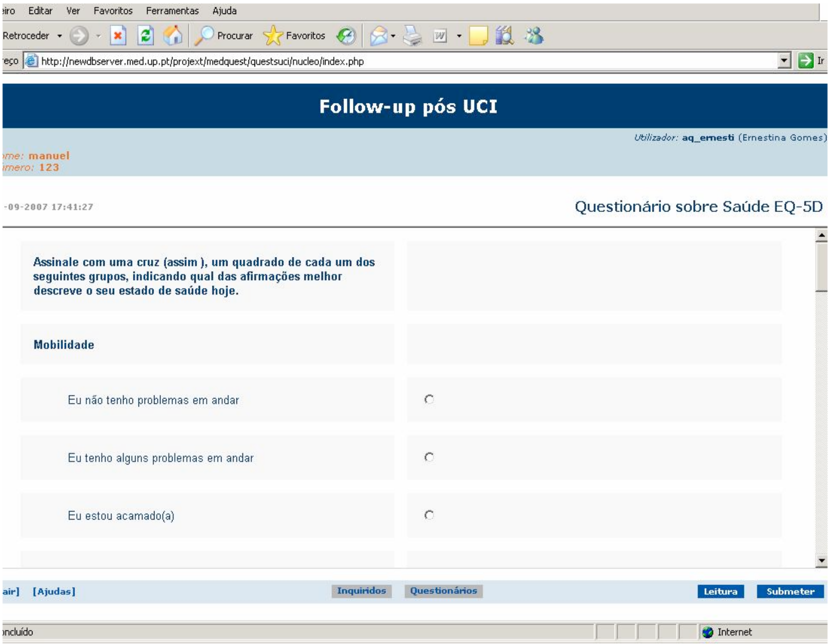
1456
Data e Hora do acidente
Nome do doente
Nº Processo hospitalar
RegTrauma
Registo de Traumatizados
v. 1.6 - 2005
Doente
Acidente
Pré-hospitalar
Hospital (1)
Hospital (2)
HGSA (1)
HGSA (2)
Bloco
Resultado
Índices
Análises
ANÁLISES
Hora
Dia
0 4
1 2 3 4 5 6 7
Bioquímica
Creatinina
Ureia
Glicose
Proteínas totais
Albumina

Addenda 5

BASE DE DADOS DA CONSULTA DE FOLLOW-UP







eiro Editar Ver Favoritos Ferramentas Ajuda

Retroceder Procurar Favoritos

reço http://newdbserver.med.up.pt/projext/medquest/questsuci/nucleo/index.php Ir

Follow-up pós UCI

Utilizador: **aq_ernesti** (Ernestina Gomes)

me: **manuel**
imero: **123**

-09-2007 17:41:27

Questionário sobre Saúde EQ-5D

Assinale com uma cruz (assim), um quadrado de cada um dos seguintes grupos, indicando qual das afirmações melhor descreve o seu estado de saúde hoje.

Mobilidade

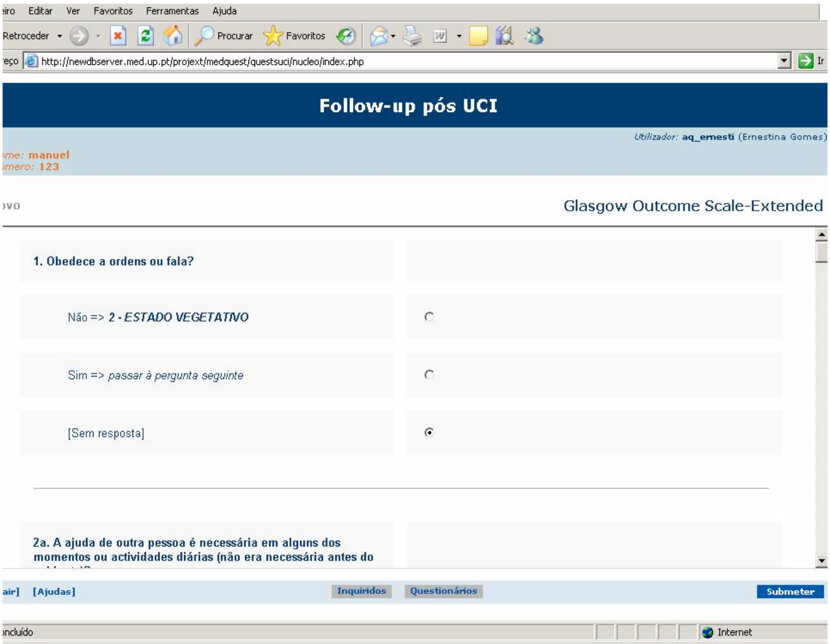
Eu não tenho problemas em andar

Eu tenho alguns problemas em andar

Eu estou acamado(a)

air] [Ajudas] Inquiridos Questionários Leitura Submeter

ncluído Internet



eiro Editar Ver Favoritos Ferramentas Ajuda

Retroceder Procurar Favoritos

reço http://newdbserver.med.up.pt/projext/medquest/questsuci/nucleo/index.php Ir

Follow-up pós UCI

Utilizador: **aq_ernesti** (Ernestina Gomes)

me: **manuel**
imero: **123**

ovo

Glasgow Outcome Scale-Extended

1. Obedece a ordens ou fala?

Não => ***2 - ESTADO VEGETATIVO***

Sim => *passar à pergunta seguinte*

[Sem resposta]

2a. A ajuda de outra pessoa é necessária em alguns dos momentos ou actividades diárias (não era necessária antes do

air] [Ajudas] Inquiridos Questionários Submeter

ncluído Internet

ADDENDA 6

Questionário de Saúde EQ – 5D
Versão portuguesa do Euroqol Instrument

Assinale com uma cruz (assim ☒), um quadrado de cada um dos seguintes grupos, indicando qual das afirmações melhor descreve o seu estado de saúde hoje.

Mobilidade

- Eu não tenho problemas em andar ☐
- Eu tenho alguns problemas em andar ☐
- Eu estou acamado(a) ☐

Cuidados Pessoais

- Eu não tenho problemas com os meus cuidados pessoais ☐
- Tenho alguns problemas ao lavar-me ou vestir-me ☐
- Eu sou incapaz de me lavar ou vestir sózinho ☐

Actividades Habituais (ex. trabalho, estudos, actividades domésticas, actividades em família ou de fazer)

- Eu não tenho problemas em desempenhar as minhas actividades habituais ☐
- Eu tenho alguns problemas em desempenhar as minhas actividades habituais ☐
- Eu sou incapaz de desempenhar as minhas actividades habituais ☐

Dor/Mau Estar.

- Eu não tenho dores ou mal estar ☐
- Eu tenho dores moderadas ou mal estar ☐
- Eu tenho dores extremas ou mal estar ☐

Ansiedade/Depressão

- Eu não estou ansioso(a) ou deprimido(a) ☐
- Eu estou moderadamente ansioso(a) ou deprimido(a) ☐
- Eu estou extremamente ansioso(a) ou deprimido(a) ☐

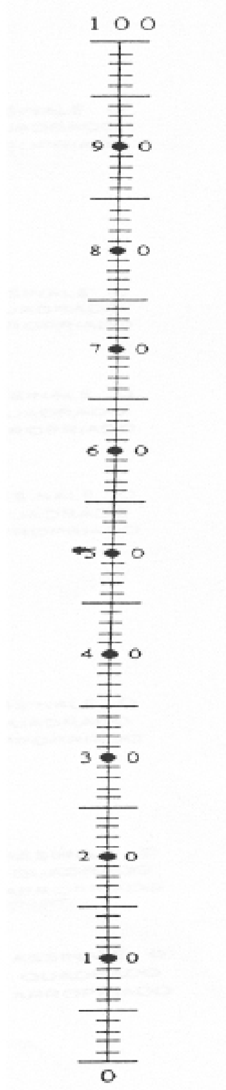
Comparado com o meu nível geral de saúde nos seis meses anteriores ao internamento em Cuidados intensivos, o meu estado de saúde hoje é:

Melhor ☐
O mesmo ☐ assinale o quadro apropriado
Pior ☐

Para ajudar as pessoas a classificarem quão bom ou mau é o seu estado de saúde hoje, desenhámos uma esca1a (semelhante a um termómetro) na qual o melhor estado de saúde que possa imaginar é marcado por **100** e o pior estado de saúde que possa imaginar e marcado por **O**.

Gostaríamos que indicasse nesta escala a sua opinião acerca do seu estado de saúde hoje. Por favor, desenhe uma linha a partir do quadrado que se encontra abaixo, até ao ponto da escala que melhor classifica o seu estado de saúde Hoje.

O melhor estado de saúde imaginável



O seu estado de saúde hoje

O pior estado de saúde imaginável

Addenda 7

GLASGOW OUTCOME SCALE – EXTENDED

1. Obedece a ordens ou fala?
    Não – **2 – ESTADO VEGETATIVO**
    Sim – Passar à pergunta seguinte.

2a. A ajuda de outra pessoa é necessária em alguns dos momentos ou actividades diárias (não era necessária antes do acidente)?
    Não – Passar à pergunta 3.
    Sim - Passar à pergunta seguinte.

2b. A ajuda necessária é na maior parte do tempo?
    Não – **4 – DISFUNÇÃO GRAVE SUPERIOR**
    Sim – **3 – DISFUNÇÃO GRAVE INFERIOR**

3a. Consegue ir ás compras sem ajuda?
    Não – Passar à pergunta seguinte.
    Sim - Passar à pergunta 4.

3b. Antes do acidente ia ás compras sozinho?
    Não - Passar à pergunta seguinte.
    Sim - **4 – DISFUNÇÃO GRAVE SUPERIOR**

4a. Consegue viajar sem ajuda?
    Não – Passar à pergunta seguinte.
    Sim - Passar à pergunta 5.

4b. Antes do acidente viajava sozinho?
    Não - Passar à pergunta seguinte.
    Sim - **4 – DISFUNÇÃO GRAVE SUPERIOR**

5a. Consegue trabalhar como antes do acidente?
    Não – Passar à pergunta seguinte.
    Sim - Passar à pergunta 6.

5b. Capacidade de trabalho neste momento?
    1 – Redução da capacidade de trabalho
    2 – Incapaz de trabalhar

5c. Antes do acidente estava a trabalhar ou a procurar emprego?
    Sim + 1 – **6 - DISFUNÇÃO MODERADA SUPERIOR**
    Sim + 2 – **5 - DISFUNÇÃO MODERADA INFERIOR**
    Não - Passar à pergunta seguinte.

6a. Consegue manter o relacionamento social e as actividades de lazer como antes do acidente?
    Não – Passar à pergunta seguinte.
    Sim - Passar à pergunta 7.

6b. Capacidade para participar em actividades sociais e de lazer?
    1 – participa um pouco menos
    2 – participa muito menos
    3 – não participa

6c. Participava nesta actividades sociais e de lazer antes do acidente?
    Sim + 3 – **5 - DISFUNÇÃO MODERADA INFERIOR**
    Sim + 2 – **6 - DISFUNÇÃO MODERADA SUPERIOR**
    Sim + 1 – **7 – DISFUNÇÃO LIGEIRA INFERIOR**
    Não - Passar à pergunta seguinte.

7a. Houve problemas psicológicos que resultaram em rupturas familiares ou de amizade?
    Não – Passar à pergunta 8.
    Sim - Passar à pergunta seguinte.

7b. Características das rupturas
    1 – Ocasionais
    2 – Frequentes
    3 – Constantes

7c. Estes problemas com a família e amigos já existiam antes do acidente?
    Não + 3 – **5 - DISFUNÇÃO MODERADA INFERIOR**
    Sim + 2 – **6 - DISFUNÇÃO MODERADA SUPERIOR**
    Sim + 1 – **7 – DISFUNÇÃO LIGEIRA INFERIOR**

8a. Há mais algum problema relacionado com o trauma que o esteja a incomodar?
    Não **– 8 – BOA RECUPERAÇÃO SUPERIOR**
    Sim – Passar à pergunta seguinte

8b. Estes problemas já existiam antes do acidente?
    Não – **7 – BOA RECUPERAÇÃO INFERIOR**
    Sim – **8 – BOA RECUPERAÇÂO SUPERIOR**