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Is routine trauma surgeon presence in the emergency department necessary for all priority one trauma cases?

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IS ROUTINE TRAUMA SURGEON PRESENCE IN THE EMERGENCY DEPARTMENT NECESSARY FOR ALL PRIORITY ONE TRAUMA CASES?

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of

Master of Science in Medicine in Emergency Medicine.

Johannesburg, 2013

DECLARATION

I, Harry Roy Nay, declare that this research report is my own work. It is being submitted for the degree of Master of Science in Medicine (Emergency Medicine) in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

02 July 2013

DEDICATION

I dedicate this research work to my family who support me in everything, and to my friends who helped me finished this project. They have given me the drive and discipline to tackle this task with enthusiasm and determination. Without their support this project would not have been made possible. Finally, I would like to thank my wife, Charmaine, for her support and encouragement. I could not have completed this effort without her assistance, tolerance, and enthusiasm.

ABSTRACT

Objectives:

The majority of injured patients transported to hospital ED's do not require emergency surgery, yet our protocols require a surgeon to be present on their arrival. There is a drive to develop clinical decision rules so as to apply "secondary triage" criteria to trauma patients in the hope that there can be more efficient use of the surgeons' time. My objective was to identify the proportion of trauma patients that required emergency trauma surgeon intervention within 60 minutes of patient arrival.

Design:

A retrospective study of all Priority 1 trauma patients that presented to the ED of three Level 1 trauma centres in three private hospitals in Johannesburg. These units are staffed with ED doctors experienced in trauma management and backed up by either specialist trauma surgeons or surgeons experienced in trauma management.

Methods:

We analysed data from 4,500 patients in our trauma centre registry (TraumaBank). We identified emergency procedural intervention and emergency operative intervention (within one hour) by a general surgeon.

Main Results:

Emergency operative intervention occurred in 2.7% of cases and emergency procedural intervention occurred in 0.8% of cases. Existing triage and secondary triage systems performed poorly with unacceptable over and under-triage.

Conclusions:

Routine surgeon presence during the initial phase of the management of trauma patients is hard to justify. Triage policies need to strike a balance between resources and optimal care. To identify those patients that require emergency operative intervention by trauma surgeons based on pre-arrival triage criteria alone, we need to look primarily at truncal penetrating injury, persistent shock and patients transferred from other facilities.

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NOMENCLATURE

Abbreviations

ACS	American College of Surgeons
ACS-COT	American College of Surgeons Committee on Trauma
ANZBA	Australian and New Zealand Burn Association
APLS	Advanced Paediatric Life Support
ATACC	Anaesthesia Trauma and Critical Care
ATCN	Advanced Trauma Care for Nurses
ATLS	Advanced Trauma Life Support
BP	Blood Pressure
bpm	Beats per minute
CT	Computed Tomography
CVP	Central Venous Pressure
DSTS	Definitive Surgical Trauma Skills
ED	Emergency Department
EMP	Emergency Medical Practitioner
EMS	Emergency Medical Services
EMSB	Emergency Management of the Severe Burn
EMT	Emergency Medical Technician
GCS	Glasgow Coma Scale
HEMS	Helicopter Emergency Medical Services
ICU	Intensive Care Unit
ISS	Injury Severity Score
ITLS	International Trauma Life Support

IV	Intravenous
LL	Loma Linda
MLL	Modified Loma Linda
mmHg	Millimetres of Mercury
MR	Major Resuscitation
NISS	New Injury Severity Score
PHTLS	Pre-Hospital Trauma Life Support
POS	Probability of Survival
RTS	Revised Trauma Score
SATS	South African Triage Scale
SBP	Systolic Blood Pressure
STAR	Specialised Trauma Air Response
TEAM	Trauma Evaluation and Management
TEWS	Triage Early Warning Score
TRISS	Trauma Injury Severity Score
TTA	Trauma Team Activation
UK	United Kingdom
USA	United States of America
WHO	World Health Organisation

Definitions

TRISS

The most commonly used tool for analysing emergency care systems is the Trauma Injury Severity Score.[1] TRISS is a validated score that can be retrospectively used to measure the effectiveness of trauma care.[2, 3] It calculates a patient's probability of survival.[8]

RTS

The Revised Trauma Score, a physiological scoring system, based on GCS, SBP and Respiratory Rate, has been successfully used to identify seriously injured trauma cases presenting to an ED[4, 5]

ISS

The Injury Severity Score, is a medical score to assess trauma severity. It is calculated by rating each injury with an abbreviated injury scale, then adding together the squares of the highest rating for each of the three most severely injured body areas.[8] It correlates with mortality, morbidity and hospitalisation time after trauma. It is used to define the term major trauma.[6]

NISS

The New Injury Severity Score is a simple modification of the ISS which is more accurate for penetrating injuries, but takes no account for physiological variables. It is defined as the sum of the squares of the abbreviated injury scale scores of each of the patient's three most severe injuries, regardless of the body region in which they occur.[7]

TEWS

The Triage Early Warning Score is a composite triage score. High scores indicate more physiological derangement and is used as a proxy for more severe illness or injury.[8] The TEWS is very user-friendly,[9] can be taught quickly to inexperienced staff[10] and uses simple clinical parameters, making it useful at all levels of emergency service delivery in a developing setting.[11]

SATS

The South African Triage Scale is a triage system that incorporates TEWS. SATS is a physiology and symptom based scale which prioritises into one of four colours and can be used in hospital EDs as well as in the pre-hospital setting. The SATS has been validated in the public, private health care setting as well as pre-hospital.[12]

TraumaBank

TraumaBank is The South African National Trauma Registry. It was purely a trauma-based registry. It has been incorporated into MediBank.

MediBank

MediBank is a computerised program that tracks a patient arriving in a hospital ED. It tracks this patient's progress from the scene, through the emergency unit, theatre visits, complications, ICU (if applicable) and discharge.[13] MediBank now incorporates TraumaBank, allowing for the capturing of all ED patients.

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PREFACE

The ACS introduced a system of trauma management whereby “the general surgeon serves as the captain of the resuscitating team and is expected to be in the ED upon arrival of the seriously injured patient.”[14]

In South Africa, ED doctors serving in Level 1 facilities (and those facilities aspiring for Level 1 status) have dedicated trauma surgical cover as advocated by the ACS. However, many facilities do not have immediate cover by a surgeon, let alone a specialist trauma surgeon.

I graduated into a system where trauma medicine followed the ACS system. I have been lucky enough to work in Level 1 facilities and as such I have been part of the ACS resuscitative system in these units. I have also worked in many Level 2 and Level 3 facilities, and when faced with a seriously injured patient requiring urgent surgical intervention, one is quickly reminded of the benefit to patient (and self) of a dedicated surgeon being available immediately – the stress and anxiety induced by a seriously injured trauma patient in the ED where one has inadequate specialist surgical cover is not easily forgotten. Furthermore, it is a well-known fact that such patients will present inappropriately to facilities which are incapable of adequately dealing with their injuries.

However, my experience of Level 1 facilities is that this surgical cover is selective in terms of time of day, and general availability of the trauma surgeon. We have been employing “selective triage” criteria for years. ED doctors are often left alone

in the ED to contend with a multitude of patients while the trauma surgeon is either delayed in traffic, busy in theatre, or generally unavailable. Although we are often informed by pre-hospital personnel that a trauma case is *en route*, many cases arrive via private transport or with miss-assessed injuries. The ED doctor is then left alone to deal with the patient until the trauma team can be activated. Even once the team has been activated, the ED doctor is often left to deal with the patient unaided as the initial classification of seriousness of the patient is often based on “mechanism of injury”: - the trauma surgeon might request more information only once certain investigations have been completed. Situations like these occur in our EDs on a daily basis, but they have a lot to do with the trust between the specific ED doctor and the trauma surgeon providing trauma cover. This is by no means a formal arrangement.

Recently, there have been some minor changes to criteria used to determine trauma surgical involvement in the ED and the ACS have made minor revisions to their trauma surgeon callout criteria. There is more involvement by ED specialists in the ED in the USA, which has resulted in formal callout arrangements. Changes to the current system have implications as to how the EDs are staffed and how the ED doctors are trained. I felt it was important to analyse the situation as it pertains to trauma cases seen in the Level 1 trauma units that we provide cover for and we still formally work with a system of routine trauma surgeon involvement for all Priority 1 trauma cases. Furthermore, I believe this research is pertinent as there is a high prevalence of trauma in South Africa. With this in mind, I decided to look at the available data to see how often the trauma surgeons were really needed.

Chapter 1 INTRODUCTION

1.1 Motivation and rationale for this research

In South Africa, ED doctors work in facilities that may vary significantly with regards to dedicated trauma surgical cover. There are a few facilities that have dedicated trauma surgical cover and which subscribe to the ACS system where "the general surgeon serves as the captain of the resuscitating team and is expected to be in the ED upon arrival of the seriously injured patient."[14] However, many facilities do not have immediate cover by a surgeon, let alone by a sub-specialist trauma surgeon.

Most EDs serving trauma units have well trained EMPs who are proficient at trauma resuscitation. They do not have dedicated trauma surgeons covering their EDs and these EMPs employ a system of "secondary triage" whereby patients are classified into tiers of required surgeon response according to their injuries. The initial care is initiated by competent ED doctors in most of the cases - the trauma team is not activated for all patients. This allows for the surgeon to focus his or her attention on cases requiring surgical skills.

EDs outside of the USA generally do not follow the system prescribed by the ACS. A number of related studies that compare European and Canadian models to the ACS system have been conducted in the USA; results indicate that with regard to improved trauma outcomes, there are no benefits of the ACS system.[15, 16] These

publications have encouraged lively debates within the emergency medicine community.[17]

Studies by ED doctors have sought to challenge the hypothesis that mandatory trauma surgeon presence on patient arrival improves the level of trauma care, while studies by surgeons suggest that the requirements mandated by the ACS are well validated. The purpose of these discussions is not to pit trauma surgeons against ED doctors but rather to ensure adequate management of the trauma patient (although issues relating to “turf” are frequently encountered). Typical reactionary responses regarding missed injuries and alleged mismanagement need to be separated from the focus of the debate.

In South Africa, the specialty of emergency medicine has been in existence for just over five years (compared to 30+ years in the USA and 15+ years in the UK). Whilst there are currently only 70 registered specialists in Emergency Medicine in South Africa,[18] there are many other non-specialist full-time and part-time practitioners in the field. In addition to the specialist EMPs, who are trained and evaluated to ensure a high level of expertise in trauma-care, many of the non-specialist practitioners are highly experienced in trauma management (In this document the term “emergency medicine practitioner” (EMP) may refer to both specialist and non-specialists in Emergency Medicine, unless otherwise specified). Nonetheless the trauma expertise of doctors staffing the EDs may be inconsistent and often inadequate, especially in rural and non-academic settings.

There is no doubt that both the timely involvement of dedicated trauma surgeons in the ED assessment and treatment of the seriously injured patient are required to achieve the optimal care of the patient. However, it is perhaps not a question of *whether* the trauma surgeon becomes involved, but rather a question of *when* the trauma surgeon becomes involved.

Change is a constant in medicine, and technological advances have resulted in a shift in focus from positive diagnostic peritoneal lavage with mandatory early exploratory laparotomy to enhanced diagnostic radiology in the form of CT scanning as well as of ultrasound examination in the ED by EMPs and trauma surgeons alike.[19] Increasingly, patients with positive findings are being managed conservatively.[20-24] Additionally, the proliferation of the ATLS course has gone a long way to address the inconsistent expertise of EMPs managing trauma patients in the ED.[25]

Retrospective studies assessing the necessity of routine trauma surgeon involvement have also been performed elsewhere in the world and this is the basis of my research. I have tried to focus the criteria so as to identify those patients requiring true emergency interventions by trauma surgeons within one hour. Other studies have looked at similar data to identify the proportion of patient requiring surgery after ED assessment and management. However, they have not focused exclusively on trauma surgery as opposed to neurosurgery, orthopaedic surgery and other types of surgery.[15, 16] Evidence-based medicine has been defined as the "conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients".[26] If they can be shown to improve

patient outcomes, clinicians need to embrace and acknowledge the benefits of protocols and guidelines such as the well-structured algorithmic approach to trauma care taught in the ACS ATLS course. However, it is advisable to look for alternatives should these protocols and guidelines prove less valuable.[27] The purpose of this research, therefore, is to determine whether the ACS-COT protocol is really applicable in South Africa, as South Africans, through the Trauma Society of South Africa, have been following the USA based ACS guidelines for trauma care.

To this end, the broad aim of this research is to determine whether the presence of the trauma surgeon in the ED at the time of patient arrival should be mandatory in the South African setting. Or more specifically, how often the unique skills of a surgeon are required within the first few minutes of a patient entering the ED. In general, ED doctors are expected to be competent at every resuscitative procedure required in the ED but unstable, bleeding patients may require urgent surgical intervention in the operating room. It is this subgroup of patients that would benefit from the early presence of the trauma surgeon as this would minimise the delay to damage control surgery. By identifying the proportion of patients at risk of requiring urgent surgical intervention it will be possible to determine the viability of the ACS system in South Africa.

Based on predetermined criteria, by accessing and analysing the data available in the South African National Trauma Registry (TraumaBank), a retrospective study was performed on trauma surgeon involvement in cases seen in the ED.[25]

1.2 Statement of the problem

The validity of the ACS-COT system hasn't been evaluated in the South African context. We do not know how appropriate the ACS callout criteria are in our Level 1 trauma units, and this study should answer the question of whether trauma surgeon presence in the ED in South African Level 1 trauma units is really necessary for all Priority 1 trauma patients.

1.3 Aim and objectives

1.3.1 Study aim

The aim of this study was to determine how often surgical procedures, which mandate the presence of a trauma surgeon, are performed during the initial phase of trauma management of Priority 1 trauma patients in a private hospital group in South Africa.

1.3.2 Study objectives

1. To identify those trauma patients that required urgent surgical intervention within one hour from initial presentation to the ED;
2. To identify those patients that required emergency operative intervention by trauma surgeons based on pre-hospital triage criteria alone (truncal penetrating trauma and persistent shock);
3. To identify which patients could be managed by ED doctors trained in trauma care (either specialist EMPs or doctors who have completed ATLS and have trained for at least 6 months in a trauma unit) in conjunction with other specialities.

Chapter 2 LITERATURE REVIEW

Trauma Systems

What Is a Trauma System?

The trauma care system is a network of definitive care facilities that provides a spectrum of care for all injured patients based on the unique requirements of the population served, such as rural, inner-city, or urban.[28] Trauma systems coordinate the efforts of hospitals and other medical facilities, as well as healthcare providers, emergency services, patient transport services, and other parties involved in providing trauma care.[28] An ideal trauma system includes all the components identified with optimal trauma care, such as prevention, access, acute hospital care, rehabilitation, and research activities.[28] The care of injured patients requires a systematic approach to ensure optimal care as no one trauma centre can do everything.

A trauma system also includes provisions for training people involved in various aspects of trauma care, including ambulance crews and hospital personnel, providing a seamless transition between each phase of care, integrating existing resources to achieve improved patient outcomes. In addition it must emphasise the prevention of injuries in the context of community health. [28]

Why is the system of trauma management important?

The magnitude of traumatic injury as a public health problem is enormous. In terms of years of productive life lost, prolonged or permanent disability, and cost, it is now recognised as one of the most important threats to public health and safety

worldwide.[28] Trauma creates a large global, socioeconomic and organisational burden. According to the Global Burden of Disease Study of 1997, projected health trends predict that by 2020, injuries from road traffic crashes alone would be the sixth leading cause of death, and that self-inflicted injuries, violence and war will occupy 10th, 14th and 15th place.[29] These numbers were adjusted in The Global Burden of Disease: 2004 Update (reviewed by the WHO in 2008) - the updated projected health trends predict that by 2030 injuries from road traffic crashes alone will be the third leading cause of death.[30] It is important to note that the other categories of trauma (poisonings, falls, fires, drowning, self-inflicted injuries, violence, war and conflict) were not included in this. There is a projected 40% increase in global deaths due to injury between 2002 and 2030. These are mainly due to road traffic accident deaths which are projected to increase from 1.2 million in 2002 to 2.1 million in 2030.[31] This presents significant challenges to health service research and development, investment and cost-effectiveness, training and evaluation.

History and development of trauma care

The theoretical foundations of trauma care and the essential characteristics of trauma systems have been continually refined over the past 40 to 45 years. The organised care of injured patients has its roots in military models of trauma care; many of the advances in caring for major trauma patients can be attributed to the lessons learned during past military conflicts.[32] During World War II, well-developed triage systems were instituted and wounded soldiers were evacuated through tiers of increasingly capable medical care.[32] Throughout the Korean and Vietnam wars, the time from injury to definitive treatment was sharply reduced by

transporting patients with serious injuries directly to acute care field military hospitals that delivered immediate, organised trauma care.[32] Although the principles learned during wartime were not automatically or easily implemented in a civilian environment, the military's success in dealing with severe injuries led to heightened public expectations about trauma care and provided an impetus for the development of trauma systems.[32]

Historically, in the USA, the care of injured patients focused on trauma centres, not trauma systems. This focus stemmed from the existence of large county hospitals, which became *de facto* trauma centres. Dedicated trauma centres, beyond these county hospitals, were developed at the beginning of 1966, when community and public education regarding the status of EMS and trauma care peaked with the publication of the classic National Research Council/National Academy of Sciences white paper “Accidental Death and Disability: the Neglected Disease of Modern Society."[33]

At this time, professional health care associations had also provided guidance for trauma system development. Events in 1976 proved to be the catalyst for the development of the modern ATLS and ACS-COT trauma systems.

Advanced Trauma Life Support

ATLS is a training programme designed for medical staff involved in the management of acute trauma cases, emphasising the first hour of initial assessment and primary management of the trauma patient.[34] ATLS had its tragic origins in February 1976 when Dr Jim Styner, an orthopaedic surgeon, tragically

crashed his light aircraft into a field in rural Nebraska. Dr Styner sustained serious injuries. His wife Charlene was killed instantly and three of his four children sustained critical injuries, while his other son suffered a broken arm. The care that he and his family subsequently received was inadequate by the day's standards. The surgeon, recognising the inadequacy of their treatment, stated, "When I can provide better care in the field with limited resources than what my children and I received at the primary care facility, there is something wrong with the system, and the system has to be changed." These events ultimately resulted in a change to the first hour of trauma care for injured patients in the USA and in much of the rest of the world.[35]

Styner, his colleague Paul Collicott, a group of local surgeons and doctors, the Lincoln Medical Education Foundation, together with the University of Nebraska founded local courses aimed at teaching advanced trauma life support skills.[36] The pilot courses were run in Aubern, Nebraska in 1977. The original aims of the courses were to train those doctors who did not manage trauma on a regular basis, such as rural general practitioners, in the initial management of the severely injured patient. These courses, adopted by the ACS-COT, served as a framework for the national ATLS courses which premiered in 1978 – a new approach to the provision of care for individuals suffering major, life-threatening injury.[35]

In January 1980, the ACS introduced the ATLS Course in the USA and abroad. Canada joined the ATLS programme the following year. In 1986, several countries in Latin America joined the ACS-COT and introduced the ATLS programme in their region.

Early reports on the implementation and evaluation of these pilot courses and the improvements in rural trauma care appeared in the literature soon after their introduction.[37, 38] Improvements were also noted in the quality of trauma care apparent in patients who arrived at a major hospital[39] and in mortality rates.[40, 41] In the late 1980s, a retrospective analysis of deaths attributable to injury reported that a significant number of these deaths could have been prevented.[42] A subsequent Working Party Report from the Royal College of Surgeons in England noted the improvement in standards of care of the injured patient in the USA after the development of ATLS.[43] Additional studies suggested an improvement related to the introduction of ATLS[44] but others had failed to show significant improvement in patient outcome and assessment.[45] Recently there are even studies that indicate an increase in mortality when trauma cases are managed by ATLS-trained personnel.[46]

By 1995, ATLS had been taught in over 25 countries and was shown to be an effective teaching course in both developing and developed countries.[47] At the time, ATLS was the internationally recognised standard for the initial assessment and management of serious injury.[48]

ATLS was introduced to South Africa in 1993 after Professor Ken Boffard and several colleagues were chosen to train in the programme two years earlier by the ACS. By 2007, more than 750 ATLS courses had been held in South Africa with more than 12 000 doctors trained, putting the country's accident and trauma rescue services in the vanguard of advanced skills world-wide.[49]

For over 35 years, the ACS-COT and its licensed subsidiary organisations have taught the ATLS course to over one million doctors in more than 60 countries. ATLS has become the foundation of care for injured patients, expanding into a global resuscitation programme by teaching a common language and a common approach.[50]

From its tragic origin, ATLS has become iconic in medical education. However, the course has had its detractors and its methods have been subjected to significant scientific scrutiny and criticism over the past 35 years. Whilst the course's methods are known to increase knowledge and skills (at least temporarily), confidence, and lead to a change in practice,[51] a number of studies discussing the shortcomings of ATLS and especially how it relates to countries outside of the USA have nonetheless been published.[52] ATLS has been criticised over the years for its philosophy, the course contents, the rigid regulations, the cost to participants and its lack of validation. The extensive changes in the ATLS course content and manual since its inception illustrate the lack of serious science that underpin what ATLS promotes,[51, 53, 54] at least until recently. There has been disappointment at exclusion of EMPs from the development of ATLS. Its administration was seen to be too rigid and there was a perceived lack of interest in non-USA ways of managing trauma.[52]

There was a call to adapt its development to become a more international course. This required input from trauma experts who wished to improve patient care rather than merely react to existing problems.[51]

In 2007, the ACS-COT increased international participation by creating three new international regions that were invited to appoint representatives to the ATLS subcommittee. The revision of the 8th edition was disseminated through these stakeholders and, following broad input by the International ATLS subcommittee, graded levels of evidence were used to evaluate and approve changes to the course content resulting in an international, multidisciplinary, and evidence-based approach which is meaningful to the global community.

The ATLS course will hopefully continue to evolve in response to growth in knowledge, change in injury patterns and evolution of trauma care and trauma systems around the world. In the future, ATLS will incorporate new learning platforms to remain current and meet the expectations of the next generation of Trauma Care Providers.[55]

ATLS teaches one safe way of initial trauma assessment and management for doctors. There are complementary courses which are based on ATLS philosophies. These are Trauma Evaluation and Management (TEAM) for medical students,[56], Advanced Trauma Care for Nurses (ATCN) for registered nurses[57] and Pre-Hospital Trauma Life Support (PHTLS) for pre-hospital care providers.[58] They allow PHTLS-trained pre-hospital care providers to follow the same principles of care that are core to ATLS. This in turn creates a smooth transition of care to ATLS and ATCN-trained providers in hospitals.[34]

The alternatives to ATLS

Anaesthesia Trauma and Critical Care (ATACC) is an international trauma course based in the UK.[59] It is an advanced trauma course that represents the next level for trauma care and trauma patient management post ATLS certification. Specifically designed for those with anaesthetic skills as well as their colleagues, ATACC is suitable for those with and without an ATLS qualification. The first course ran in October 2001. The course is offered numerous times per year to candidates who are drawn from all areas of medicine and trauma care. The course teaches trauma management from the roadside through to the critical care unit and as such includes both pre-hospital and in-hospital care.[60]

International Trauma Life Support (ITLS) is accepted internationally as the standard training course for pre-hospital trauma care. It's used as a state-of-the-art continuing education course and as an essential curriculum in many paramedic, EMT and first-responder training programmes. The ITLS Advanced course builds on this knowledge, emphasising evaluation steps and sequencing as well as techniques for resuscitating and packaging patients. ITLS Advanced is appropriate for advanced EMTs, paramedics, trauma nurses, doctors and other advanced EMS personnel.[61]

Emergency Management of the Severe Burn (EMSB)

Specific injuries, such as major burn injuries, may be better managed by modified ATLS protocols such as EMSB - a training course and protocols developed by the Australian and New Zealand Burn Association (ANZBA) and also adopted by the British Burn Association.[34] The aim of this course is to provide sufficient factual

information regarding the presentation, diagnosis and initial management of the patient with severe burns, which would enable medical and nursing practitioners to deal competently with this urgent and often life threatening problem. The course is appropriate for medical and nursing practitioners who work in the field of burn care, from members of the burns unit to medical and nursing staff in isolated areas.[62]

Advanced Paediatric Life Support (APLS) is a programme created by the American Academy of Paediatrics and the American College of Emergency Physicians to teach health care providers how to take care of sick children.[63] The first course was run in 1984. APLS focusses on critical condition recognition and the stabilisation of paediatric patients.[64] Day three of the course deals with the injured child.

The ACS system and their guidelines

The ACS is an association of surgeons that was established in 1913. They work to improve the quality of care for the surgical patient by setting standards for surgical education and practice, striving to improve all phases of care of injured patients, and working to improve teaching and the practice of trauma surgery as well as injury prevention.[65]

The ACS unequivocally states that ‘trauma is a surgical disease’. It has led the way in improving trauma care both in the USA and in the rest of the world by defining the problem epidemiologically, societally and financially, and by lobbying governments for support.[66]

The ACS-COT made substantial contributions to the conceptual framework of trauma care systems by advocating for a network of trauma centres with verified capabilities. The ACS-COT assumed the mantle of leadership in 1976 by identifying the key characteristics for categorisation of hospitals as trauma centres in the first edition of their publication, "Optimal Hospital Resources for Care of the Seriously Injured".[67] After undergoing successive revisions, this document became recognised as the standard for trauma hospital performance.[32]

Trauma centre designation criteria set strict requirements for staffing, specialist availability, response times, training, quality improvement and community education. Additionally, trauma centres require organised trauma teams that respond promptly to trauma alerts, a surgeon who serves as trauma director and provides oversight to the hospital's trauma programme, trauma nurse coordinators and committees that provide quality improvement and direction for the hospital's trauma programme.[68] The initial trauma-care system advocated by the ACS-COT was an exclusive approach ("exclusive" because a few high-level trauma centres participate in the trauma system, while smaller acute care hospitals are excluded) that had two components: facilities dedicated to the care of trauma patients, and a system of pre-hospital bypass whereby critically injured patients were transported directly to trauma centres (a Trauma Centre is a regional medical centre that has the specialised resources and health professionals to care for victims with critical injuries 24 hours a day, 7 days a week), circumventing lesser facilities that were closer.[69, 70] This simple focus on transport to definitive care facilities was associated with a significant reduction in preventable deaths and injury-related mortality – certainly within dense urban centres.[71]

In 1987 ACS-COT developed an external review committee to authenticate hospital capabilities. This committee is responsible for verifying that a trauma centre has the necessary resources for delivering optimal trauma care.[72] As a guide, it uses the *Resources for Optimal Care of the Injured Patient,* which outlines the resources needed for optimal trauma care.[28] Only those trauma centres that have successfully completed a voluntary process of verification are recognised. This programme helps hospitals to evaluate and improve trauma care, providing an objective, external review of the relevant features of the programme. These include commitment, readiness, resources, policies, patient care, and performance improvement, as well as the level of staffing of the EDs.[72]

In 1990, there was a change in focus from trauma centres to trauma systems. The exclusive approach had been determined to be inadequate, especially with regards to trauma outside of the major metropolitan areas.[69] This new inclusive system ("inclusive" because nearly all hospitals participate in the trauma system) was determined to better serve the needs of the entire population.[73] The inclusive system allowed all acute care facilities to participate in trauma care to the extent that their resources allowed. It enabled patients to be assessed and stabilised before being transported to better equipped facilities if indicated. This also facilitated care at the local clinics for less severely injured patients.[73]

Studies at the time supported evidence to suggest that inclusive systems of trauma care were associated with a reduction in injury-related mortality within a region compared with exclusive systems – especially in patients with multiple

injuries.[74, 75] However, later studies disputed these facts showing less impressive benefits of the American model of a trauma centre compared with other geographical areas without a trauma centre.[76, 77]

There are vast differences in the nature of trauma, such as the dichotomies that exist in rural and urban areas, as well as those in adults and children.[78-80] Extrapolating findings from one area might not be appropriate in another. On the basis that "one size does not fit all" and the fact that verification is not mandatory, many hospitals use the ACS-COT criteria as a guideline only.[81]

Trauma Management outside the USA

Throughout the world many countries use the ACS-COT guidelines as a basis for their trauma systems, but they are often not universally implemented. The ACS has had a major influence on trauma care worldwide. In spite of this, the concept of routine surgeon presence on patient arrival has not been widely accepted outside of the USA.[82] EMPs form the backbone of trauma care in EDs in Europe and Canada and surgeons are consulted on an as-needed basis.[83, 84] They report similar morbidity and mortality at American centres.[85]

In South Africa, some of the major government hospitals' trauma centres are guided by the ACS system, as are some of the private hospitals. However, only two private hospitals in South Africa have been designated with Level 1 trauma centre status.

The role of the trauma surgeon in trauma management

Since 1976, the ACS-COT advocated that the trauma surgeon in designated trauma centres be integrally involved in all aspects of the continuum of care for critically injured patients. The ACS-COT developed and refined guidelines for field triage of patients to a trauma centre[14, 86] and stipulated that the presence of an attending (an attending surgeon is a senior surgeon or consultant) general surgeon in the ED on arrival of the patient is “essential” for all “major resuscitations” in trauma centres designated at Level 1, 2, or 3.[14] Evaluation of outcomes of patients treated in trauma centres versus non-trauma centres confirmed that risk of death was considerably lower when care was provided in trauma centres that met the ACS-COT Level I criteria (including the immediate presence of an experienced trauma surgeon in the ED for all critically injured patients).[87] Compliance with this principle was mandatory to obtain or maintain trauma centre certification.[88] This resulted in facilities allocating substantial resources to maintain trauma surgeon cover for ED response.[89]

Thus the role of the surgeon in the ED was set by the ACS-COT guidelines: the surgeon was to be the leader of the resuscitation team. This in turn created the need for an increased number of Trauma / Acute Care Surgeons.[28]

The discipline of trauma surgery

In the USA, trauma surgeons complete a one to two year fellowship in surgical critical care following five years of general surgery residency. This allows them to sit for the American Board of Surgery certifying examination in Surgical Critical

Care, which is generally considered to be the board certification for "trauma surgery".[90]

In Europe, training programmes usually take place under supervision of the national surgical boards, who also certify for trauma surgery. There is also an official European trauma surgical exam. However, emergency surgery is not a widely recognised specialty in Europe.[90]

In the UK, there is limited training and no credentials that trauma surgeons can acquire.[90] The Royal College of Surgeons of England is responsible for training consultants via the Definitive Surgical Trauma Skills course (DSTS), which remains the only course of its kind in the UK. Originally designed to teach the military, the course now trains both military as well as civilian surgeons.[90-93]

The crisis in trauma surgery

There has been a concern regarding a crisis in the delivery of emergency trauma care in the USA.[94] The reality is that fewer and fewer general surgeons coming out of training either wish to or feel comfortable in taking care of trauma and critically ill patients. Lifestyle is an issue in trauma care since the bulk of work occurs at night and on weekends. Lifestyle demands continue to play a major role in the selection of trauma as a career. Personal lifestyle issues were cited as the number one impediment to a career in trauma surgery in the recent survey of members of the American Association for the Surgery of Trauma, the Eastern Association for the Surgery of Trauma, and the Western Trauma Association. This ranked above income, medicolegal issues, length of training, scope of practice, and disruptive nature of practice as impediments to trauma surgery as a career.[95]

Other factors negatively affecting the trauma field include the high visibility of the field that often results in a high rate of litigation and high risk of personal exposure to viral infections, especially when dealing with penetrating trauma victims.[96, 97] In addition, the work hours associated with the field of trauma are long and difficult in an exciting but stressful vocation.[98] Furthermore, some surgeons provide on-call services to more than one hospital simultaneously, making the on-call schedule difficult for many to negotiate.[99]

In the USA, as more patients with blunt trauma are treated without surgery and general trauma care itself involves fewer operative procedures, significant portions of the emergency general surgery calls are taken by trauma surgeons.[90] As a result, a new specialty has arisen in the last few years - the trauma/critical care surgeon and emergency general surgeon have merged into the acute care surgeon.[100, 101] Acute Care Surgery encompasses emergency surgery, critical care and trauma care. The re-invention of the trauma surgery discipline into acute care surgery expands the operative scope to include selected neurosurgical and orthopaedic procedures and expands the non-trauma scope to include critical care and emergency surgeries.[102]

In 1992 it was predicted by Moore et al[103] that strict ACS requirements for surgeon presence in the ED would necessitate the increased involvement of general surgeons with limited trauma experience and enthusiasm. In a discussion regarding a paper by Roettger et al, Rue expressed the prevalent opinion that “all general surgeons can do trauma, but all general surgeons can’t do trauma well.”[104]

The ACS has recently acknowledged that “a new and alarming trend has emerged—many surgeons no longer feel qualified to manage the broad range of problems they are likely to encounter in an ED.”[99] Thus, one cannot continue to assume that any general surgeon is qualified to provide optimal trauma care.[105]

The role of EMPs in trauma management

Emergency Medicine was defined by the International Federation for Emergency Medicine in 1991 as:[106]

> *“A field of practice based on the knowledge and skills required for the prevention, diagnosis and management of acute and urgent aspects of illness and injury affecting patients of all age groups with a full spectrum of undifferentiated physical and behavioural disorders. It further encompasses an understanding of the development of pre-hospital and in-hospital emergency medical systems and the skills necessary for this development."*

It is impossible and impractical to staff an ED with experienced representatives from every specialty. The specialty of Emergency Medicine evolved because there was a need for specialised generalists with the necessary expertise to deal with emergencies that can occur in any age group, at any time, in one or many body systems, with the ability to make diagnoses, start appropriate treatment, and refer to other appropriate specialists if the problem is not solved immediately.[107, 108] EMPs are specialists in resuscitation and the initial management of trauma, as well as in “minor” injuries.[109]

The speciality of Emergency Medicine has advanced the levels of care offered by incorporating radiology techniques (ultrasound) and intensive care medicine (advanced airway skills), and many countries are embracing these developments.[108] In South Africa, the specialty of emergency medicine is still in its infancy. Possibly the most significant phenomenon as of March 2004 is the recent establishment and recognition of emergency medicine as a separate speciality in South Africa.[110] In a hallmark paper by MacFarlane et al, it was mentioned that the quality of ED medical staff may vary considerably. Some are extremely good and have dedicated their careers to ED practice, while others are marking time while waiting to move on to other posts, having little knowledge or experience in acute resuscitation. Compounding this is a lack of accurate ED data and quality assurance. In smaller hospitals, the medical staff may simply be a junior, newly qualified doctor allocated to the ED. As a result, EDs can be stressful, unfriendly places marked by a distinct lack of optimal patient care.[110] However, there are still many highly trained non-specialist ED doctors working full time in the Level 1 trauma centres.

It is not uncommon for surgeons to claim that trauma is a surgical disease and therefore only surgeons should be involved in the care of these patients.[111, 112] Both emergency medicine and surgery registrars require training in the care and management of acute trauma victims. In caring for the trauma patient, conflicts may arise as to who is the most appropriate clinician to both run the trauma resuscitation as well as perform the necessary procedures.[111, 113] Emergency medicine registrars can correctly claim that not all “Level 1 trauma patients” arrive at Level 1 centres, and therefore EMPs must be competent in the management

and resuscitation of the acute trauma patient when a surgeon is not immediately available.[112] In many facilities the EMP is the only available doctor with trauma experience, and if the patient is to survive until the surgeon arrives or until transport to another facility is available, he must be managed by providers who are trained and skilled in the care of the trauma patients.[112] In a recent survey of EMPs and surgeons, EMPs were found to be comfortable managing trauma while many surgeons did not feel competent to deal with the complex trauma patient. Ironically, however, the majority of surgeons responded that surgeons should primarily manage the trauma patient.[112]

Surgeons vs EMPs in the acute management of trauma: Who should manage trauma patients – surgeons or non-surgeons?

Medical evolution over the past 40 years has fundamentally altered the landscape of trauma medicine. There is more consistent trauma expertise in doctors who staff the EDs, and patients are being treated by practitioners who are competent in trauma care. There have been dramatic advances in the speed and resolution of computed tomography – these have largely obviated the need for exploratory surgery; even in the setting of documented intra-abdominal injury, most blunt trauma patients can now safely be treated non-operatively.[20, 22] There is no longer the need for emergency exploratory laparotomies within the “golden hour”: watchful conservative management is often indicated.[19] The practice of trauma surgery has transitioned from frequent emergency laparotomies to fairly routine critical care and ward management.[22, 23, 114] Nonetheless, when urgent surgery is required it is truly urgent and a high level of expertise and experience is beneficial.

Emergency medicine is a recognised medical specialty in many countries while on the other hand, trauma surgery is not a widely recognised specialty in Europe and in the USA, it has no sub-speciality status.[115] In most central and eastern European countries orthopaedic “traumatologists” are mainly responsible for the coordination of trauma care while general surgeons deal with acute non-traumatic abdominal emergencies.[116, 117] Other conditions such as vascular, cardiothoracic, urological or neurosurgical emergencies are managed by respective specialists. Even regarding conditions of the abdomen, some hospitals in the UK have allocated the management of upper gastrointestinal and hepatobiliary surgical emergencies, and colorectal emergencies, respectively, to different hospitals and their specialists.[118, 119]

The majority of patients in EDs requiring surgical decision-making and acute intervention have either musculoskeletal injuries or acute abdominal pain. However, it seems impractical to include orthopaedic surgeons, digestive surgeons, vascular surgeons and urologists etc. in the EDs for the purpose of performing primary clinical examinations on patients, most of whom do not need acute surgical intervention.[115] With the exception of trauma teams or extended acute surgical teams (trauma team concept extended to other life-threatening conditions such as ruptured abdominal aortic aneurysms), the best way to utilise the expertise of surgeons is to concentrate on the essence of what they are trained for: to operate and care for surgical patients.[115] This includes the decision-making process related to a possible operation. For this they need to merely come to the ED when a consultation for a specific patient is required; they do not need to perform the bulk of their duties there.

Most EDs in the USA associated with trauma centres are routinely staffed with emergency medicine graduates who are well-trained and adept at trauma resuscitation and its associated procedures.[94] The new breed of competent EMPs has driven research in an effort to gain recognition of their value in the ED. They have sought to challenge the principles of the ACS with regards the callout criteria used in activation of the trauma surgeon and the trauma team.[82] The premise is that a well-trained ED doctor can handle the vast majority of challenges in the ED and that once the patient has been assessed and managed by the ED doctor, then the trauma surgeon can, if necessary, be involved.[107] This was initially seen as confrontational by the trauma surgeons as it challenged their position as "captain of the team". However, surgeons themselves have also recently begun questioning the long standing ACS certification requirements.[120, 121]

Trauma systems require a coordinated, integrated, multispecialty team approach.[81] EMPs with their broad, multi-system, priority-based and rapid decision-making training are well placed to take a leading role in the early management of trauma patients before they require definitive surgical care.[81] The presence of a surgeon in the initial response to trauma is a matter of debate, if not dispute. EMPs share much of the responsibility for trauma care with surgical specialties.[122] Doctors interested, committed and specialised in the work carried out in the EDs are the best people to do it; this includes both the diagnostic work-up of the majority of patients as well as dealing with the initial response to the deranged physiology in critically ill or injured patients.[115]

Despite the differences in the infrastructure, the practicalities of the delivery of emergency medicine in many countries are remarkably comparable. In the case of trauma care, the threshold for activating the hospital trauma team response has typically been recalibrated to reflect the local realities, taking into account service-delivery and training needs.[122] Management of multiple injuries, however, almost always adheres to the basic ATLS guidelines. For example, in some hospitals, if the ED is very busy, the trauma team may be called even for those patients who do not meet strict callout criteria.[122] The person leading the team, again a matter for local policy, is often the senior-most clinician (whether the senior surgical trainee or senior EP trainee) who manages the resuscitation in real-time.[122] This may be followed in due course by a review, if appropriate, by the heads of departments and/or the trauma committee.[122]

There is even debate about what kind of surgeons should treat emergency surgery patients. Elective specialists claim to be experts in the surgical problems of “their” organ-systems. However, evidence shows that properly trained emergency surgeons can perform emergency surgery just as well as elective surgical specialists.[123] Besides, emergency surgeons are more familiar in dealing with acutely deranged physiology and have more experience in applying the principles of damage control surgery when needed.[115] Furthermore, the majority of emergency surgical interventions are technically straight-forward, such as an appendicetomy or explorative laparotomy. Highly demanding interventions such as complex neurosurgery, cardiac or vascular surgery are not required on a daily basis except in very large centres and in most cases, these specialists could be

on-call at home with an obligation to be available at the hospital within 30 minutes.[115]

While not proven by objective data, it is clear that effective trauma care is a continuum including, but not limited to, care rendered in the ED. Expertise in trauma care requires understanding of all phases of care whether practiced by surgeons, EMPs or other non-surgeons.[124] Advanced training models for EMPs might allow increased effectiveness of care both inside the ED and beyond it.[124]

Large gaps remain in our knowledge of the best method of optimising trauma systems. We have little data on the economic value of trauma systems or on which elements provide cost-effective differences to patient morbidity, hospital ward and ICU stay.[81] Similarly, little data exists to show that well trained ambulance personnel provide a cost-effective alternative to paramedics or doctor-led pre-hospital responses.[81]

How is it possible to identify which trauma patients require surgical care, and which require non-surgical care that can be administered by EMPs? There are several systems of triage and secondary triage which deal with this issue.

The ACS-COT triage or trauma team activation system

Triage is the process of determining the priority of patients' treatments based on the severity of their condition. Triage may result in determining the order and priority of emergency treatment, the order and priority of emergency transport, or the transport destination for the patient.[125] Pre-hospital or field triage criteria are

used to determine which patients are transported to trauma centres and for which patients the trauma team is activated.

The ACS-COT triage algorithm uses GCS, SBP, and respiratory status as the factors to determine which patients need to go to the trauma centre. If a patient does not fulfil these initial criteria, then the second step is evaluating the presence of penetrating injuries (of the head, neck or torso) (supplemental criteria based on physician discretion are: more than one proximal long bone fracture, a crushed, degloved or mangled extremity, proximal amputation, pelvic fractures, open or depressed skull fracture, or paralysis. Mechanism of injury is part of a third step if the patient does not already qualify on the first two steps). The system is based on patient physiology, anatomic location of injury and mechanism of injury; criteria vary, however, between locations, the ability to triage, and available resources.

Secondary Triage

In advanced triage systems, secondary triage is typically implemented by paramedics and skilled nurses in the EDs of hospitals during disasters.[125] It is an in-depth reassessment of a patient's condition that allows for a change in triage category.[126] Primary trauma triage governs which injured patients warrant routing to trauma centres, whereas secondary trauma triage specifies what hospital resources (including trauma surgeons) should be mobilised for their care.[102]

Not all patients transported to a Level 1 facility receive full trauma team activation (full trauma team activation refers to automatic activation of the entire trauma team, including the general/trauma surgeon; this is based on predefined criteria);

rather, they are vetted through a system of secondary triage in order to focus surgeon attention on those cases most likely to require surgical skills.[127] Secondary triage restricts trauma team activations to appropriate cases. Secondary triage allows for modified trauma team activation, often referred to as tiered trauma activation (tiered trauma activation allows for initial activation of a portion of the trauma team (usually excluding the general surgeon) with subsequent activation of the full team if necessary).[127]

Compared with the rest of the world, EMS personnel in South Africa experience a remarkable spectrum of clinical exposure, and their training is of the highest standard worldwide.[110] South African pre-hospital emergency care practitioners are immersed in enormous volumes of pre-hospital trauma care, and unfortunately tend to "burn out" quickly.[110] Many paramedics contemplate lucrative contracts abroad, or redirect into other industries.[110] Ambulance crew often represent the first point of contact with medical services. In the pre-hospital environment, key decisions regarding commencement of therapy and both priority and destination of patient transfer are often made in the absence of full clinical information, by staff with varying degrees of training and expertise.[128] Such judgements are largely based on subjective processes, clinical experience and are rarely evidence based.[128-131] Current rates of critical illness detection and outcome prediction in the pre-hospital environment are low.[128]

The SATS also applies to trauma cases and it is an excellent tool for patient triage in both urban and rural settings.[132] Studies indicate that SATS has good performance characteristics and is a valid scale with under-triage and over-triage

within the accepted ACS-COT ranges.[133, 134] Despite all the excellent work that has gone into the development of SATS, the EDs will always be overburdened by inappropriate triage when there is resistance to the acceptance of the triage tools in the pre-hospital EMS community.[10, 135] When all patients are brought directly to the hospital irrespective of their triage category and bypassing other health care facilities, this exhausts hospital resources.[136] Activation of the Air ambulance service to transport seriously injured patients from the scene of an accident requires a secondary triage by control centre staff. In spite of this there are still patients who are flown by air ambulance who are discharged home from the ED.[137] This is also evident in international studies.[138]

Challenging the ASC-COT criteria.

The ACS-COT criteria have been researched and studied extensively over the years and they still form the basis of many alternate systems of triage and activation.[24, 139-144] Optimal triage of trauma patients has been the source of vigorous debate over the years. This ACS-COT criteria are based on an acceptability of a 5% to 10% under-triage rate and a 30% to 50% over-triage rate.[28, 145] It is this very issue that seems to be the most vexing: how do we ensure the required minimum over-triage without missing significant numbers of injuries?[145] A trauma unit is easily overburdened by inappropriate trauma activations. There is a natural tendency for over-triage in the activation criteria, in order to minimise the possibility of missing serious injuries.[146] Mechanism of injury activations are a prime example of ineffective use of trauma centre resources.[147] As many as 50% of blunt trauma patients initially thought to be seriously injured and transported to a trauma center are not admitted or are discharged from the

hospital within 24-hours.[139, 148] Over-triage can result in fatigue and apathy in the trauma team, especially when the patient's injuries do not warrant activation. Reduction in unnecessary activations preserves manpower.[98] Over-triage overwhelms not only the trauma system at a specific trauma centre, but also the trauma surgeon. Tiered trauma activations have been used successfully without an increase in morbidity or mortality[149]

Tiered trauma activations

There have been a number of researchers in the past 10 years studying the value of having a trauma surgeon routinely present during trauma resuscitations. Some studies have looked at patient-oriented outcomes (morbidity and mortality)[150, 151] whilst others have focused on disease-oriented outcomes (time to theatre, errors in judgment).[152] There have been complicated comparisons between institutions as well as comparisons within the same institution with the surgeon based at home doing out-of-hospital calls (nights and weekends) and in-house calls during normal hours.[151, 153-155] Studies have been centred on new secondary triage policies which defer surgeon involvement.[142, 144, 156-158]

Respiratory compromise or intubation has been targeted as an ACS major resuscitation criterion which is least likely to require surgical intervention by a trauma surgeon (EMPs may well be more likely to be experts in airway management than surgeons).[120] Conclusions from one study, after exclusion of stab wounds, was that pre-hospital or ED intubation alone rarely leads to emergency surgical intervention and that "the decision to have the trauma surgeon

present upon the patient's arrival is better made by trained ED doctors than a blanket requirement for all intubated patients regardless of physiology".[120]

Another study sought to determine the influence of activation based on SBP. They found that lowering the trauma team activation criterion from 90mmHg to 80mmHg preserved trauma surgery manpower without patient harm.[98]

In South Africa we are yet to officially implement this system of secondary triage and updated ACS guidelines. However, we have limited resources (few available trauma surgeons) and because so few institutions have been awarded a Level 1 status (especially in private facilities), this has resulted in only a handful of hospitals working with trauma surgeon cover.

Thus, what was initially perceived as a challenge of authority by the trauma surgical community has resulted in better callout criteria and more efficient use of resources.

Alternative trauma activation systems

The Loma Linda Rule

In 2006, investigators from the Loma Linda University in California derived a simple clinical decision rule to predict the need for emergency operative intervention or emergency procedural intervention for injured patients arriving in the ED.[159] The Loma Linda Rule lists only three major resuscitation criteria used for trauma team activation: penetrating injury, SBP<100mmHg, and a pulse rate >100beats/min. In an attempt to validate this rule, a study conducted in 2011 in

Denver evaluated a sample of 20 872 patients. A secondary goal of the study was to refine the Loma Linda Rule to potentially improve its predictive accuracy. See Table 2-1.

Table 2-1 Major resuscitation criteria.

ACS Major Resuscitation Criteria[28]
SBP <90 mmHg any time in adults and age-specific hypotension in children
Respiratory compromise, obstruction, or intubation
Gunshot wound to the neck, chest, or abdomen
GCS Score <8, with mechanism attributed to trauma
Transfer from other hospitals, who receive blood to maintain vital signs
Physician discretion
Loma Linda Rule
Penetrating injury
SBP<100mm Hg
Pulse rate >100 beats/min
Refined Loma Linda Rule
Penetrating injury to the torso*
SBP<90mm Hg
Pulse rate >110 beats/min
SBP, Systolic Blood Pressure
*Defined as penetrating injury to the neck, chest, or abdomen

The authors' concluded that this new rule was more sensitive for predicting the need for emergency operative intervention or emergency procedural intervention when directly compared with the ACS major resuscitation criteria. This may improve the effectiveness and efficiency of trauma triage with the original rule being more sensitive (95.6% vs. 89.7%) and the refined rule more specific (75.2% vs. 56.3%).[160]

How often are the skills unique to a trauma surgeon required in major trauma activations?

The most logical goal of secondary trauma triage is to predict when the unique skills of trauma surgeons are needed. For research purposes, this has taken the form of two questions: Did a trauma surgeon take the patient to the operating room within one hour of arrival, i.e. “emergent operative intervention”? Or did the trauma surgeon perform an ED thoracotomy or cricothyroidotomy, i.e. “emergent procedural intervention”?[159-162]

In 2008, the ACS softened its traditional assertion that “trauma is a surgical disease,”[163] acknowledging the largely non-operative nature of modern trauma care.[82, 94, 164] Despite this evidence that immediate surgical intervention is infrequently required in major trauma and that most urgent procedure can be performed by EMPs, the ACS have made no adjustments to their system to recommend surgeon presence at every trauma activation (see Table 2-2). Whether this is appropriate for patient care and is cost-effective and sustainable, remains to be seen.

The concept of mandatory surgeon presence on patient arrival, an ACS trauma centre mandate despite a lack of supporting evidence,[82] has never been required and is not routinely practiced in Europe or Canada with no evidence of inferior trauma outcomes.[83-85]

The premise that trauma outcomes are improved by the routine presence of surgeons on patient arrival lacks an objective evidentiary basis, despite being an ACS trauma centre certification requirement. Future research is necessary to

clarify which trauma patients require either emergency or urgent unique expertise of a general surgeon during the initial phase of trauma management. Individual trauma centres should be permitted the flexibility necessary to perform such research and to use such findings to refine and focus their secondary triage criteria.[82]

Table 2-2 Latest ACS statement on surgeon availability for trauma activations.

"It is expected that the surgeon will be in the ED on patient arrival, with adequate notification from the field. The maximum acceptable response time is 15 minutes for Level I and II trauma centres and 30 minutes for Level III trauma centres, tracked from patient arrival. The program must demonstrate that the surgeon's presence is in compliance at least 80% of the time. Demonstration of the attending surgeon's prompt arrival for patients with appropriate activation criteria must be monitored by the hospital's trauma Performance Improvement and Patient Safety program." [165]

Chapter 3 MATERIALS AND METHODS

3.1 Ethics

This research was approved by the Human Research Ethics Committee of the Faculty of Health Sciences of the University of the Witwatersrand (protocol M10447 - see Appendix 4). No personal identifying patient data was divulged in the study. Permission to conduct the study has been obtained from the management of the participating hospitals. Furthermore, clearance was obtained from the Human Research Ethics Committee for Research of the University of the Witwatersrand, and from the Research Ethics Committee of the hospital group.

The data collected was stored on a password-protected computer accessible only to the researcher and supervisor. Coded hospital numbers were used to prevent duplication of records.

3.2 Study Design

This was a retrospective descriptive study.

3.3 Study Setting and Population

The study was conducted in three private hospitals in Johannesburg (which all contribute data to the TraumaBank database). These are Level 1 Trauma centres staffed with ED doctors experienced in trauma management and backed up by either specialist trauma surgeons or surgeons experienced in trauma management.

Inclusion criteria:

1. All Priority 1 trauma patients presenting to the ED of the participating hospitals that were captured into TraumaBank.

Exclusion criteria:

1. Incomplete critical data relevant to the analysis performed.

3.4 Study Protocol

3.4.1 Data collection

Data was extracted from TraumaBank and collated into a spreadsheet with the assistance of an expert in the TraumaBank system. The data in the TraumaBank registry and obtained for the purpose of this study included:

1. The total number of Priority 1 patients seen, with basic demographic (race, sex, age) and epidemiological (mechanism of injury) data;
2. The number of shocked patients (SBP less than 90mmHg or an equivalent age-specific value in children identified either pre-hospital or in the ED);
3. The number of patients requiring formal surgical intervention within one hour of presentation to the ED (those who left the unit to go to theatre directly) (those that went to theatre directly with the trauma surgeon) (those that went directly to theatre with surgeons of other disciplines – e.g. neurosurgeons or orthopaedic surgeons);
4. The number of patients with penetrating truncal injuries (gunshot chest; gunshot abdomen; stabbed chest; stabbed abdomen);
5. The number of patients requiring a procedure in the ED (i.e. endotracheal intubation, surgical airway placement, intercostal drain placement, diagnostic peritoneal lavage, extended focussed assessment with sonography in trauma, central line insertion, wound repair, fracture reduction and / or splinting);

6. The number of patients requiring a surgical procedure in the ED (e.g. ED laparotomy or thoracotomy).

3.4.2 Outcome Measures

Emergency operative intervention and emergency procedural intervention served as a composite outcome. Emergency operative intervention was defined as requiring operative intervention by a trauma surgeon within one hour of ED arrival, and major emergency procedural intervention included performance of surgical procedures (cricothyroidotomy, thoracotomy or caesarean section) and non-surgical procedures (endotracheal intubation, central venous catheterisation, or intercostal drain placement) in the ED. This subgroup of patients then served as the sample from which outcomes were abstracted.

3.4.3 Sample Size

All cases with complete data were included in the study – any Priority 1 trauma patient who presented to the participating EDs from the starting date of TraumaBank on 25 January 2006 to 30 May 2011. This amounted to 4570 patient records.

3.4.4 Data Analysis

Data was transferred from TraumaBank into an electronic spreadsheet (Microsoft® Excel, Microsoft® Office 2007, Microsoft® Corporation). Data analysis was carried out in SAS (SAS Institute Inc., *SAS® Software, version 9.3 for Windows,* Cary, NC, USA: SAS Institute Inc. (2002-2010).

The 95% confidence level was used throughout, unless otherwise specified.

Tests for significant relationships were carried out using Pearson's X^2 test at the 95% confidence level. Fisher's exact test was used in the case of 2x2 tables, or where the requirements for Pearson's X^2 test could not be met. The strength of the associations was determined by Cramer's V (the Phi coefficient was used in the case of 2x2 tables). The absolute values of these coefficients were interpreted as follows:

0.50 and above	high/strong association
0.30 to 0.49	moderate association
0.10 to 0.29	weak association
below 0.10	little if any association

Continuous variables were summarised with means and standard deviations as well as medians and interquartile ranges. Categorical or discrete variables were described by frequency distributions.

The specific analyses that were performed included:

- Representation of demographic data (see above) for the entire study population and within the following subgroups:
    - Patients meeting major resuscitation criteria by the ACS-COT, Loma Linda and Revised Loma Linda criteria
    - Patients requiring urgent surgical procedures
        - By subgroup of nature of procedure
    - Patients with penetrating truncal injuries
    - Patients requiring a non-surgical procedure in the ED

- Patients requiring a surgical procedure in the ED.
- The number (and proportion or frequency) of all patients that:
  - met major resuscitation criteria by the ACS-COT, Loma Linda and Revised Loma Linda criteria
  - underwent emergency surgery
  - had penetrating truncal injuries
  - had non-surgical procedures in the ED
  - had surgical procedures in the ED

3.4.5 Significance level

A $p < 0.05$ was considered to be significant for all statistical tests.

3.5 Methodological limitations of this study

This was a retrospective study with all the associated methodological limitations. The quality of the database was sub-optimal, especially from the first year after development, with many records containing incomplete data.

Chapter 4 RESULTS

Description of the study population

There were 4570 patient records in the main data set. Some of the patients in this dataset had missing information and they were excluded from the relevant analyses of patients who went to theatre or had surgical procedures in the ED. For this reason some of the sample sizes may differ slightly from analysis to analysis depending on the integrity and completeness of the data (which data points were excluded from each analysis).

Demographics

Sex

The patients in the data set showed a male preponderance, with 3602 (79%) males and 952 (21%) females.

Ethnicity

The majority of the cases in the data set were White (46%) and Black (41%) patients (see Figure 4-1).

Age

The median age of the patients was 34 years with an interquartile range (IQR) of 25 to 46 years. The mean age (± standard deviation) was 36 ± 15.5 years. About half of the patients (53%) were aged between 21 and 40 years (see Figure 4-2).

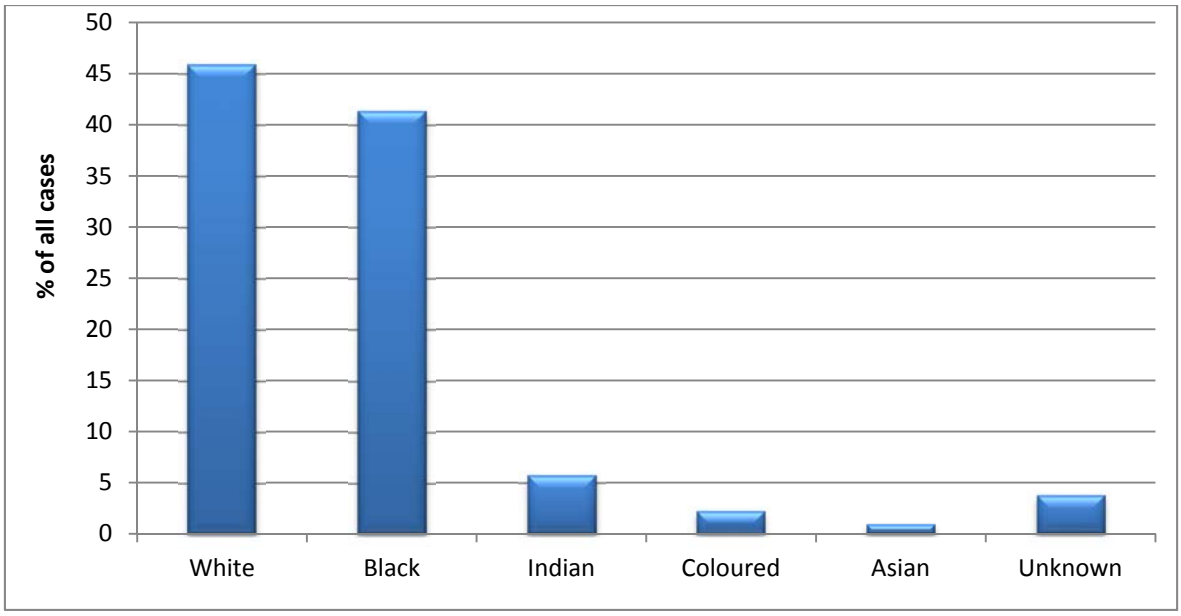


Figure 4-1 Demographics - ethnicity

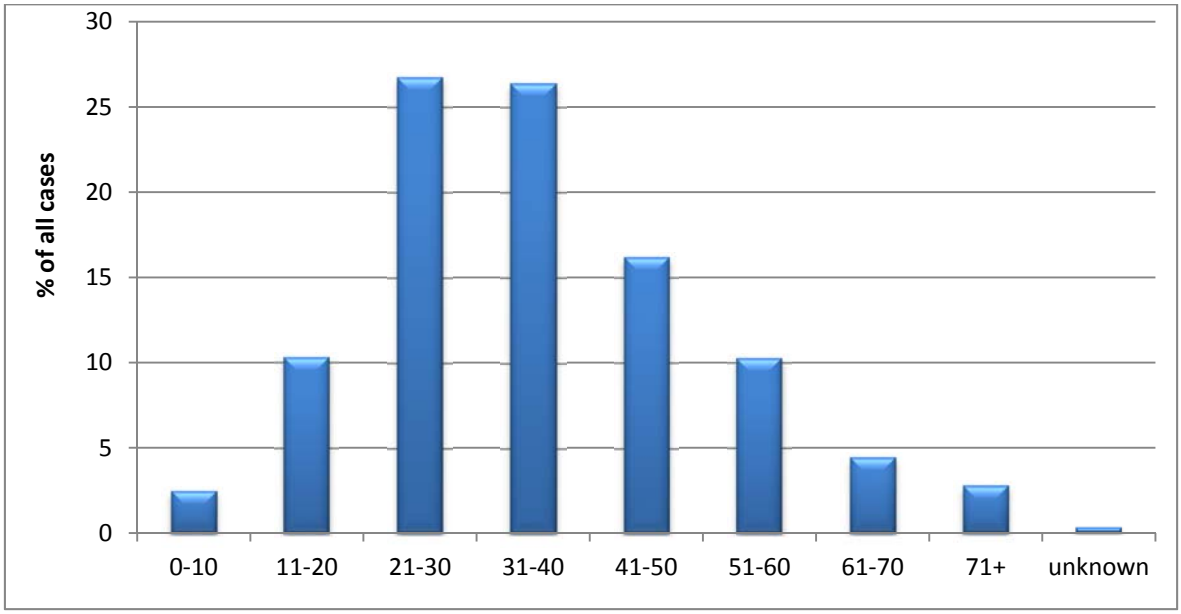


Figure 4-2 Demographics – age distribution

Day of presentation

When evaluating the day of the week of presentation, pairwise comparisons of the proportion of patients who presented in the ED on different days of the week (with adjustment for multiple comparisons) showed that there were significantly more

patients on Saturdays and Sundays than on Mondays (z-test for proportions with adjustment for multiple comparisons; p=0.004 and p=0.019 respectively) and significantly more patients on Saturdays than on Tuesdays, Wednesdays and Thursdays (z-test for proportions with adjustment for multiple comparisons; p=0.012, 0.007 and 0.004 respectively) (see Figure 4-4).

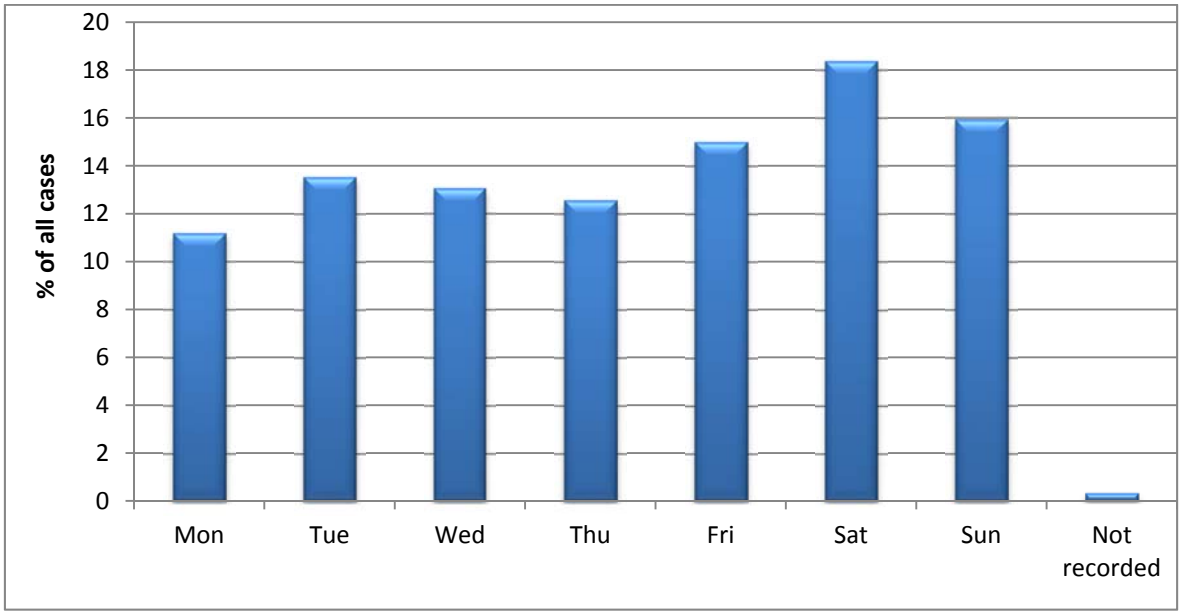


Figure 4-3 Day of the week of presentation

Source of patients

The majority of patients arrived from the scene of the injury (73%) with a median pre-hospital time from first paramedic contact to arrival in the ED of 40 minutes (IQR of 30-55 minutes) (this does not include the time from the accident to the time of paramedic arrival). The next most common source was transfer from another hospital (14%) with a median transfer time of 65 minutes (IQR 39-90 minutes) (this does not include the time from the accident or the time spent at the transferring hospital before arrival of the paramedical personnel performing the transfer). This gives the following distribution of patients (see Figure 4-4):

There was a significant, but very weak, association between patient source and time spent in the ED (Pearson's X^2 test: $p<0.001$; Cramer's $V=0.08$): a slightly lower proportion of patients who arrived from primary sources spent no more than one hour (≤ 1h) in the ED, compared to the other two groups (see Figure 4-5).

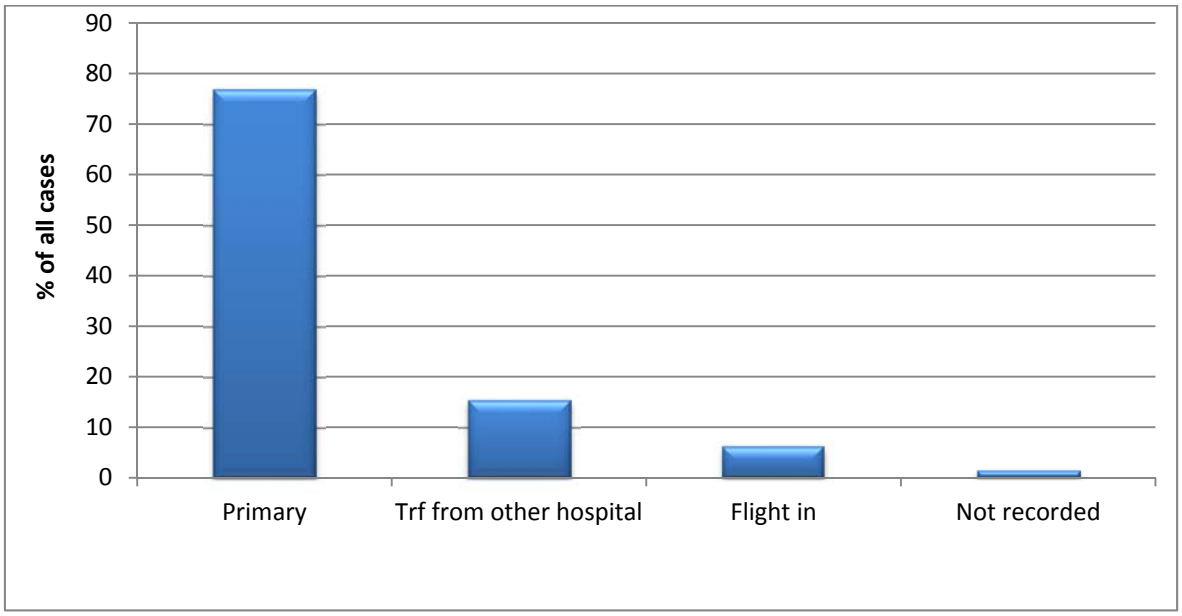


Figure 4-4 Source of Priority 1 patients presenting to the ED

("Primary" indicates scene of accident)

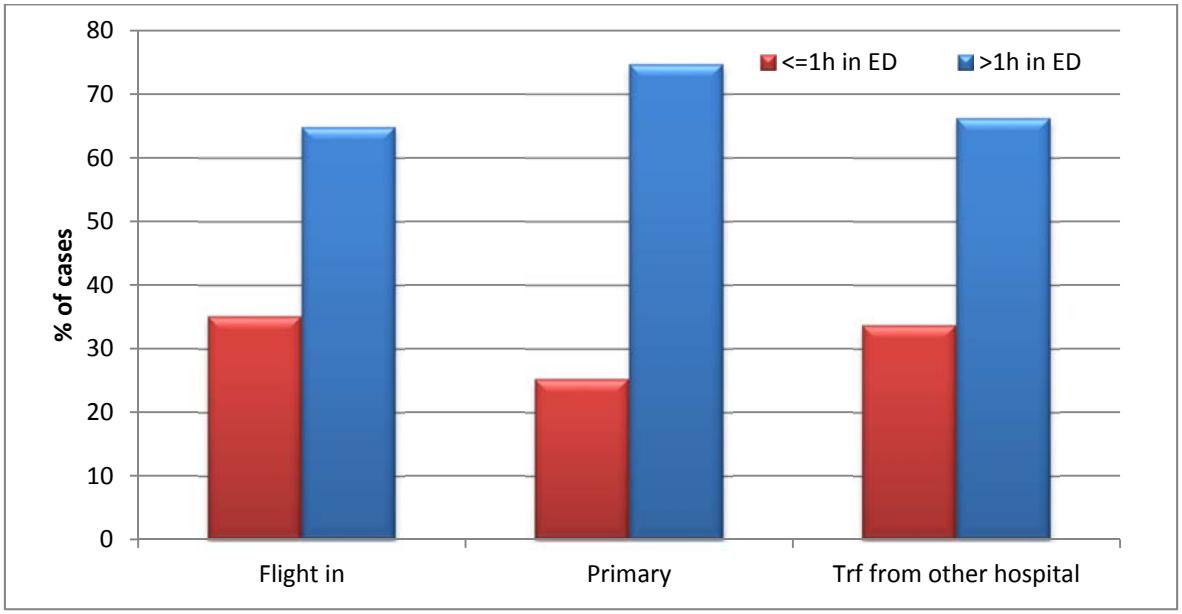


Figure 4-5 Time in the ED categorised by patient source

The median and mean times in the ED for different patient sources are tabulated below (see Table 4-1):

Table 4-1 Time in ED for each patient source category

Patient source	n	Time in the ED (min)				
		Median	IQR		Mean	SD
Flight in	279	74	54	96	79	34
Primary	3422	89	60	124	99	53
Trf from other hospital	697	74	54	95	81	44

There was a significant, but very weak, association between patient source and whether or not patients went to theatre (Pearson's X^2 test: p=0.006; Cramer's V=0.05): a slightly higher proportion of patients who were transferred from other hospitals went to theatre, compared with the other two groups (see Figure 4-6).

Mode of transport to hospital

Most patients arrived at the ED by ambulance (74%), with arrival by helicopter and private transport making up just over 10% each (see Figure 4-7).

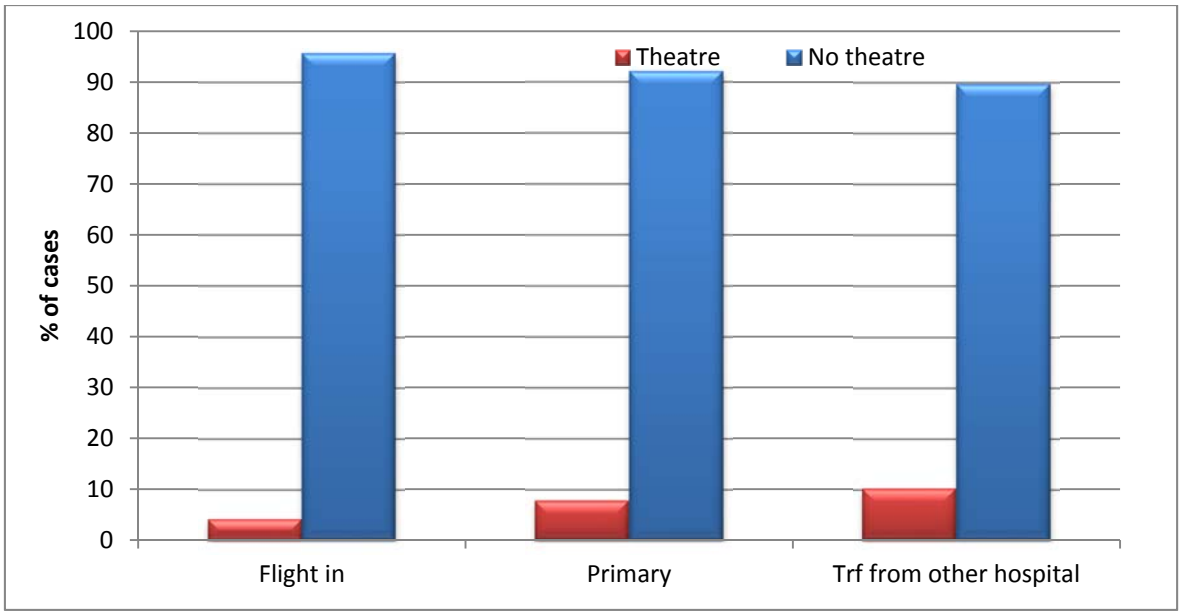


Figure 4-6 Proportion of patients transferred to theatre for each patient-source category

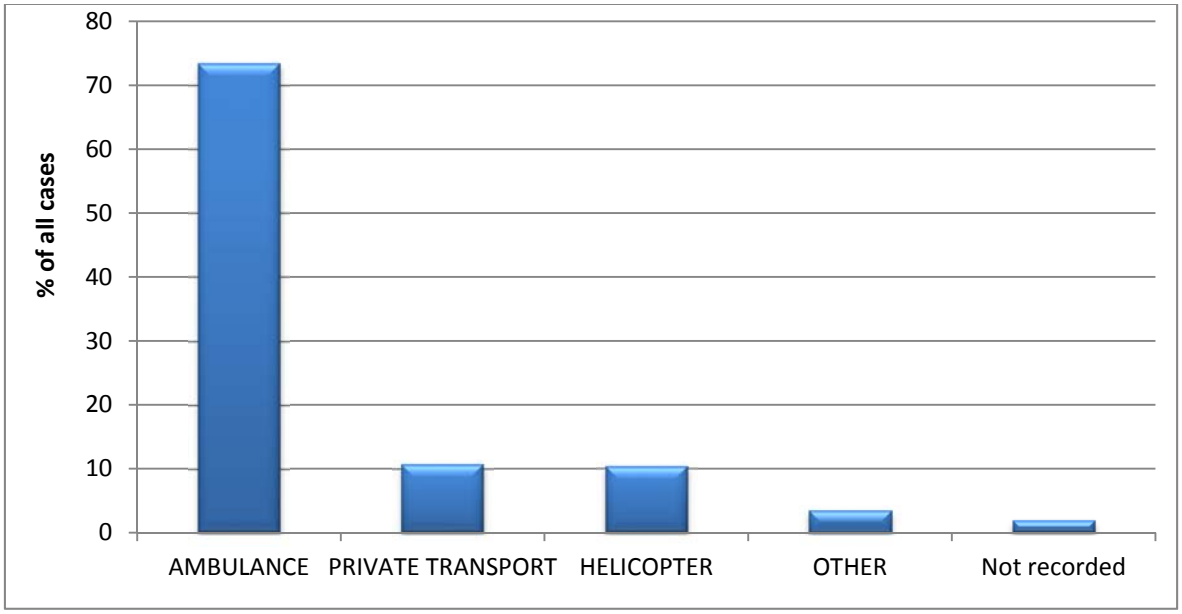


Figure 4-7 Mode of transport to the ED

There was a significant, but very weak, association between mode of transport and time spent in the ED for patients who arrived by helicopter, ambulance or by private transport ('Other' and missing data for transport was excluded) (Pearson's

X^2 test: $p<0.001$; Cramer's $V=0.08$): a slightly higher proportion of patients who arrived by helicopter spent no more than one hour (≤ 1h) in the ED (see Figure 4-8).

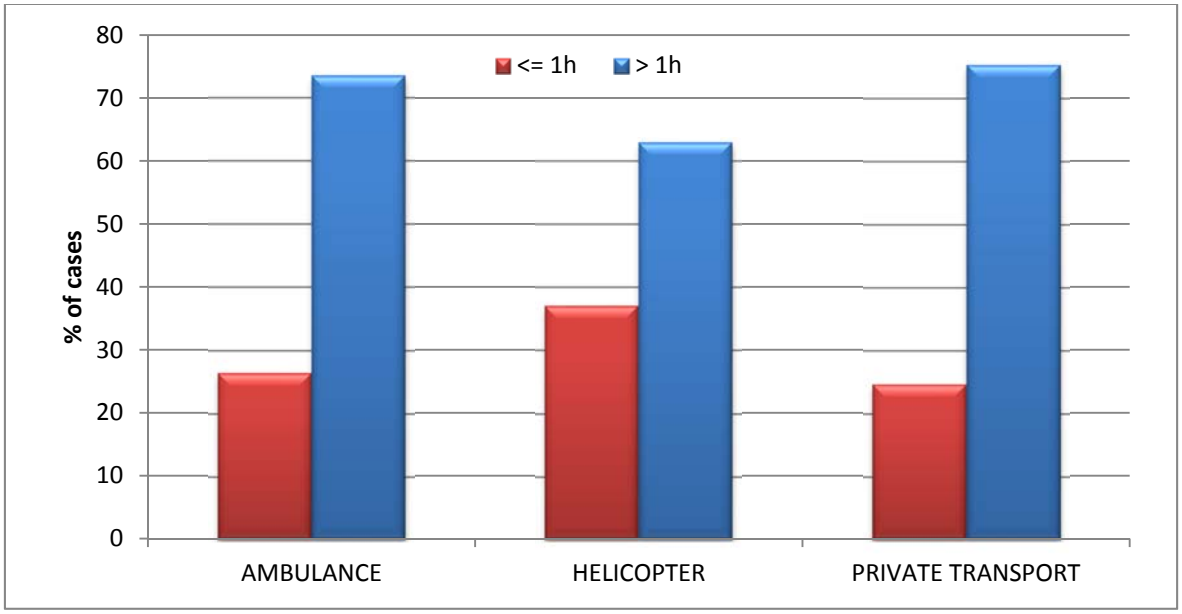


Figure 4-8 Time spent in the ED for each mode of arrival

The median and mean times in the ED for patients arriving by different modes of transport are tabulated below (see Table 4-2):

Table 4-2 Time in the ED for each mode of transport

Transport	n	Time in the ED (min)				
		Median	IQR		Mean	SD
AMBULANCE	3298	84	60	119	96	51
HELICOPTER	467	70	54	99	79	39
PRIVATE TRANSPORT	474	89	62	128	100	54

There was a significant, but very weak, association between mode of transport and whether or not patients went to theatre for patients who arrived by helicopter, ambulance or by private transport (patients in the 'Other' category and missing data for transport were excluded) (Pearson's X^2 test: $p<0.001$; Cramer's $V=0.08$): a slightly higher proportion of patients who arrived by helicopter went to theatre (see Figure 4-9).

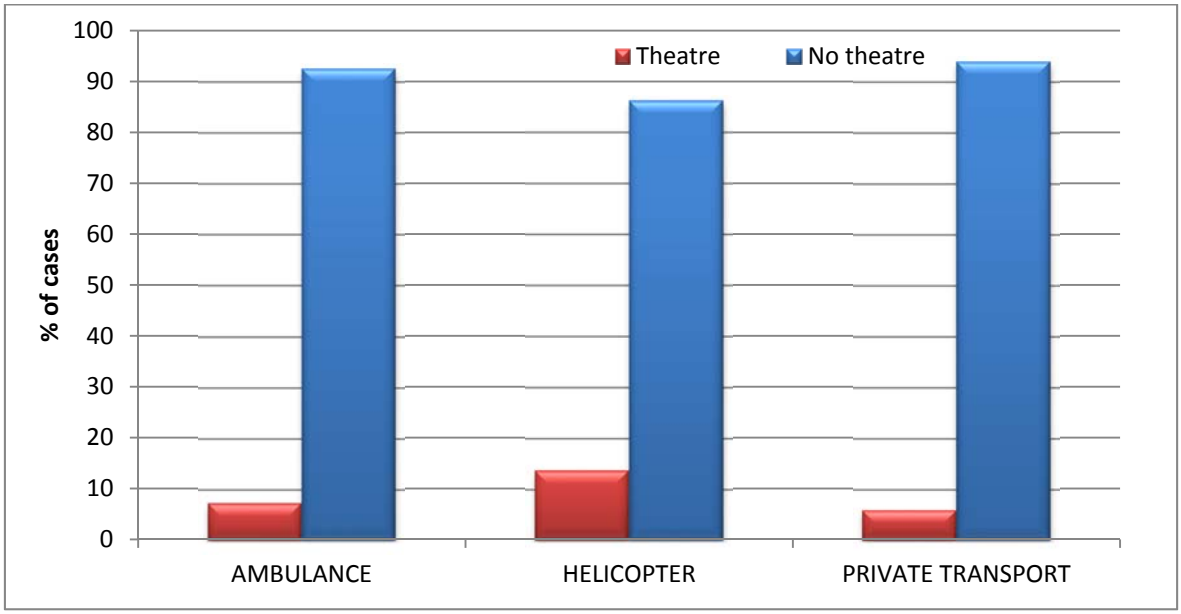


Figure 4-9 Disposition to theatre for each mode of transport

ED Disposition

Time in the ED

The median time that a patient spent in the ED was 84 minutes (IQR 60-119 min). The mean time (± standard deviation) was 95 ± 51 minutes. The time in the ED for 2.7% of patients was unknown. Only 27% of patients, whose time in the ED was known, spent no longer than one hour in the ED (see Figure 4-10).

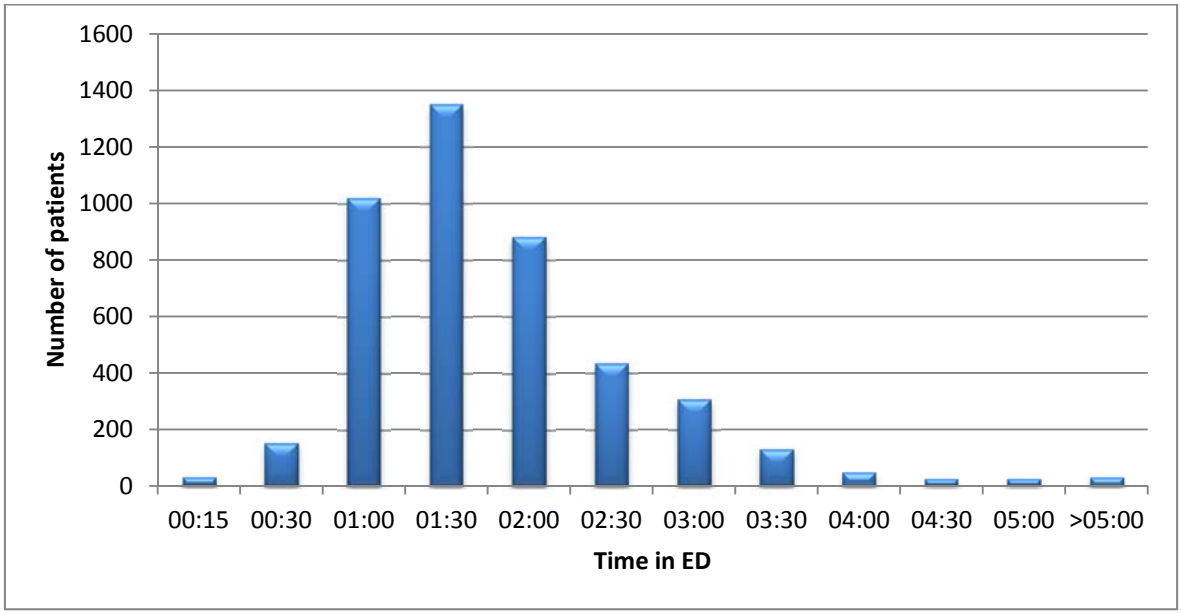


Figure 4-10 Distribution of times spend in the ED

Disposition from the ED

The majority of patients went from the ED to ICU (48%) or High Care (30%), while 8.0% went directly to theatre from the ED. Admissions to the ward accounted for 6.9% of dispositions, transfers 3.1%, discharges 1.9% and 1.8% of patients in the data set died. The disposition of 0.8% of patients in the data was not recorded (see Figure 4-11).

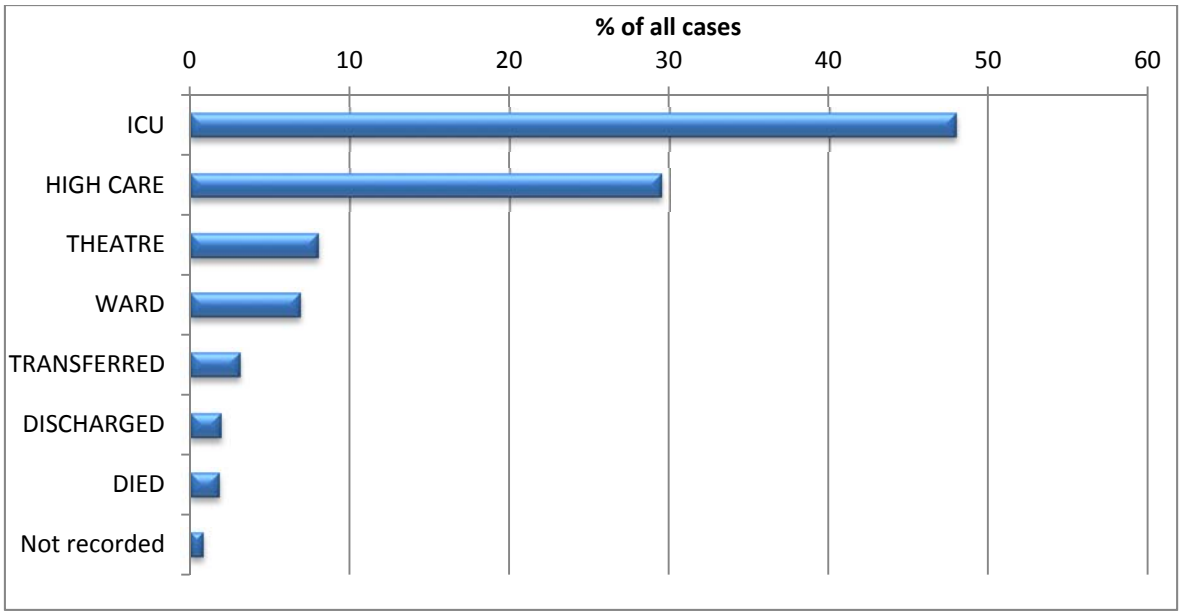


Figure 4-11 Disposition of patients from the ED

ED disposition to theatre

There was a significant, but weak, association between disposition and time spent in the ED (Pearson's X^2 test: $p<0.001$; Cramer's $V=0.10$): a slightly higher proportion of patients who died or went to theatre spent no more than one hour (≤ 1h) in the ED compared to those patients with other dispositions (see Figure 4-12).

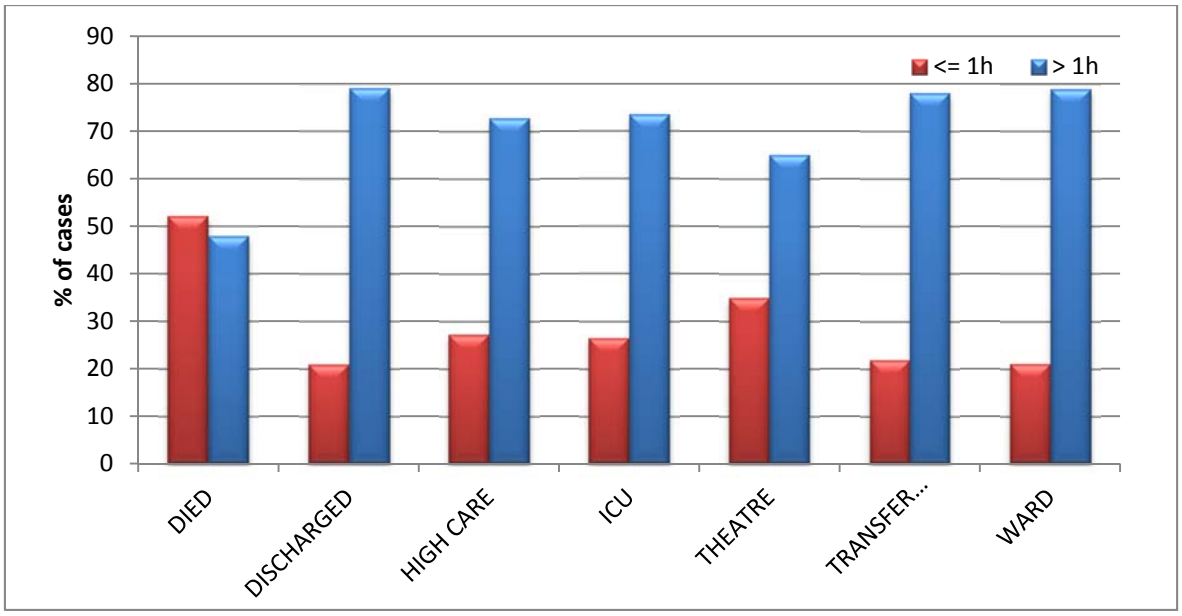


Figure 4-12 Disposition of patients from the ED for patients staying shorter or longer than one hour in the ED

The median and mean times in the ED for the different dispositions are tabulated below (see Table 4-3):

Table 4-3 Time spent in the ED categorised by the site of disposition

Disposition	n	Time in the ED (min)				
		Median	IQR		Mean	SD
DIED	71	57	25	103	77	74
DISCHARGED	86	107	76	156	114	59
HIGH CARE	1319	83	60	117	93	47
ICU	2139	84	60	115	94	49
THEATRE	365	77	55	105	84	44
TRANSFERRED	137	105	70	161	120	70
WARD	308	95	71	144	110	59

With regard to those patients who went to theatre (8.0% of the patients), there was a significant but very weak association between whether patients went to theatre or not and time spent in the ED (Fisher's exact test: $p<0.001$; Phi coefficient=0.05). A slightly higher proportion of patients who went to theatre spent no more than one hour (≤ 1h) in the ED compared to those who did not go to theatre (see Figure 4-13).

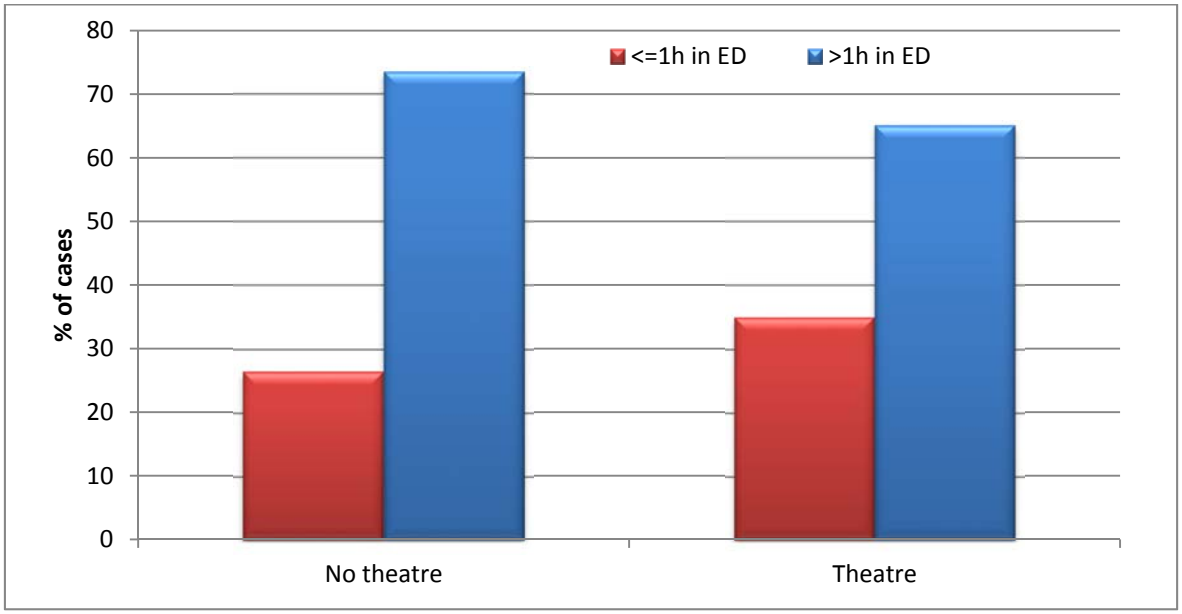


Figure 4-13 Proportion of patients spending no more than one hour in the ED by destination of disposition

The median and mean times in the ED for the patients who went to theatre and those that did not go to theatre are tabulated below (see Table 4-4):

Table 4-4 Times in the ED for patients transferred to theatre and other dispositions

Theatre	n	Time in the ED (min)				
		Median	IQR		Mean	SD
No	4060	84	60	119	96	51
Yes	365	77	55	105	84	44

The 365 patients who went to theatre (8.0% of the total data set) are split as follows according to their source and time spent in the ED (see Table 4-5):

Table 4-5 Origin of patients who went to theatre from the ED

	Patient source				
	Primary	Transfer from other hospital	Flight in	Unknown	Total
Overall					
n	275	72	12	6	365
% of total	75.3%	19.7%	3.3%	1.6%	100.0%
Time in ED ≤ 1h					
n	85	31	5	2	123
% of patient source	30.9%	43.1%	41.7%	33.3%	33.7%
% of total	23.3%	8.5%	1.4%	0.5%	33.7%

Table 4-6 Patient characteristics relative to emergency operative or major surgical procedural intervention

Characteristics	Emergency Operative or Procedural Intervention		Total No. (%)
	Yes (%)	No (%)	
Total number of cases	161 (3.7)	4200 (96.3)	4361
Median age (IQR)	36 (27-44.5)	34 (25-46)	34 (25-46)
Men	147 (91.3)	3305 (78.7)	3452 (79.2)
Median Injury Severity Score (IQR)	16 (9-25)	9 (4-18)	9 (4-19)
Mechanism:			
Penetrating	45 (28.0)	412 (9.8)	457 (10.5)
Blunt	43 (26.7)	1950 (46.4)	1993 (45.7)
Blunt & Penetrating	5 (3.1)	80 (1.9)	85 (2.0)
Burn	7 (4.4)	217 (5.2)	224 (5.1)
Other	5 (3.1)	89 (2.1)	94 (2.2)
Not recorded	56 (34.8)	1452 (34.6)	1508 (34.6)
How injury occurred:			
Road traffic accident	32 (19.9)	1486 (35.4)	1518 (34.8)
Fall	8 (5.0)	277 (6.6)	285 (6.5)
Assault	27 (16.8)	218 (5.2)	245 (5.6)
Burns	6 (3.7)	182 (4.3)	188 (4.3)
Gunshot wound	16 (9.9)	130 (3.1)	146 (3.4)
Stab wound	5 (3.1)	98 (2.3)	103 (2.4)
Industrial accident	6 (3.7)	70 (1.7)	76 (1.7)
Crushing injury	1 (0.6)	63 (1.5)	64 (1.5)
Explosion	2 (1.2)	46 (1.1)	48 (1.1)
Sports injury	0 (0.0)	47 (1.1)	47 (1.1)
Aircraft crash	0 (0.0)	28 (0.7)	26 (0.6)
Other	54 (33.6)	579 (13.7)	629 (14.7)
Not recorded	4 (2.5)	980 (23.3)	984 (22.6)

Assessment of injury scores

The **ISS and NISS** categorisations of the patients are shown in the graph below (see Figure 4-14). The median ISS score was 9 (IQR 4-19; mean 13.0 ± 11.7) while the median NISS score was 12 (IQR 5-27; mean 17.7 ± 16.5).

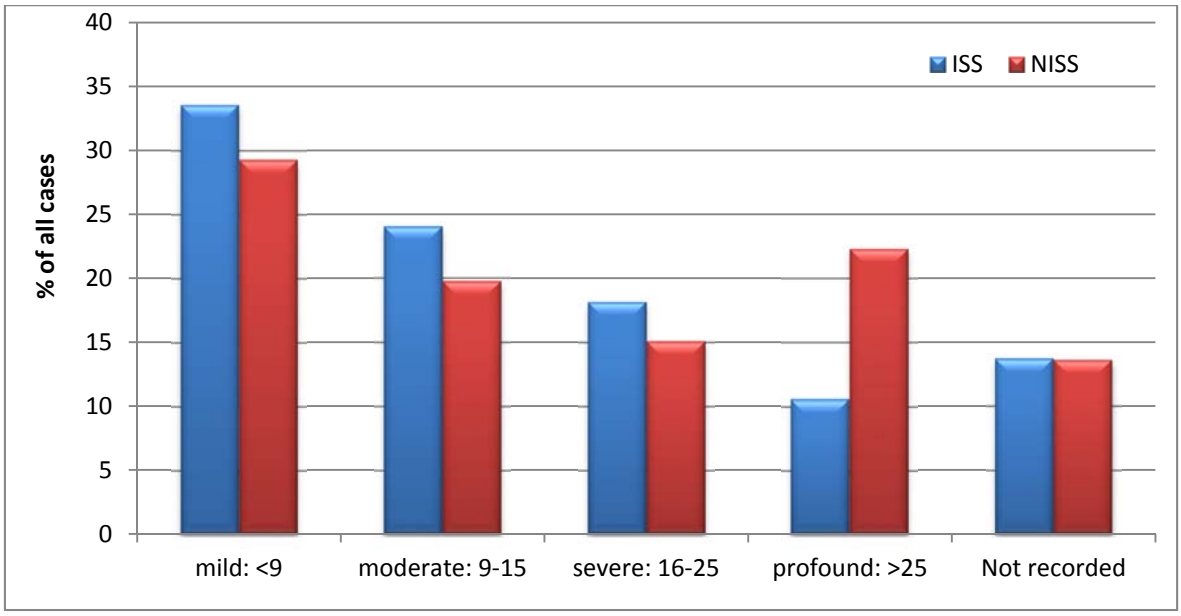


Figure 4-14 ISS and NISS score categories

There was a significant but weak association between patient source and the categorised ISS scores of the patients (Pearson's X^2 test: $p<0.001$; Cramer's $V=0.16$). Patients from primary responses (and those brought into the ED by car) had a higher proportion of mild injury severity (and a lower proportion of severe and profound injury severity) compared to patients transferred from other hospitals or flown in to the ED (see Figure 4-15).

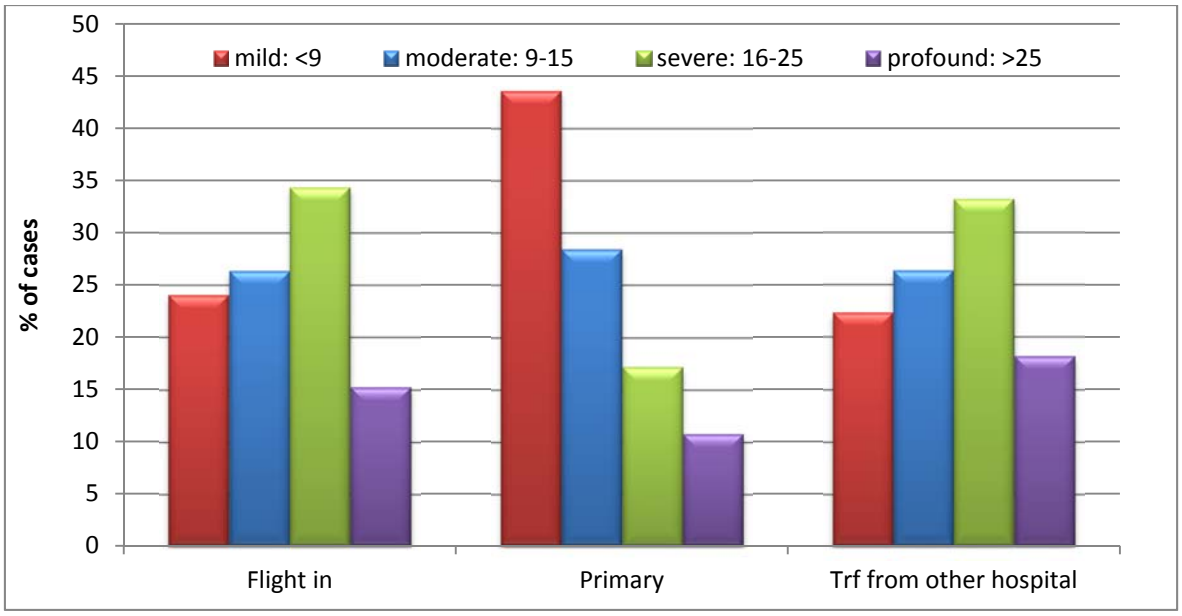


Figure 4-15 ISS Scores for each patient source

A similar conclusion may be drawn from the association between patient source and the categorised NISS scores of the patients (Pearson's X^2 test: $p<0.001$; Cramer's $V=0.16$) (see Figure 4-16).

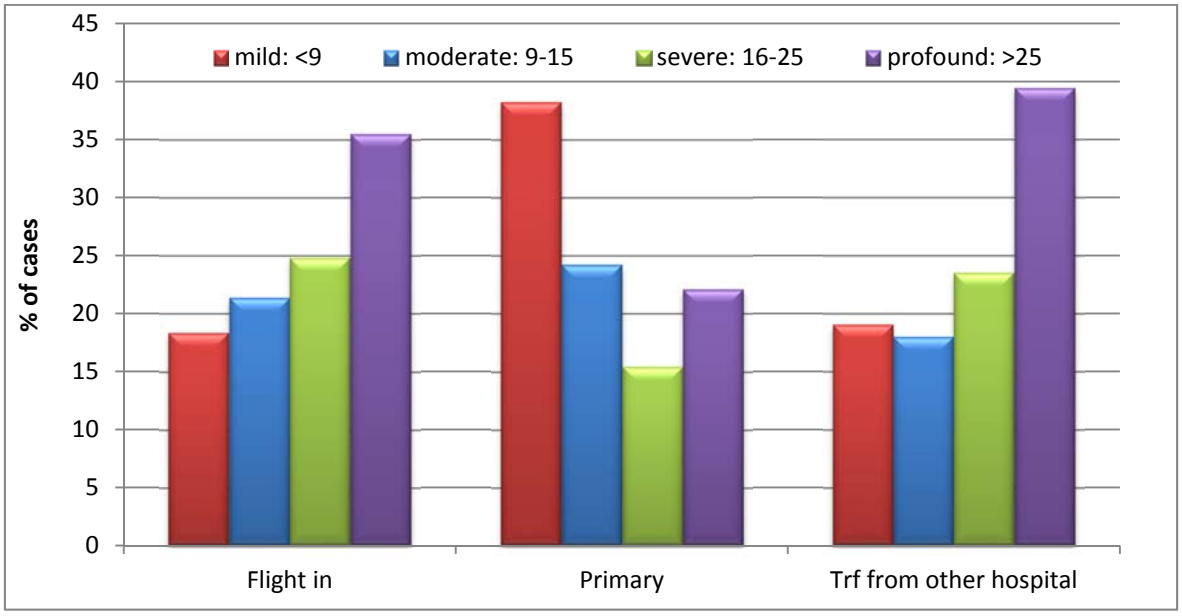


Figure 4-16 NISS Scores for each patient source

There was a significant moderate association between patient disposition and the categorised ISS scores of the patients (Pearson's X^2 test: $p<0.001$; Cramer's $V=0.31$). In the groups who were discharged, transferred, or sent to High Care or a general ward there were higher proportions of mild injury severity patients (and lower proportions of severe and profound injury severity patients) compared to the other dispositions, while death was associated with the highest proportion of profound injury severity patients. The death, theatre and ICU groups had higher proportions of severe and profound injury severity patients than the other groups (see Figure 4-17).

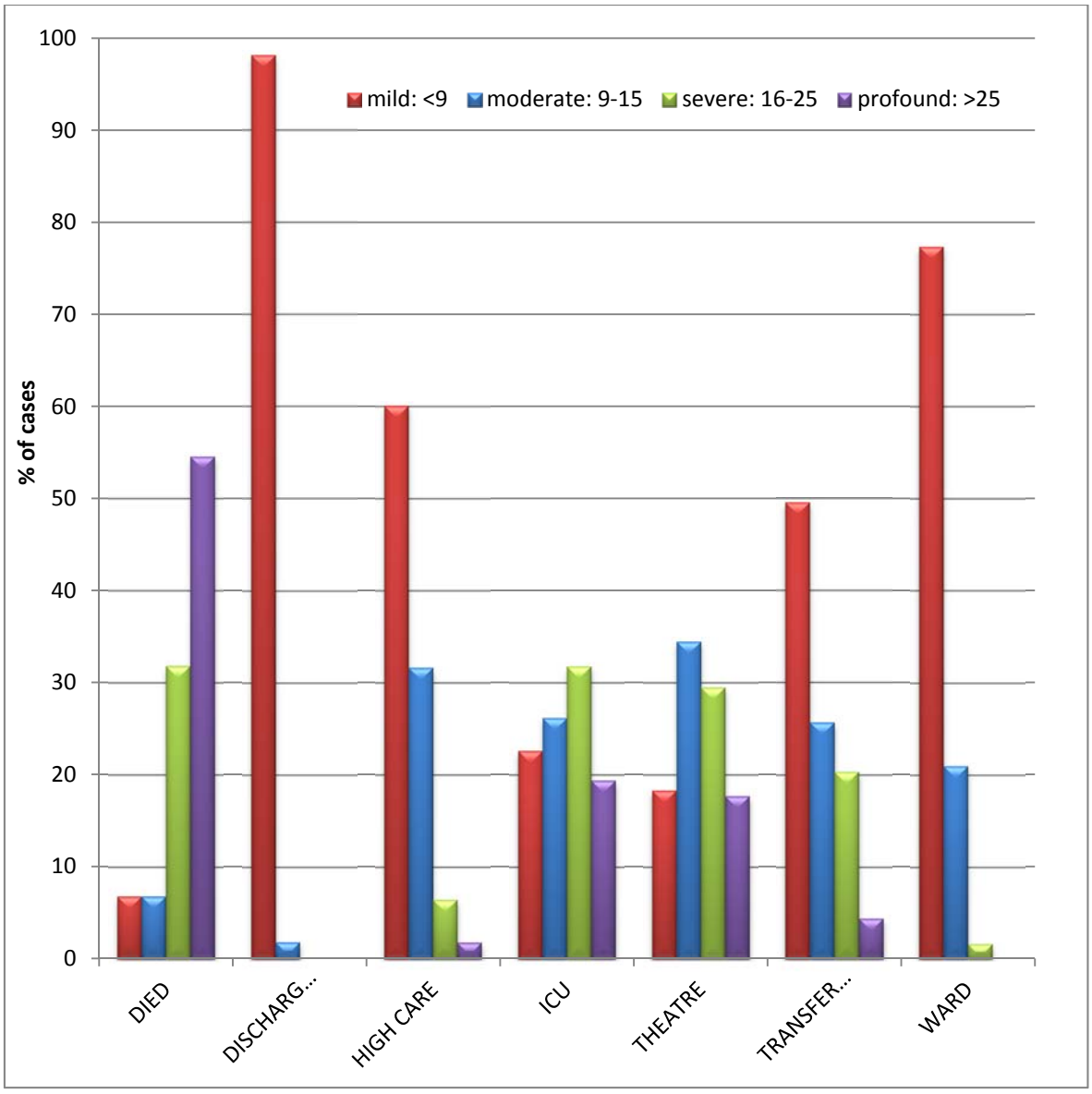


Figure 4-17 Disposition of patients in each ISS category

A similar conclusion may be drawn from the association between patient disposition and the categorised NISS scores of the patients (Pearson's X^2 test: $p<0.001$; Cramer's $V=0.32$) (see Figure 4-18).

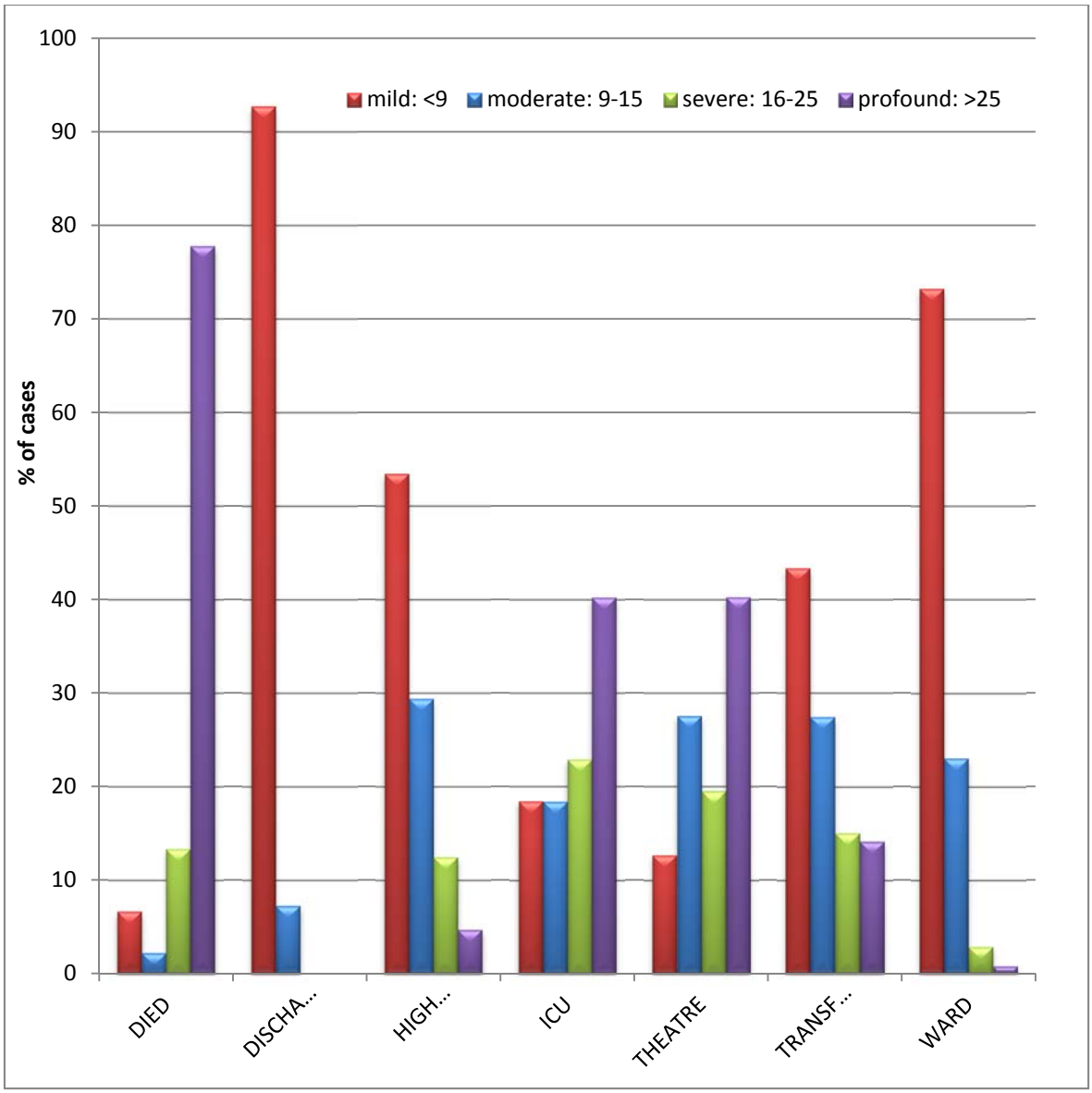


Figure 4-18 Disposition of patients in each NISS category

For those patients who went to theatre, there was no significant association between the categorised ISS score (or categorised NISS score) and whether or not patients went to theatre within the first hour in the ED (Pearson's X^2 test: p =0.46 (ISS) and p=0.42 (NISS)).

Probability of survival

The categorised probability of survival scores are illustrated below (see Figure 4-19).

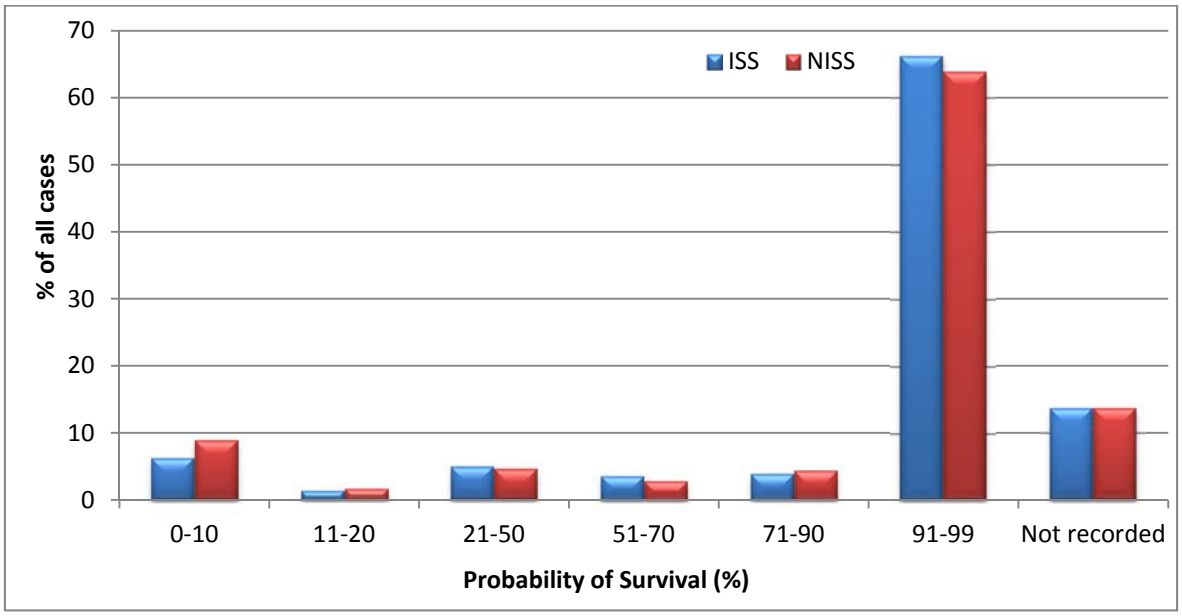


Figure 4-19 Probability of survival categorised by ISS and NISS Scores

The occurrence of deaths with regard to probability of survival as calculated from the ISS and NISS scores showed that 61% of the deaths in the data set were associated with a probability of survival of 0% to10% based on the NISS, compared to only 48% based on the ISS (see Figure 4-20).

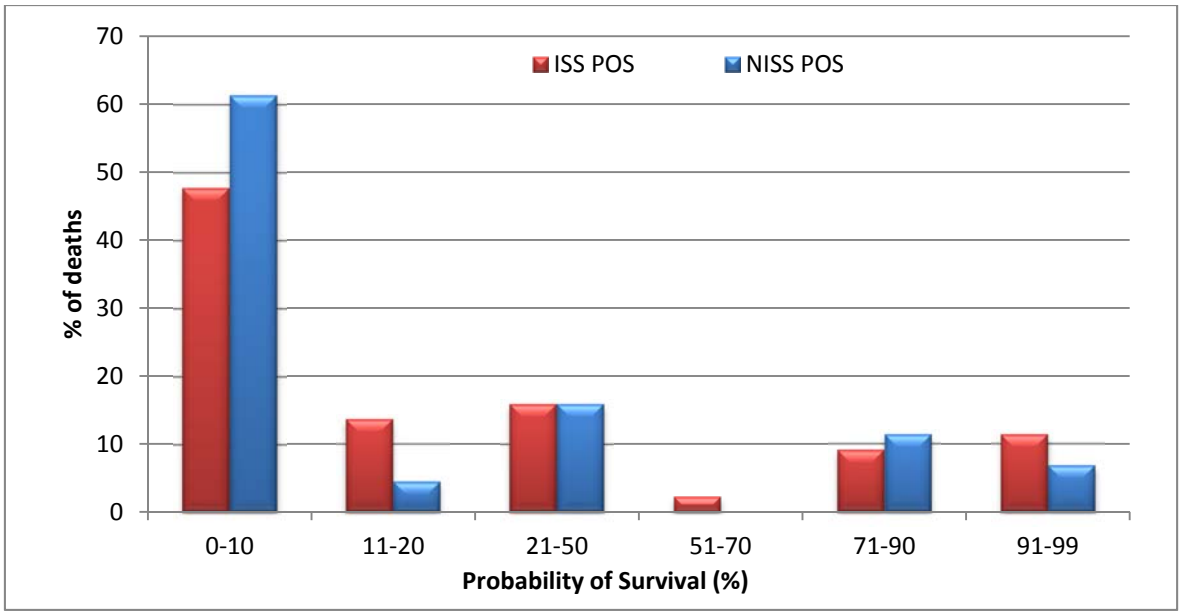


Figure 4-20 Percentage of deaths within each probability of survival category

There was a significant but weak association between ISS probability of survival and the mechanism of injury (excluding 'Other') (Pearson's X^2 test: $p<0.001$; Cramer's $V=0.10$): Blunt & Penetrating injuries had a higher proportion of cases in the 91% to 99% probability of survival category than Burns cases, while Burns cases had a higher proportion of cases in the 21% to 50% probability of survival category than the other injury mechanism categories (see Figure 4-21).

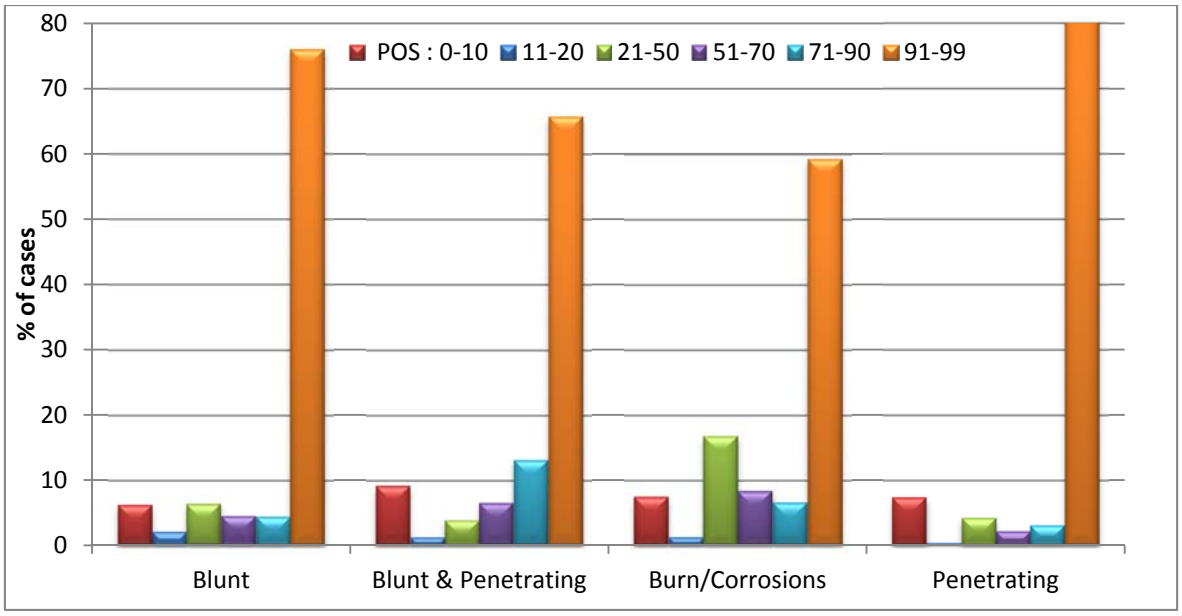


Figure 4-21 Probability of survival for each category of mechanism of Injury

There was a significant but weak association between ISS probability of survival and the outcome (whether or not patients went to theatre within the first hour after arrival) (Pearson's X^2 test: $p<0.001$; Cramer's $V=0.09$): Patients who went to theatre within the first hour in the ED were associated with a lower proportion of cases in the 91% to 99% probability of survival category compared to those who did not go to theatre or who did so after one hour in the ED (see Figure 4-22).

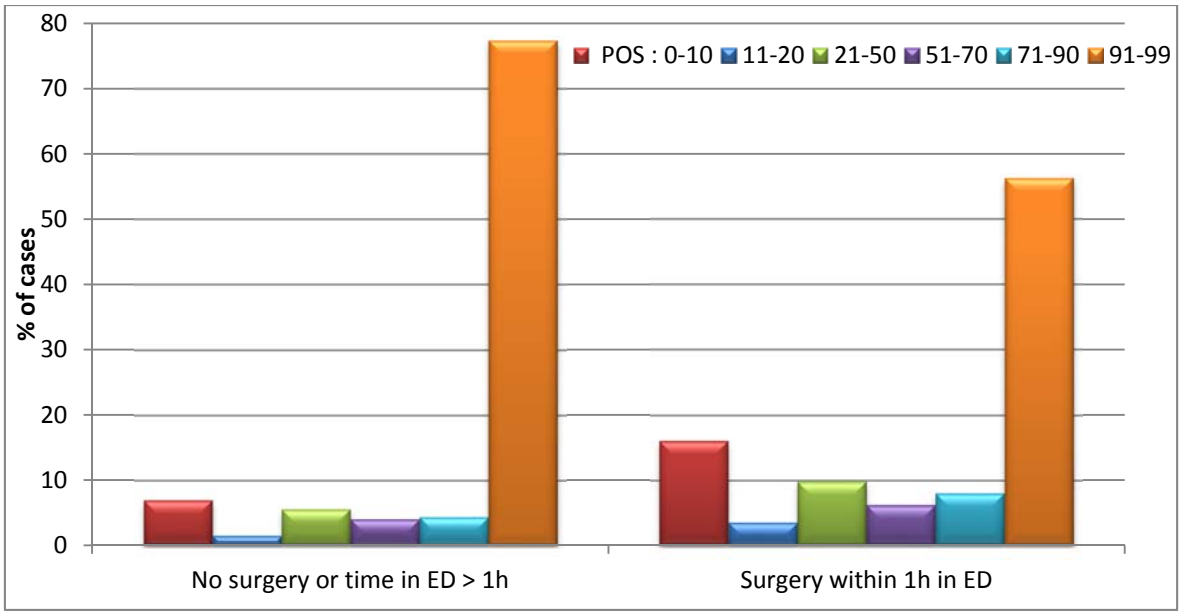


Figure 4-22 Probability of survival for patients requiring emergency surgery

Glasgow coma scale scores

The pre-hospital and ED GCS categorisations of the patients are shown in Figure 4-23. The median GCS score in both cases was 15 (IQR 13-15). The pre-hospital GCS had a mean of 12.7± 4.1 while the ED GCS had a mean of 12.4 ± 4.7. Data for a large proportion of pre-hospital cases (38%) was not recorded.

There was a significant, but very weak, association between GCS category and outcome (whether or not the patient when to theatre within the first hour in the ED) (Pearson's X^2 test: $p<0.001$; Cramer's $V=0.07$): a slightly higher proportion of patients with a lower GCS score went to theatre within the first hour in the ED (see Figure 4-24).

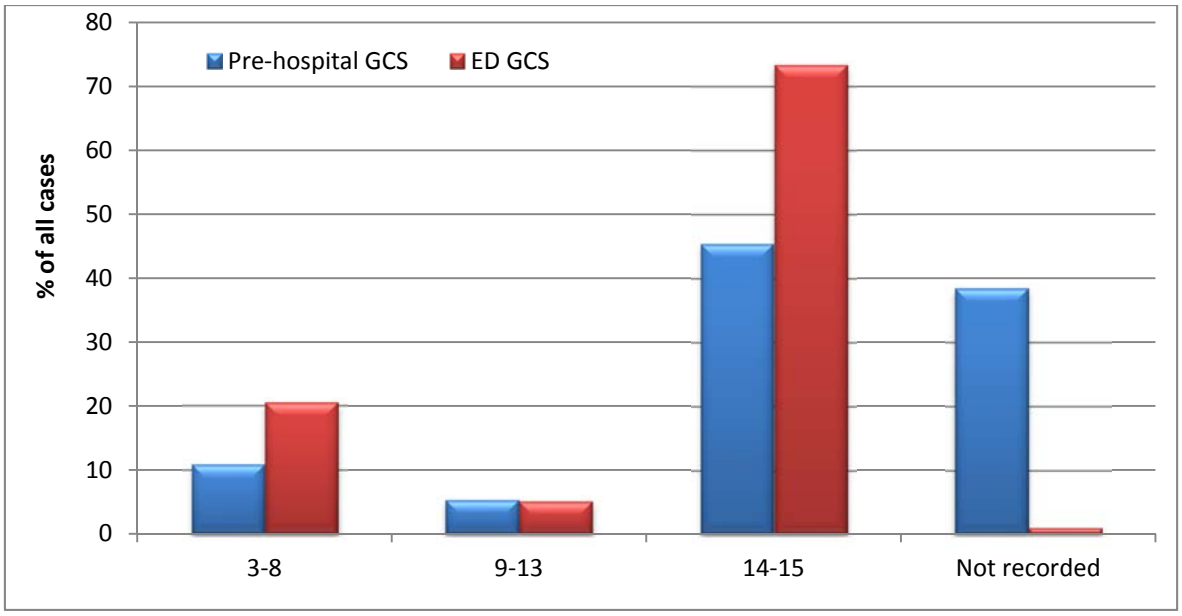


Figure 4-23 GCS scores from pre-hospital and ED records

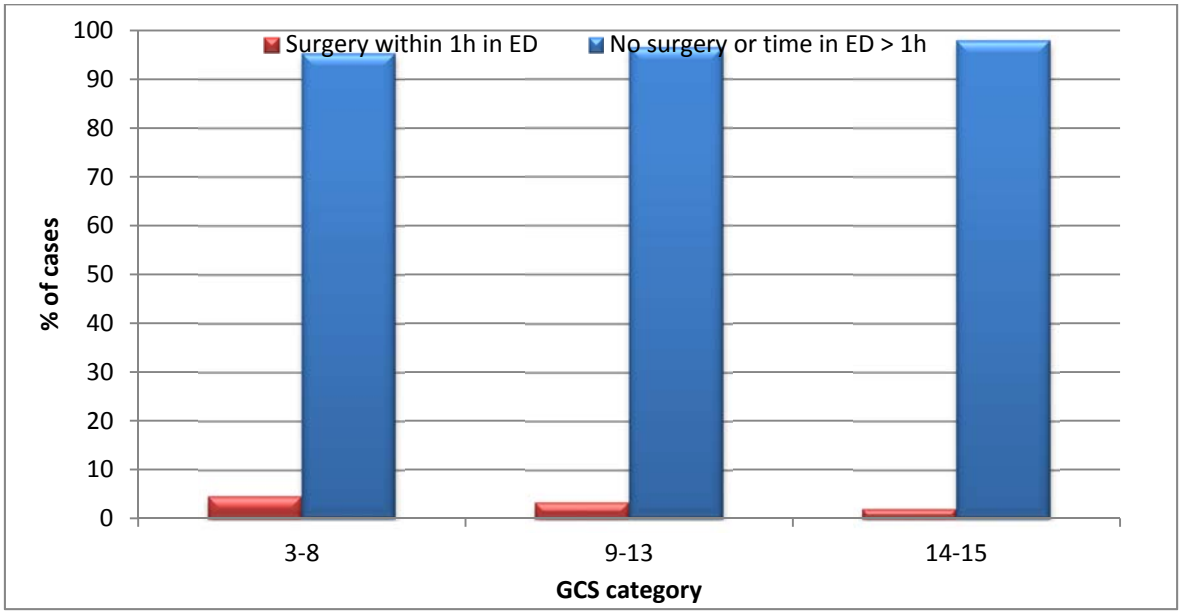


Figure 4-24 GCS scores for patients requiring emergency surgery

There was a significant moderate association between GCS category and disposition (Pearson's X^2 test: $p<0.001$; Cramer's $V=0.33$): the GCS 3 to 8 category was associated with higher proportions of deaths, transfer directly to theatre or ICU admission and lower proportions of High Care and ward admissions

than the GCS 14 to 15 category. The GCS 9 to 13 category was associated with higher proportions of ICU and lower proportions of High Care admissions than the GCS 14 to 15 category (see Figure 4-25).

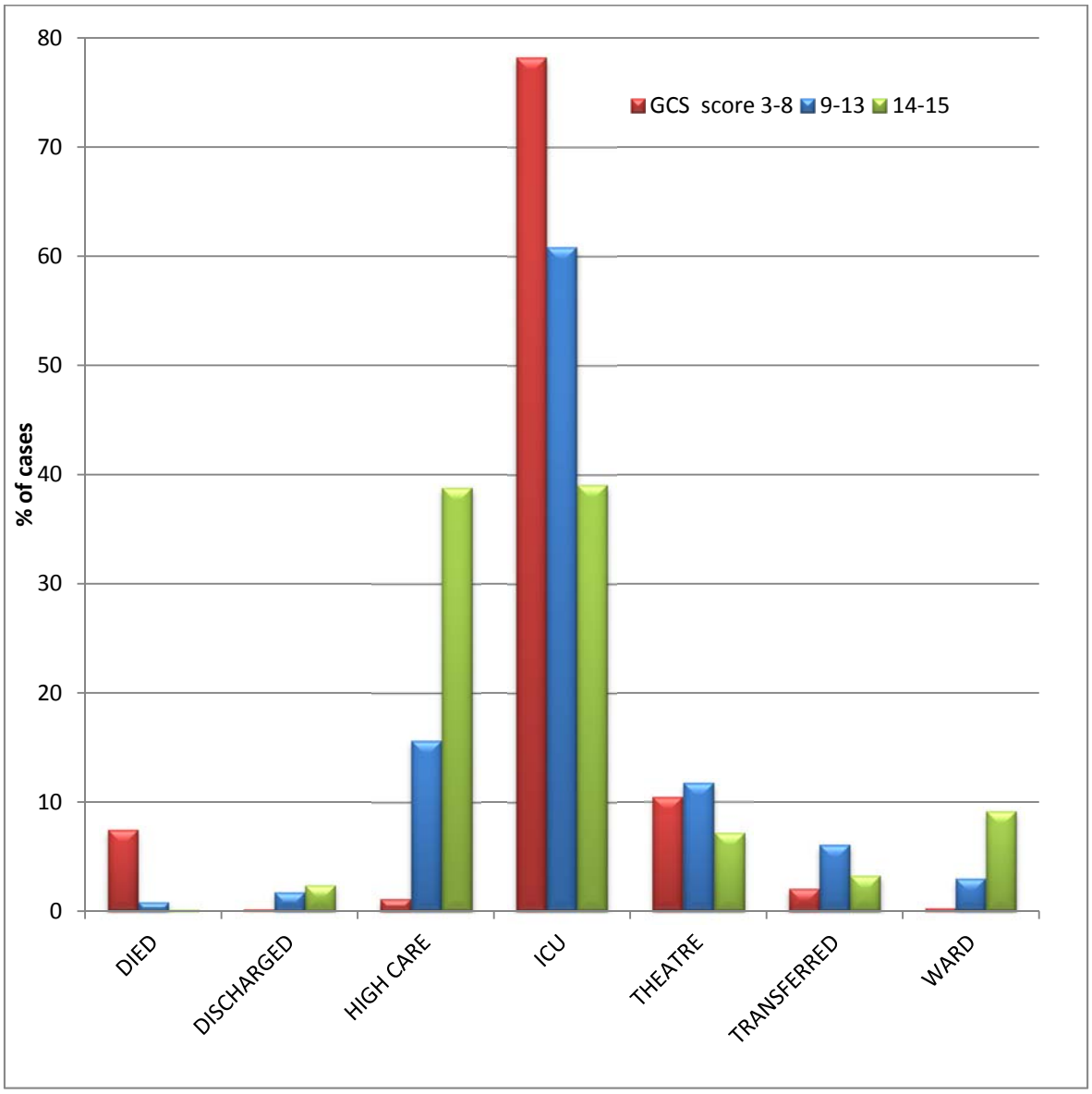


Figure 4-25 Proportions of patients in each GCS category for each destination from the ED

Causes of injury

The most frequent causes of injury were road traffic accidents (35%) followed by other and unspecified traumatic events (16%). The cause of injury was unknown in 23% of cases (see Figure 4-26).

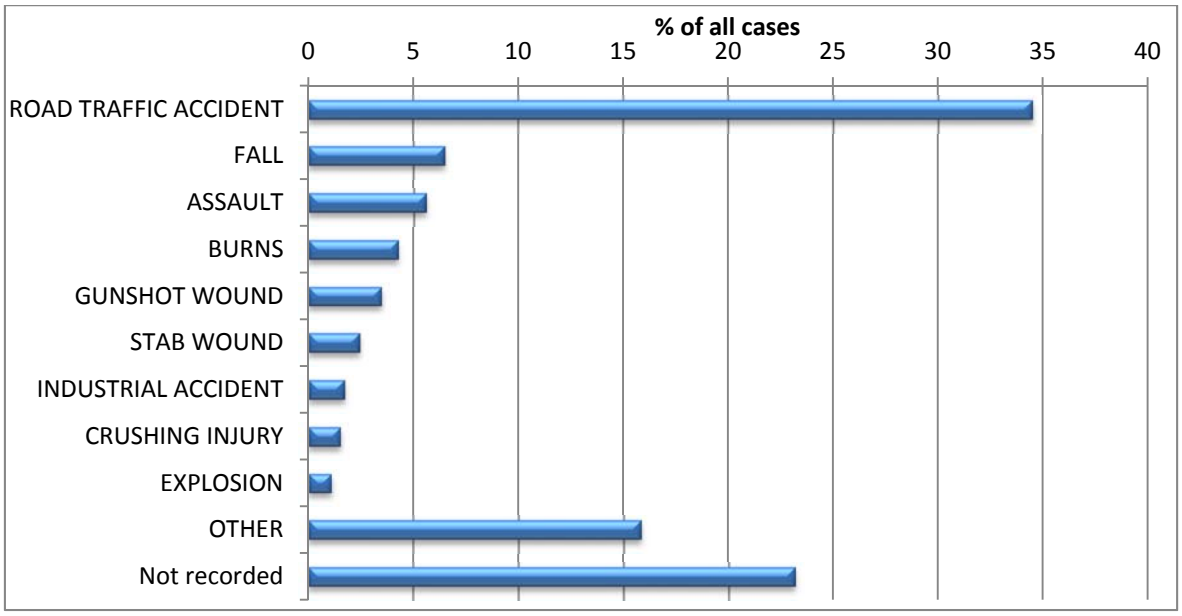


Figure 4-26 Causes of injury for the whole study population

Mechanism of injury

Blunt trauma was the leading cause of injuries (45%), followed by penetrating injuries (11%). The mechanism of injury was unknown (not recorded) in 35% of cases (see Figure 4-27). The exact nature of "Blunt & Penetrating" trauma was not defined.

If we disregard those cases with missing data and mechanism given as 'Other', there was a significant, but weak, association between mechanism of injury and time spent in the ED (Pearson's X^2 test: $p<0.001$; Cramer's $V=0.11$): a slightly

higher proportion of patients who had penetrating injuries spent no more than one hour (≤ 1h) in the ED (see Figure 4-28).

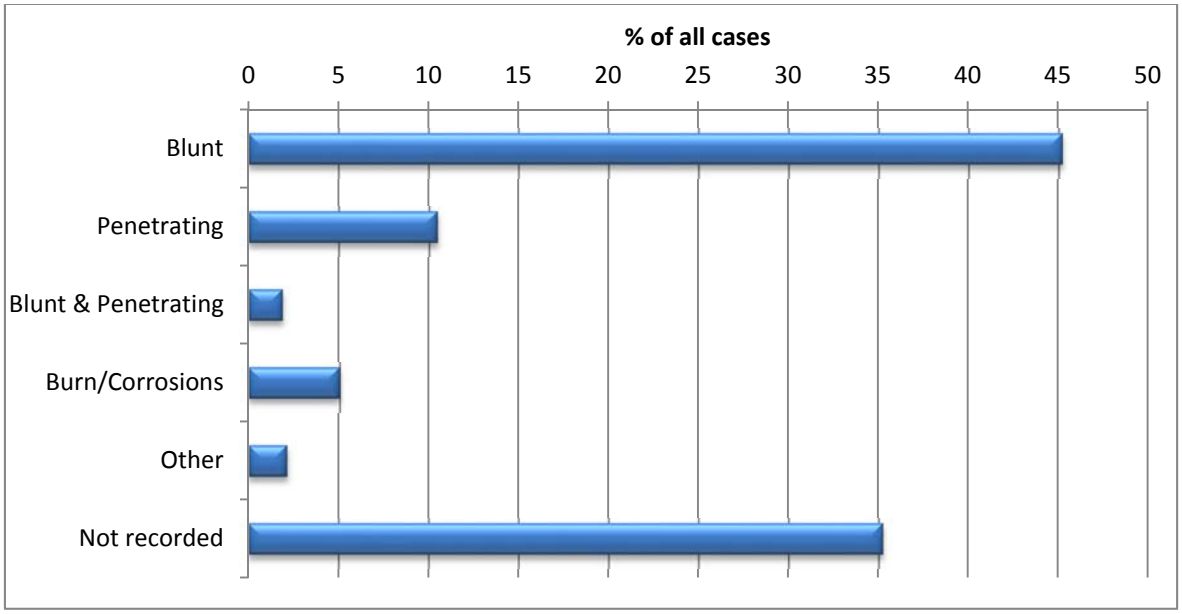


Figure 4-27 Mechanism of Injury

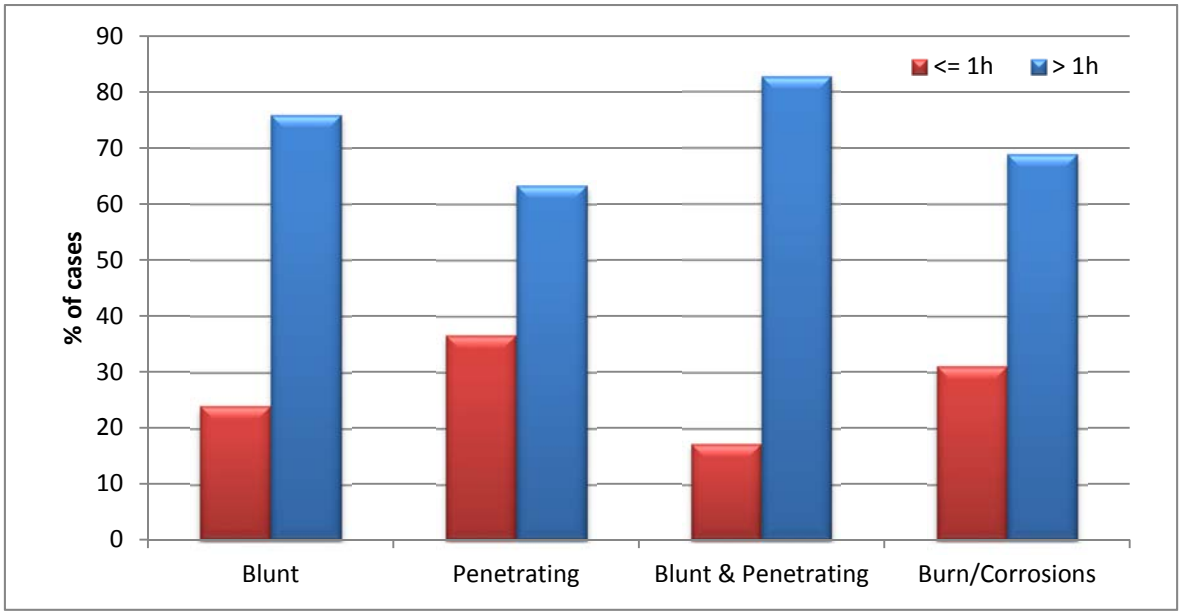


Figure 4-28 Mechanism of injury for patients requiring emergency surgery

The median and mean times in the ED for patients injured by different mechanisms are tabulated below (see Table 4-7):

Table 4-7 Time spent in the ED for each mechanism of injury

Mechanism	n	Time in the ED (min)				
		Median	IQR		Mean	SD
Blunt	2000	85	64	119	96	49
Blunt & Penetrating	81	109	70	134	107	47
Burn/Corrosions	225	82	54	99	84	41
Penetrating	464	74	54	100	83	46

There was a significant, but weak, association between mechanism of injury and whether or not the patient went to theatre (Pearson's X^2 test: $p<0.001$; Cramer's $V=0.19$): a slightly higher proportion of patients who had penetrating injuries went to theatre (see Figure 4-29).

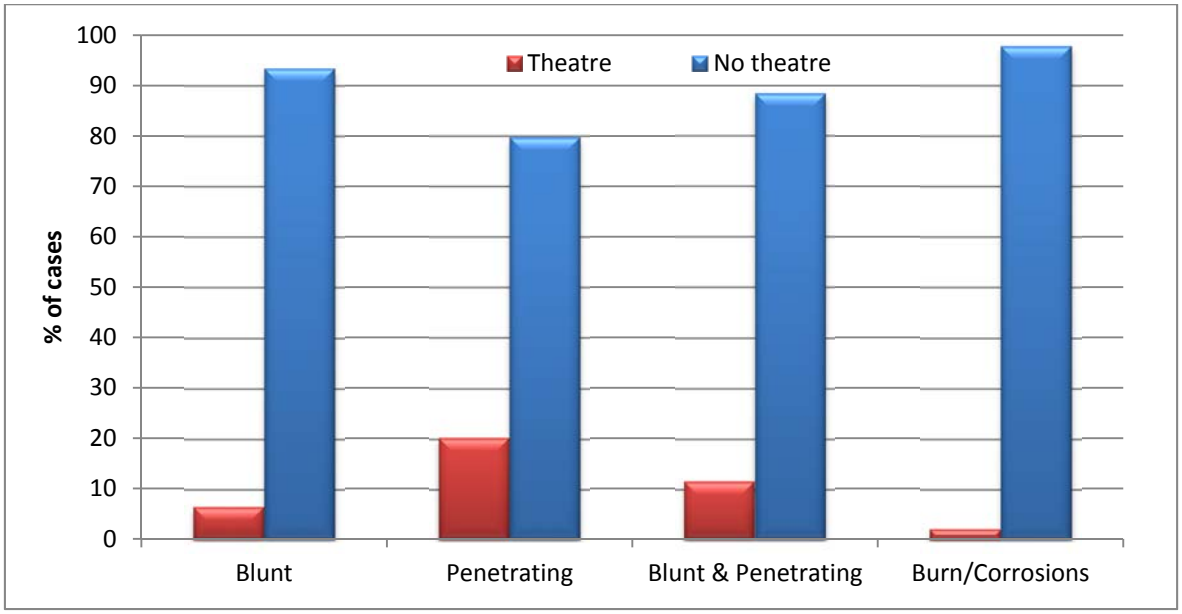


Figure 4-29 Disposition to theatre for each mechanism of injury

When considering only blunt and penetrating injuries, there was a significant but weak association between injury mechanism and disposition (Pearson's X^2 test: $p<0.001$; Cramer's $V=0.20$): amongst blunt injury patients, a higher proportion went to ICU and High Care, and a lower proportion to theatre, compared to penetrating injury patients (see Figure 4-30).

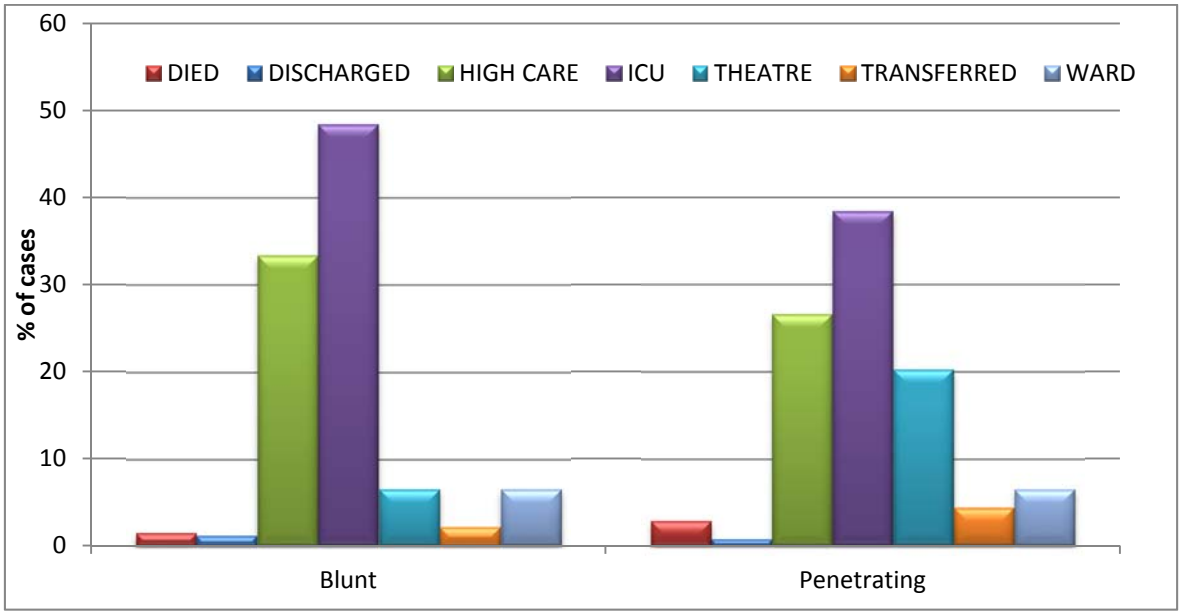


Figure 4-30 Disposition of patients with blunt and penetrating injury

When analysing only blunt and penetrating injury patients who went to theatre, there was a significant difference between the actual time to theatre between the two groups (t-test: $p=0.005$). The mean time to theatre for blunt injury patients was 93 ± 8 min (95% CI for the mean) while that for the penetrating injury patients was 76 ± 8 min.

Mechanism of injury and injury severity

In blunt and penetrating injury patients, there was a significant but weak association between injury mechanism and the categorised ISS scores of the

patients (Pearson's X^2 test: p<0.001; Cramer's V=0.12). Penetrating injuries were characterised by a higher proportion of patients with moderate injury severity and a lower proportion of patients with profound injury severity, compared to blunt injury patients (see Figure 4-31).

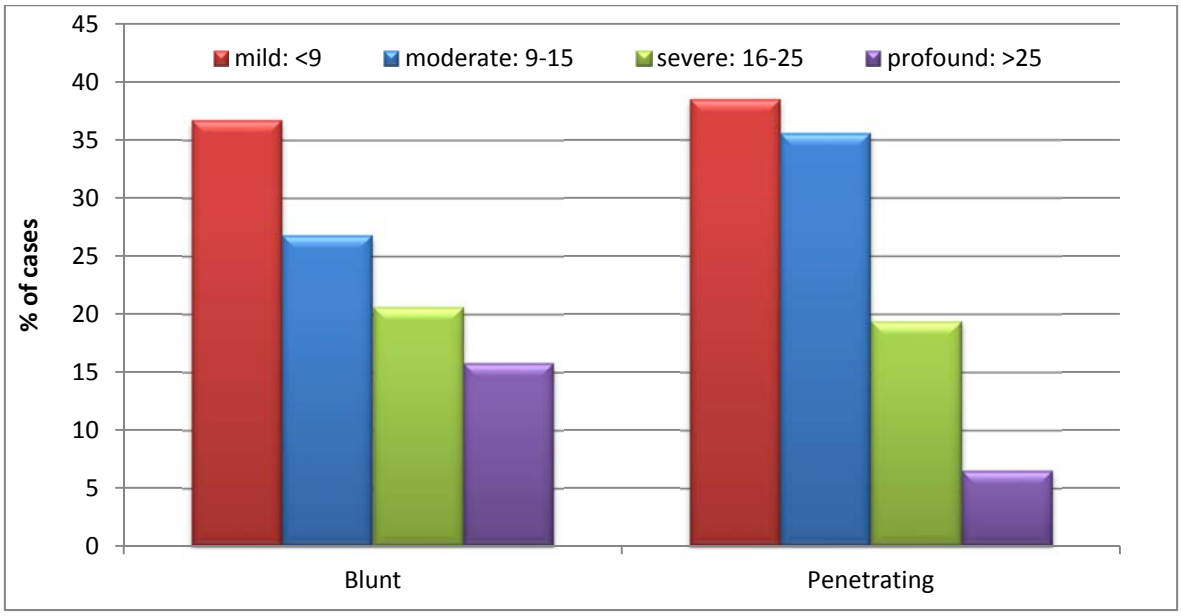


Figure 4-31 ISS Scores for patients with blunt and penetrating trauma

In blunt and penetrating injury patients, there was also a significant but weak association between injury mechanism and the categorised NISS scores of the patients (Pearson's X^2 test: p<0.001; Cramer's V=0.12). Penetrating injuries were characterised by a lower proportion of patients with severe and profound injury severity compared to blunt injury patients (see Figure 4-32).

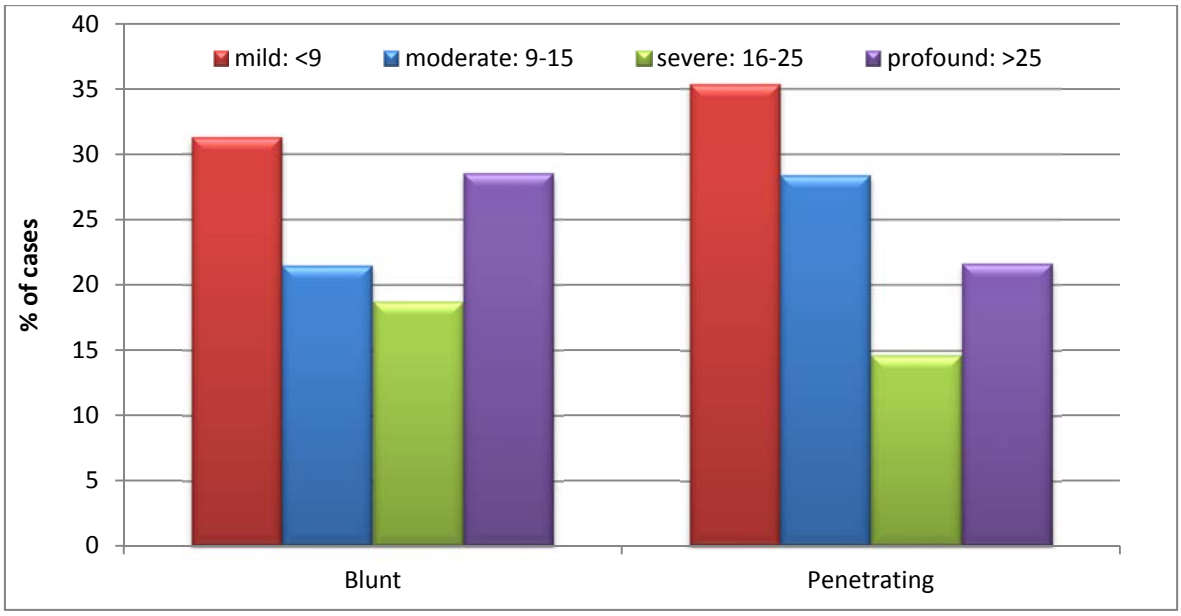


Figure 4-32 Blunt vs Penetrating vs NISS Scores

Location of penetrating truncal injuries

Of the patients who did have a penetrating truncal injury, the most common location was the thorax (39%) and the abdomen (35%). All three truncal regions were injured in 1.1% of patients (see Figure 4-33).

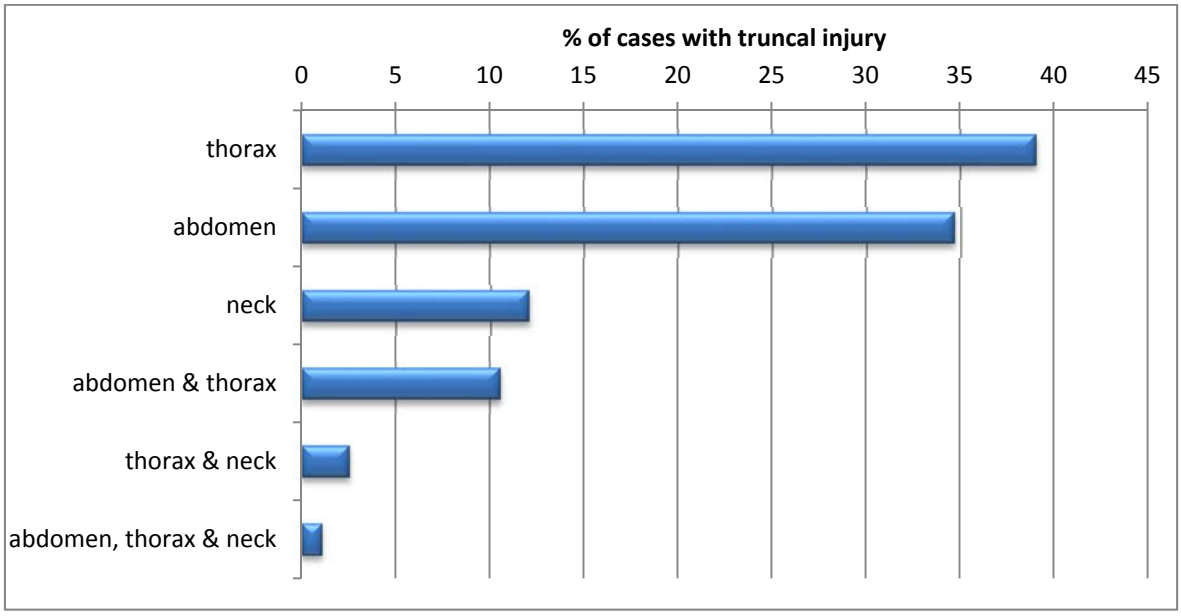


Figure 4-33 Location of penetrating truncal injuries

For the testing of associations, all abdominal injuries were grouped together and the remaining thorax and neck injuries were grouped together. There was a moderate association between injury location and whether or not patients went to theatre (Fisher's exact test: $p<0.001$; Phi coefficient=0.36): a higher proportion of patients with abdominal injuries went to theatre, compared to those with only neck or thoracic injuries (or a combination of these) (see Figure 4-34).

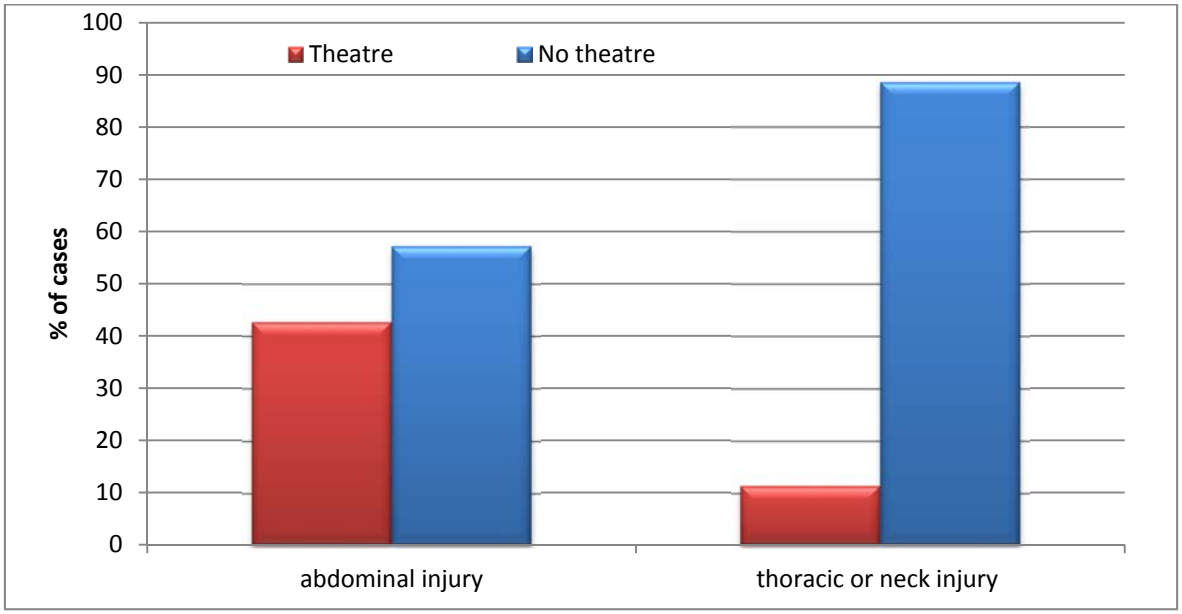


Figure 4-34 Disposition to theatre for patients with penetrating abdominal injuries and other truncal penetrating injuries

There no significant association between injury location and whether or not patients spent up to one hour in the ED (Fisher's exact test: $p =0.23$).

The median and mean times in the ED for different injury locations are tabulated below (see Table 4-8):

Table 4-8 Time in the ED for patients with penetrating abdominal injuries and other truncal penetrating injuries

Injury location	n	Time in the ED (min)				
		Median	IQR		Mean	SD
Abdominal	122	69	55	95	78	38
Thoracic or neck	132	81	55	110	87	43

Major resuscitation criteria component variables

Pulse Rate

The median pre-hospital pulse rate was 90 bpm (IQR 78-105 bpm; mean 92 ± 22 bpm) while the median ED pulse rate was 89 bpm (IQR 76-105 bpm; mean 92 ± 24 bpm). Note that 42% of the pre-hospital data was missing (compared to only 1.5% of the ED data).

Systolic Blood Pressure

The median pre-hospital BP was 120 mmHg (IQR 100-138 mmHg; mean 119 ± 27 mmHg) while the median ED BP was 130 mmHg (IQR 114-148 mmHg; mean 129 ± 30 mmHg). Note that 43% of the pre-hospital data was missing (compared to only 2.1% of the ED data).

Pre-hospital airway management

The information was not recorded in 37% of cases. Diverse methods involving masks were grouped as ‘Basic’, those involving intubation as ‘Advanced’ and cricothyroidotomies and tracheostomies were grouped as ‘Surgical’ procedures.

Surgical procedures were recorded as being used in 0.19% of cases (see Figure 4-35).

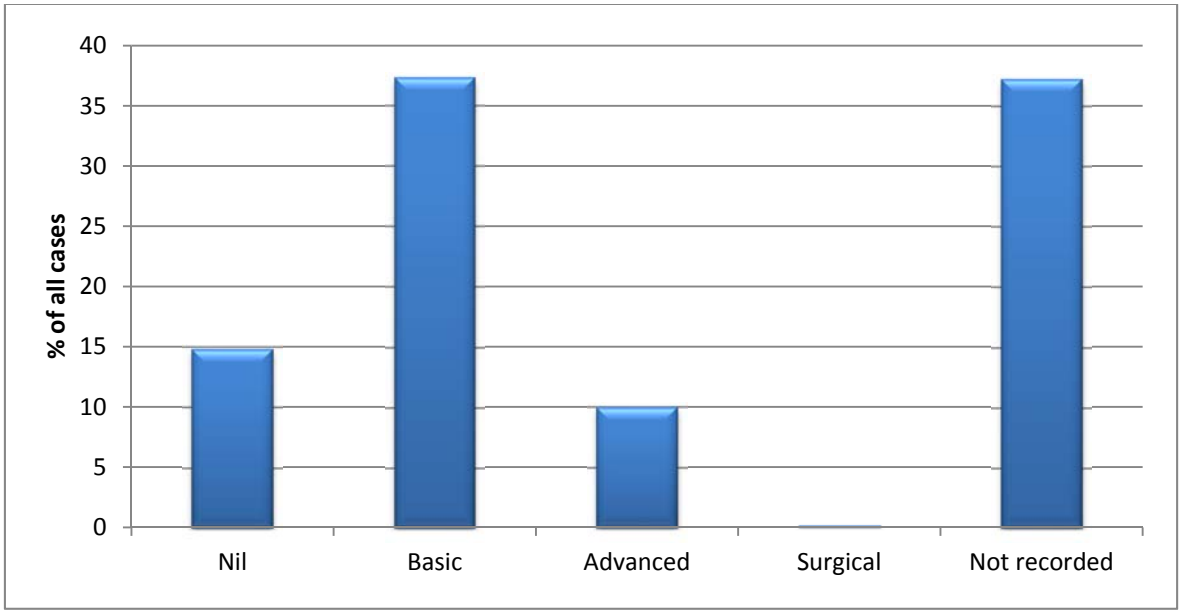


Figure 4-35 Pre-hospital airway management

ED airway management

The information was not recorded in only 1.3% of cases. The original categories were grouped as described as for the pre-hospital airway equipment. Surgical procedures were used in 0.48% of cases (see Figure 4-36).

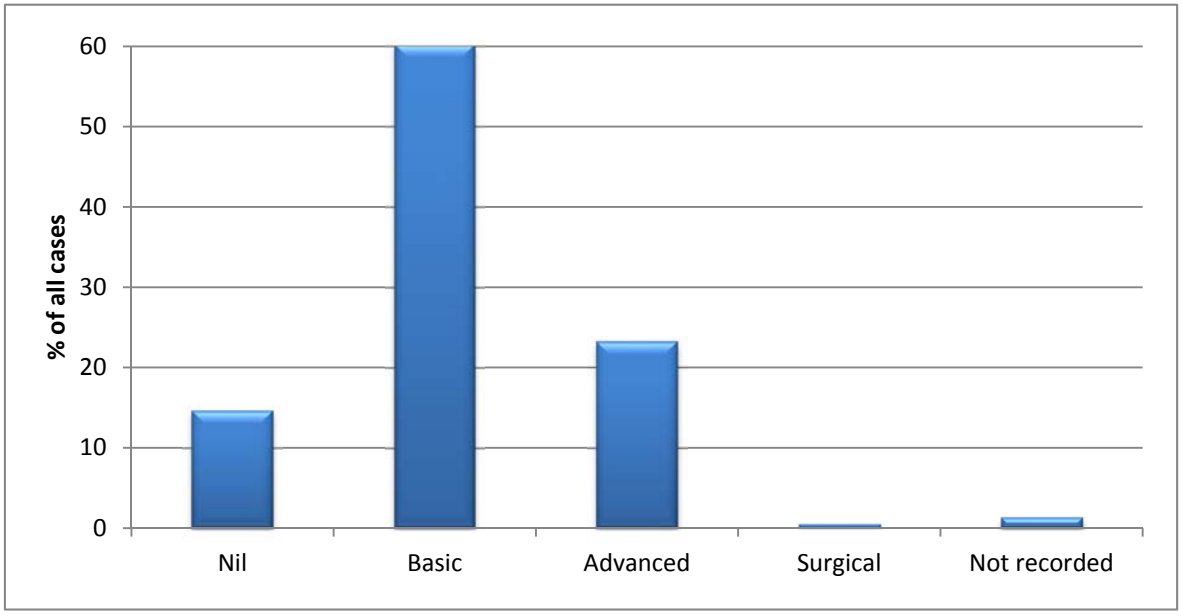


Figure 4-36 ED airway management

ED venous access

Most patients required a single IV cannula (65%), followed by patients who received a CVP catheter (25%) (see Figure 4-37).

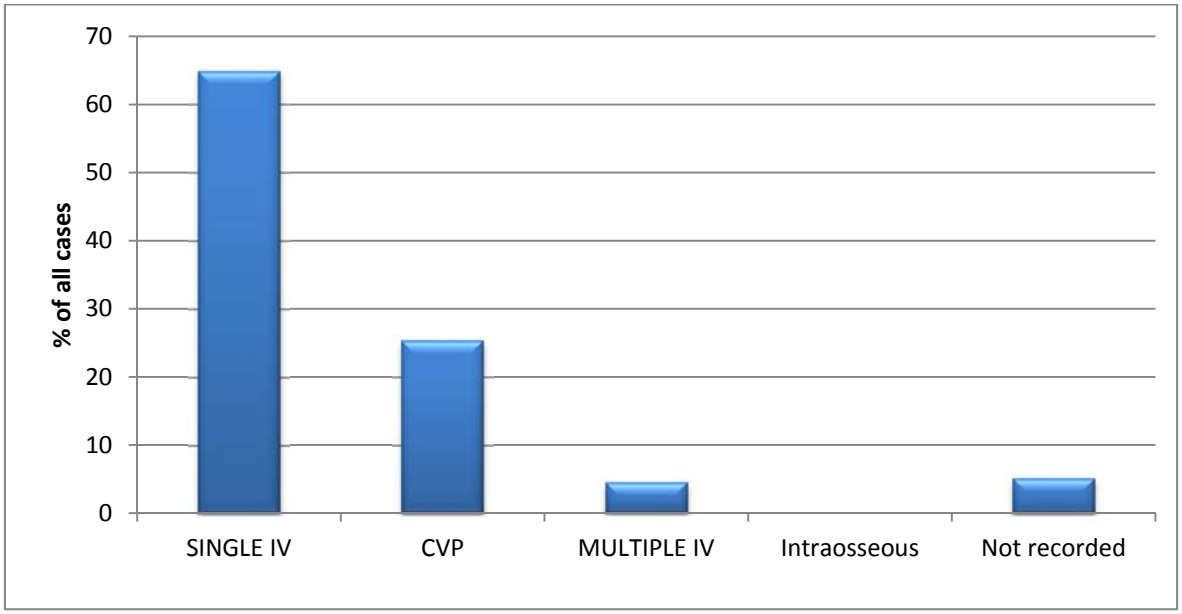


Figure 4-37 ED venous access

Implementation and analysis of major resuscitation (MR) rules

Before patients could be categorised according to the different sets of rules, the data availability for the different rules and their implementations had to be evaluated. All pre-hospital variables had large proportions of missing data (in excess of 33%). This was not necessarily problematic since in the major resuscitation classifications, missing pre-hospital data is replaced by ED data if it is available. However, cause of injury also contained a high proportion of missing data (23%) (which affected implementation of the ACS rule), as did mechanism of injury (35%) (which affected implementation of the LL rule).

Patients were classified as requiring major resuscitation if they met at least one of the criteria and as not requiring major resuscitation if they did not meet all of the criteria. Where data for some criteria were missing and the patient could not be classified as needing major resuscitation on the basis of the data which was available, the patient was then deemed not classifiable.

The proportion of patients classified as requiring major resuscitation, as well as those who could not be classified, is shown below. It is clear that the LL rule gave the highest proportion of patients requiring major resuscitation as well as the highest proportion of patients which could not be classified. Despite the large amounts of missing data for individual variables, when used in combination for the various rules, the proportion of non-classifiable cases was relatively low (<4% for all rules) (see Figure 4-38).

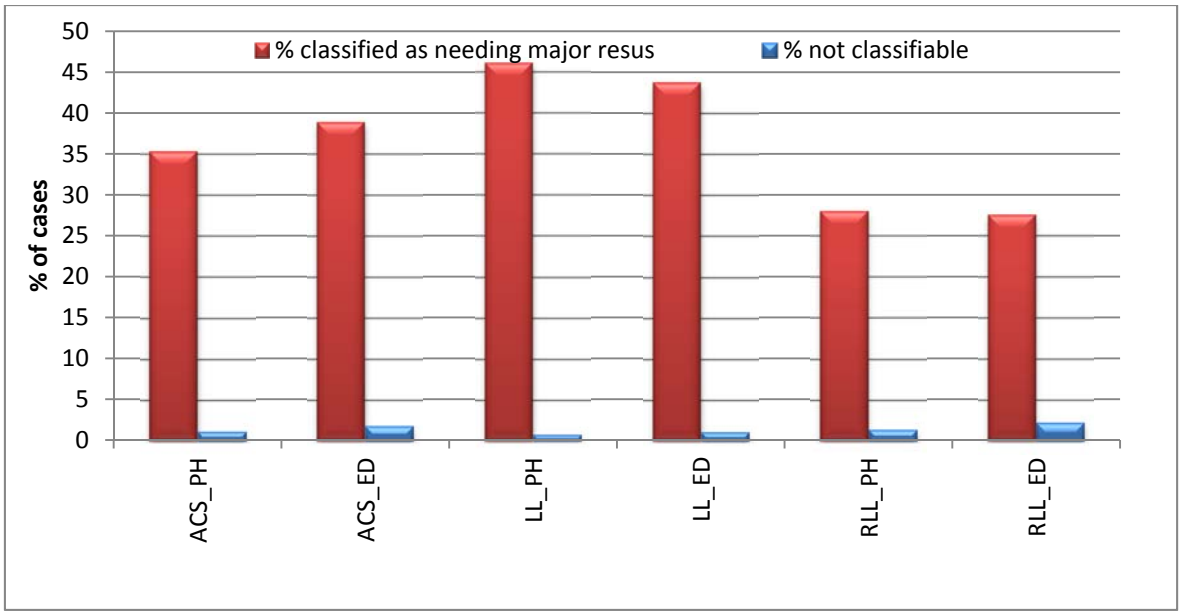


Figure 4-38 Proportion of patients classified as requiring major resuscitation by the different rules using pre-hospital (PH) or ED data

The sensitivity and specificity of each of these rules was determined with respect to the outcome, viz. whether or not the patient went to theatre within the first hour after presentation. Patients who could not be classified (as a result of missing data) were excluded from the calculations.

The results (see Table 4-9) show that none of the rules achieved a sensitivity of 90% while all the rules achieved a specificity of at least 50%. The rule with the highest sensitivity was the LL rule, which achieved sensitivities of 78-80%, depending on the implementation. There were no significant differences between the sensitivities of the pre-hospital and ED implementations of any of the three rules. There were no significant differences between the specificities of the pre-hospital and ED implementations of any of the three rules, with the exception of the ACS rule, where the ED implementations had lower specificities than the pre-hospital implementations.

Table 4-9 Sensitivity and specificity of the three rules

Rule	Sensitivity		Specificity	
	%	95% CI	%	95% CI
ACS_PH	66.7	58.7-74.0	65.2	63.7-66.7
ACS_ED	73.1	65.4-80.0	61.4	59.8-62.9
LL_PH	79.5	72.3-85.5	54.8	53.3-56.4
LL_ED	77.6	70.2-83.9	56.9	55.4-58.5
RLL_PH	64.7	56.7-72.2	73.0	71.6-74.3
RLL_ED	63.9	55.8-71.4	73.1	71.7-74.5

There were significant, but weak, associations between the group of patients meeting major resuscitation criteria and whether or not patients needed major surgical procedures in the ED or surgery within the first hour in the ED (Fisher's exact test: $p<0.001$; Phi coefficient ranged from 0.09 to 0.13 over the three rules): a slightly higher proportion of patients who were identified as requiring major resuscitation underwent major surgical procedures in the ED or went to theatre within the first hour in the ED. There was no significant difference in the sensitivity or specificity of any of the rules when applied to the South African age limits paediatrics (age greater than 12) rather than the age limits (greater than 14) used in most international studies.

Additional evaluation of the sensitivity of individual predictive components within the predictive rules is shown below (see Table 4-10).

Table 4-10 Sensitivity and specificity of predictive components for the need for major resuscitation

Rule	Sensitivity		Specificity	
	%	95% CI	%	95% CI
Penetrating injury	47.1	37.3-57.2	81.6	80.1-83.1
Penetrating truncal injury (all)	22.3	16.1-29.6	94.6	93.9-95.3
Penetrating abdominal injury (vs. other penetrating truncal injuries)	77.1	59.9-89.6	57.4	50.5-64.1
Hypotension:				
SBP < 80 (PREH)	16.8	11.3-23.6	95.9	95.2-96.5
SBP < 90 (PREH)	24.5	18.0-32.1	92.2	91.4-93.0
SBP < 100 (PREH)	36.8	29.2-44.9	85.4	84.3-86.5
SBP < 80 (ED)	19.0	13.1-26.1	95.5	94.8-96.1
SBP < 90 (ED)	26.1	19.4-33.9	92.8	92.0-93.6
SBP < 100 (ED)	32.0	24.7-40.0	88.9	87.9-89.9
Tachycardia:				
Pulse rate > 100 (PREH)	56.5	48.3-64.5	69.8	68.4-71.2
Pulse rate > 110 (PREH)	42.2	34.3-50.4	82.2	81.0-83.4
Pulse rate > 100 (ED)	51.7	43.4-59.9	70.2	68.7-71.6
Pulse rate > 110 (ED)	38.4	30.6-46.7	82.3	81.1-83.5

The patients identified as requiring major resuscitation AND who went to theatre, had a duration of stay in the ED is shown below (see Figure 4-39).

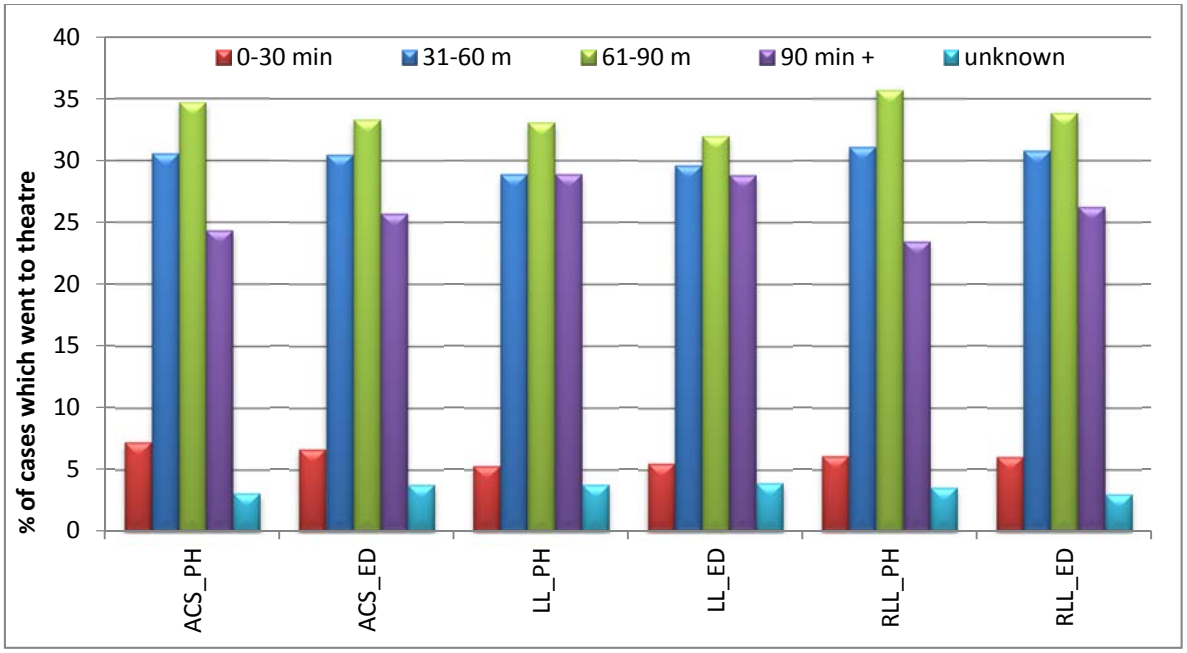


Figure 4-39 Time to theatre - patients classified as requiring major resuscitation

The mean and median times in the ED for the patients identified as requiring major resuscitation by the different rules are tabulated below (see Table 4-11):

Table 4-11 time in the ED for patients classified as requiring major resuscitation

Rule	n	Time in the ED (min)				
		Median	IQR		Mean	SD
ACS_PH	1503	75	55	100	84	44
ACS_ED	1652	77	59	104	86	46
LL_PH	1952	80	59	114	92	49
LL_ED	1852	84	59	115	93	50
RLL_PH	1179	80	59	110	88	45
RLL_ED	1163	80	59	114	90	47

Where the mechanism of injury was known (and not listed as 'Other') the proportion of patients with each mechanism of injury identified as requiring major resuscitation was calculated. There was a significant association between mechanism of injury and requiring major resuscitation (Pearson's X^2 test: $p<0.001$). The association was strong for the LL rule (Cramer's V=0.48-0.51 depending on implementation) since this rule explicitly takes injury mechanism into account.

The association was moderate for the RLL rule (Cramer's V=0.34-0.35 depending on implementation), which identified a higher proportion of penetrating injury cases than other injury mechanisms. The association was weak for the ACS rule (Cramer's V=0.21-0.23 depending on implementation) but it should be noted that this rule identified a higher proportion of burns and penetrating injury cases as requiring major resuscitation than other injury mechanisms (see Figure 4-40).

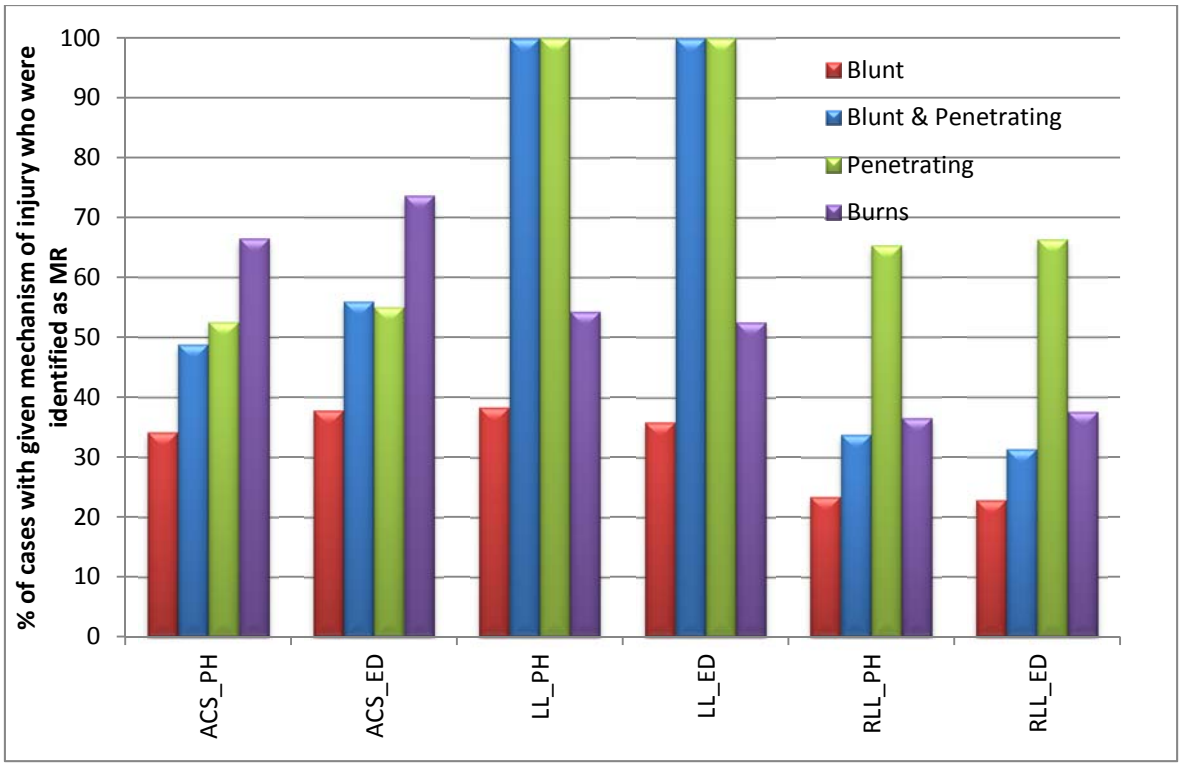


Figure 4-40 Proportion of patients classified as requiring major resuscitation for each category of mechanism of injury

High proportions of burn cases were identified by the three rules as requiring major resuscitation mainly because of ED airway intervention, low GCS score and transfer from other hospitals (one of the ACS criteria to classify a patient as requiring major resuscitation is the transfer in of a patient who requires blood transfusion to maintain his blood pressure. This degree of information was not available in the database and all transfers in were therefore included). The table below (see Table 4-12) shows the percentage of patients who qualified as requiring major resuscitation based on the individual criteria used in each of the rules, split by injury mechanism. For the LL and RLL rules, burns patients qualified for major resuscitation mainly on the basis of a high pulse rate.

Table 4-12 Components of the three rules which were positive

% patients qualifying	Injury mechanism				
	Blunt	Blunt & Pen	Burns	Other	Pen
Pulse rate > 100 bpm (LL)	29.7	38.1	47.9	26.2	33.1
Pulse rate > 110 bpm (RLL)	17.8	23.8	32.9	14.8	19.3
BP < 90 mmHg (ACS, RLL)	7.0	7.1	6.0	9.1	12.8
BP < 100 mmHg (LL)	10.4	15.5	12.0	10.2	17.3
ED airway equipment (ACS)	25.8	43.5	46.3	30.0	21.3
GCS (ACS)	21.7	31.8	38.4	22.2	16.7
How it happened (ACS)	0.0	2.4	0.0	3.4	29.1
Pt source (ACS)	15.4	17.9	48.5	20.0	17.0

The proportion of patients within each category of disposition identified as requiring major resuscitation was calculated. There was a significant association between disposition and classification as requiring major resuscitation (Pearson's X^2 test: $p<0.001$). The strength of the association was weak for the LL rule (Cramer's V=0.27) which identified a higher proportion of death, theatre and ICU cases compared to other dispositions, but also identified relatively high proportions of these other disposition categories due to its high sensitivity but low specificity.

The association was moderate for the RLL rule (Cramer's V=0.29-0.32 depending on implementation), which identified a higher proportion of penetrating injury cases than other injury mechanisms.

The association was moderate for the ACS rule (Cramer's V=0.37-0.44 depending on implementation) identifying nearly all deaths and high proportions of theatre and ICU cases compared to the other dispositions (see Figure 4-41).

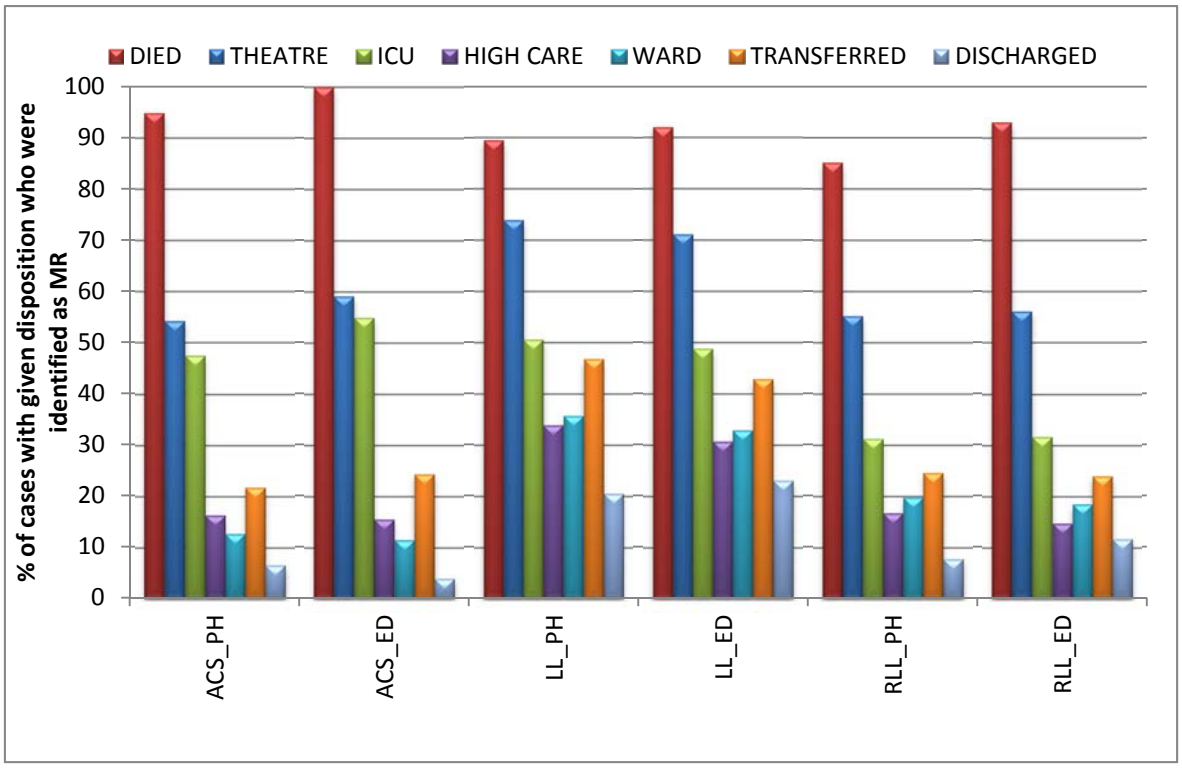


Figure 4-41 Disposition of patients classified as requiring major resuscitation

Analysis of cases with penetrating truncal injuries

The demographic profile of patients with truncal penetrating injuries was also similar to that of the overall data set injuries (n=274; 6.0% of the main data set). The median time in the ED was 74 min (IQR 55-102 min; mean 88 ± 41 min). Of

these patients, whose ED time was recorded, 35% were in the ED for one hour or less. Similarly to the overall data set, the majority of patients arrived as a result of primary responses (70%) followed by transfers from other hospitals (19%). In contrast to the overall data set, slightly more patients arrived by private transport (and fewer by ambulance).

Whilst gunshot wounds accounted for 30.7% of the cases and stab wounds for 29.2%, the majority were unspecified in the dataset.

The disposition of the patients was somewhat different to the overall data set, with more patients going to theatre (25%) and fewer going directly to ICU or High Care (see Figure 4-42).

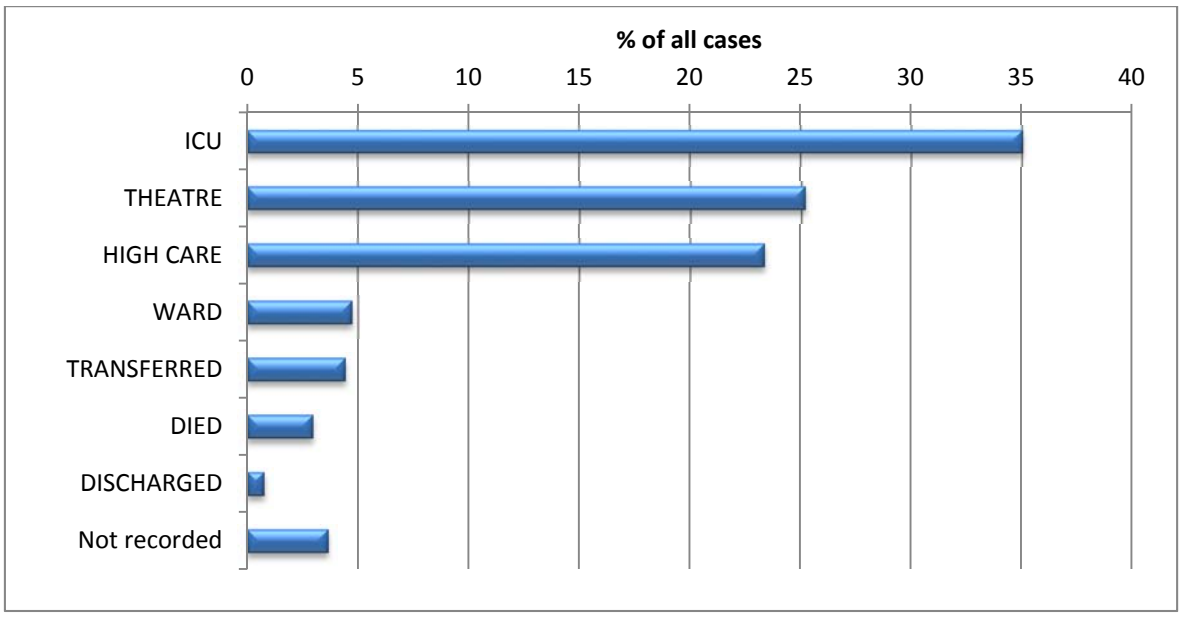


Figure 4-42 Disposition of patients with penetrating truncal injury

Of the 69 truncal injury patients who went to theatre, 45% spent less than one hour in the ED, and 16% had been transferred from another hospital (including

flights in). There was no significant association between disposition and time spent in the ED (≤ 1h vs. > 1h) (Fisher's exact test, p=0.51).

The proportion of truncal penetrating injury cases classified as requiring major resuscitation by each of the three rules is shown below. The LL and RLL rules classified (almost) all the PT injury cases as requiring major resuscitation (by definition), while the ACS rule fared considerably worse (see Figure 4-43).

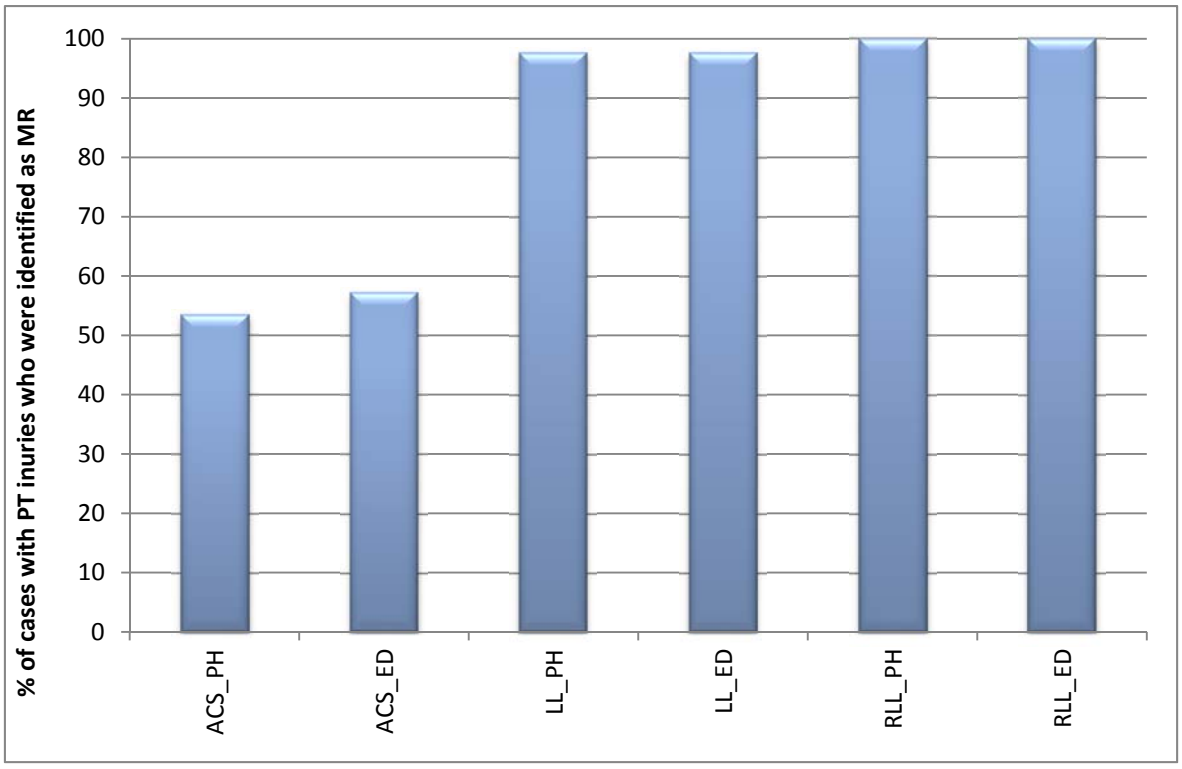


Figure 4-43 Accuracy of predictive rules for patients with penetrating truncal injuries

Analysis of patients transferred directly from the ED to theatre

There were 361 patients transferred directly from the ED to theatre, representing 7.9 % of the total number (4544) of Priority 1 trauma cases in the data set.

Time spent in the ED

The majority (63%) of theatre cases spent more than one hour in the ED before moving on to surgery. The median time spent in the ED was 77 min (IQR= 55-105 min; mean 84 ± 45 min) (see Figure 4-44).

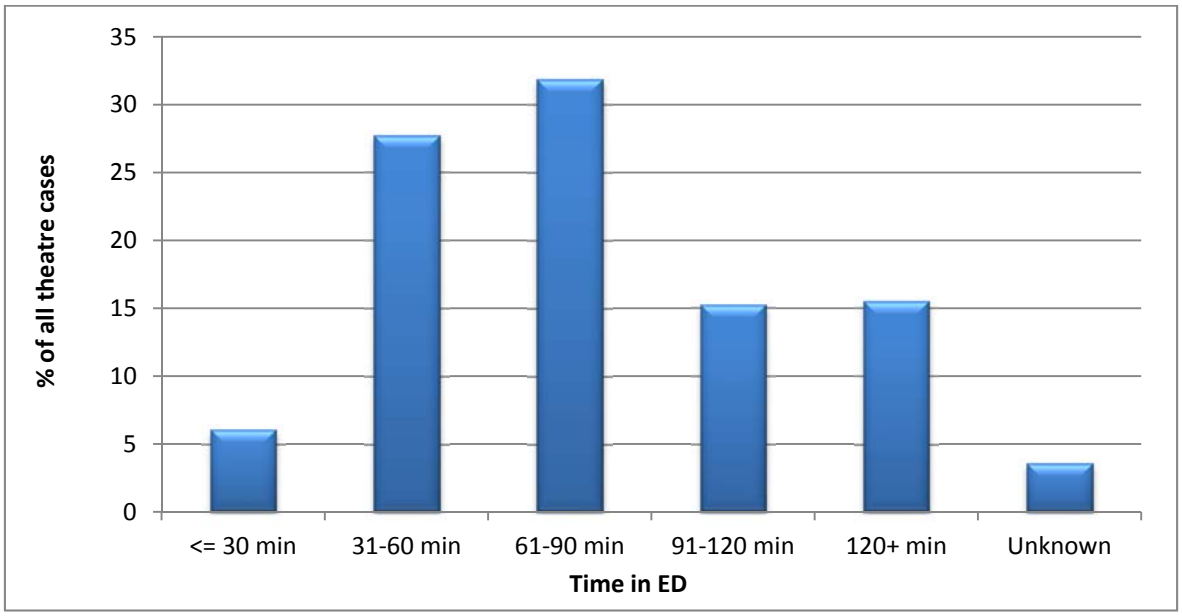


Figure 4-44 Amount of time spent in the ED before transfer to theatre

Analysis of patients requiring emergency surgery

The further analysis was restricted to the 123 patients (34%) who went to theatre within one hour of arrival at the ED. These cases represent 2.7% of the total number (4544) of Priority 1 trauma cases in the data set. The median time spent in the ED by these patients was 46 min (IQR 39-55 min; mean 45 ± 13 min).

Demographic characteristics of patients requiring emergency surgery

The median age was 36 years (IQR= 27-47 years; mean 37.5 ± 14.6 years) and 94% of these patients were male. The ethnicity was not significantly different to that of the main patient population.

Origin of patients requiring emergency surgery

The majority of patients (65%) arrived by ambulance, while 21% arrived by helicopter (see Figure 4-45).

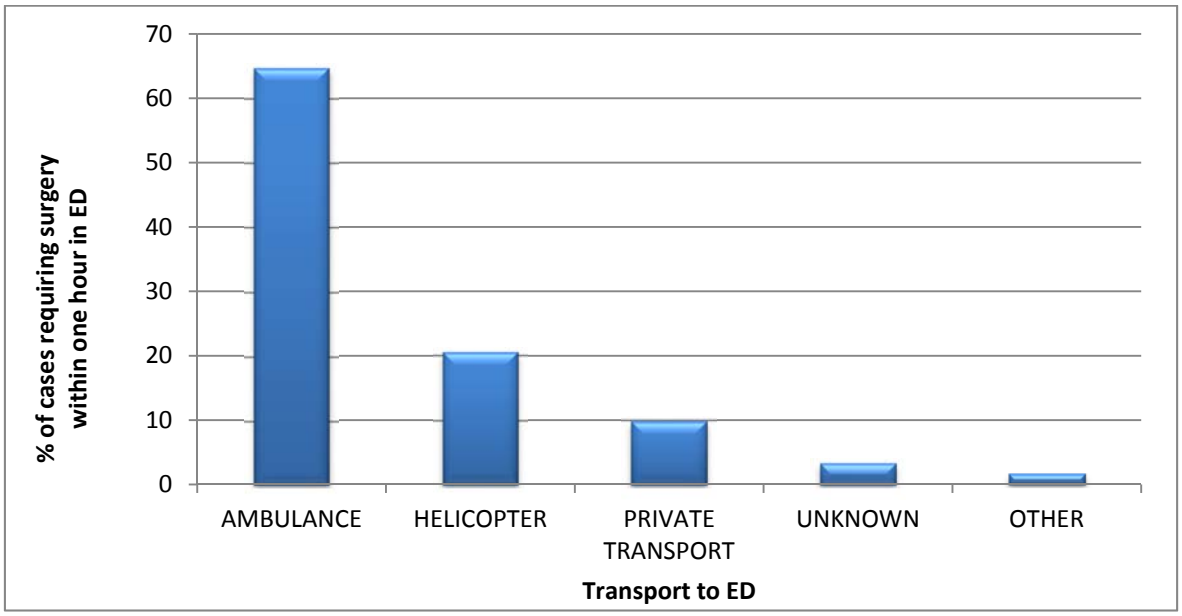


Figure 4-45 Mode of transport for patients transferred to theatre within one hour of arrival

There was no significant association between the mode of transport and the time spent in the ED (≤30 minutes vs. 31-60 minutes).

Of the patients who went to theatre within 60 minutes, 66% arrived directly from the scene, while 30% were transferred in. A higher proportion of those patients

transferred in (3.8%) went to theatre within 60 minutes when compared to those that arrived directly from the scene (2.4%).

Of the 361 patients who went to theatre, (35%) spent up to 60 minutes in the ED. Of these, 25% had been transferred from another hospital (30% if you include flights in).

Performance of the major resuscitation rules in patients requiring emergency surgery

See below.

ED Procedures

There were 4 499 cases in the data set for which information on ED procedures was available.

Major and minor procedures

Nearly half (45%) of the cases in the data set had neither a major nor a minor procedure performed in the ED, while 32% had only major procedures performed, and 14% had both major and minor procedures performed (see Figure 4-46).

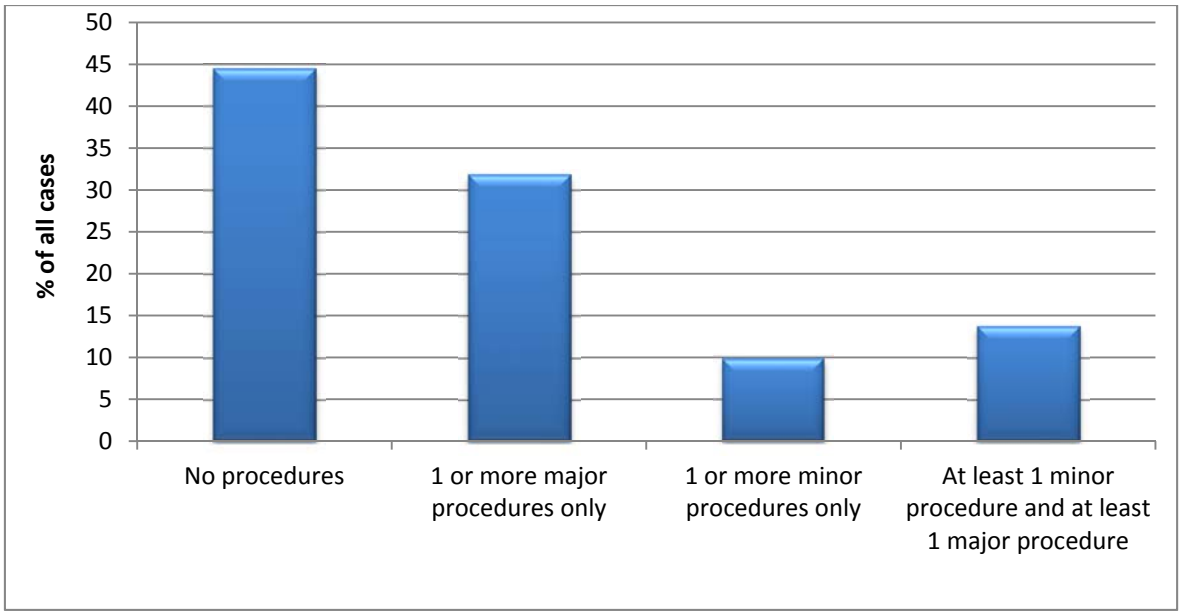


Figure 4-46 ED procedures – major and minor procedures

Of all patients, 24% had at least one minor procedure (irrespective of whether they also had a major procedure or not) and 46% of patients had at least one major procedure (irrespective of whether they also had a minor procedure or not) (see Figure 4-47).

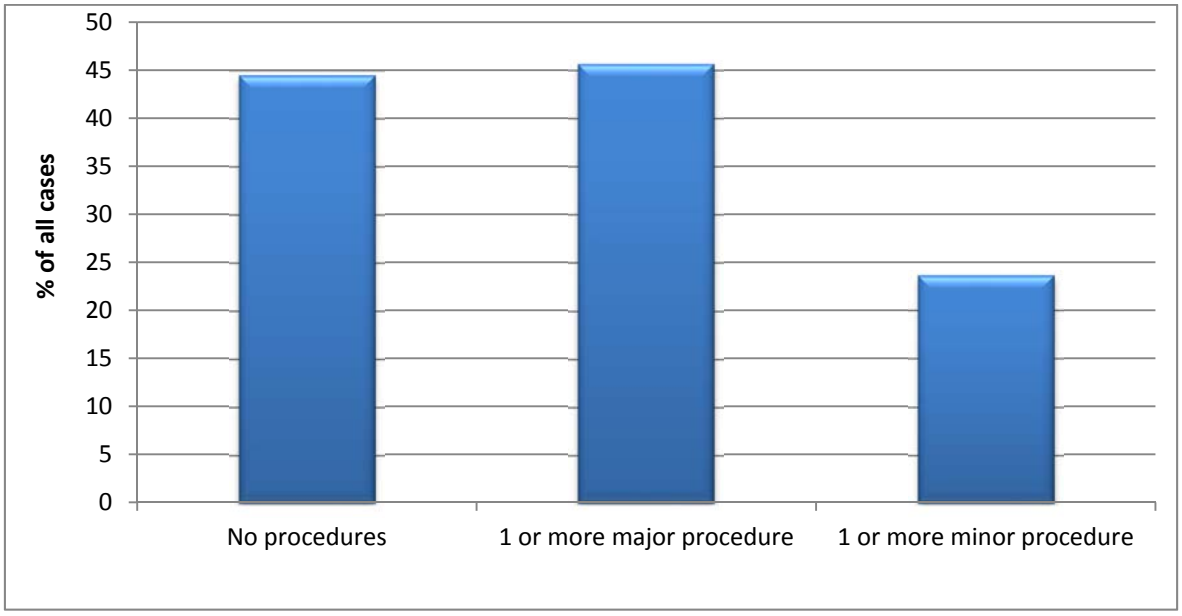


Figure 4-47 ED procedures – refined to show proportions of patients requiring major and minor procedures

The proportion of all patients who required various numbers of non-surgical and surgical procedures is shown in the graphs below (see Figures 4-48, 4-49 and 4-50).

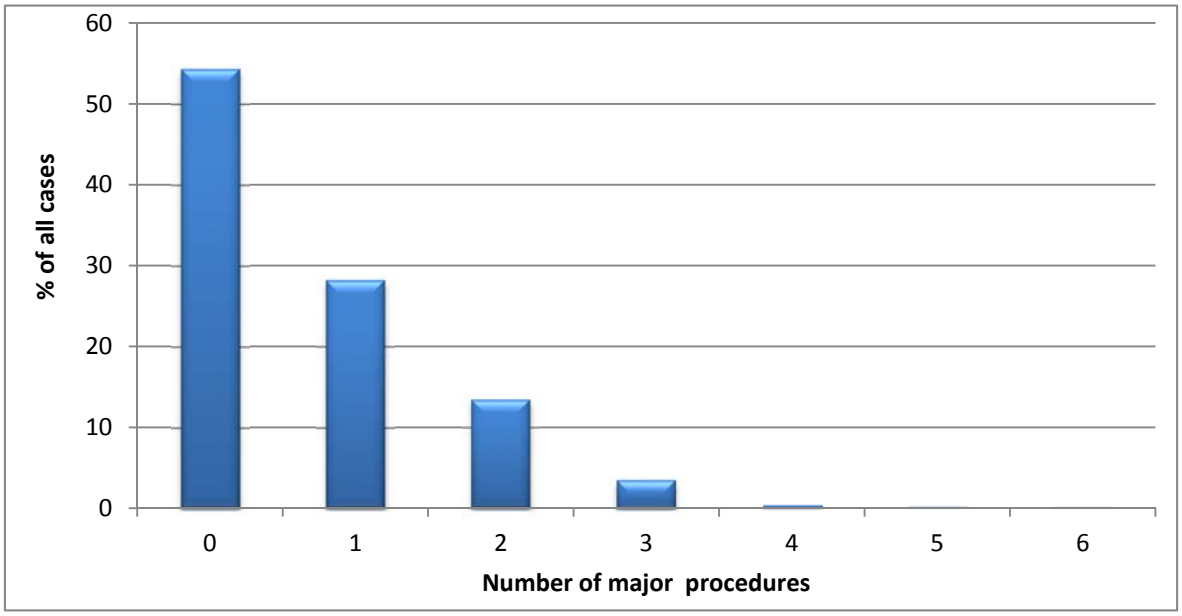


Figure 4-48 Major procedures in the ED

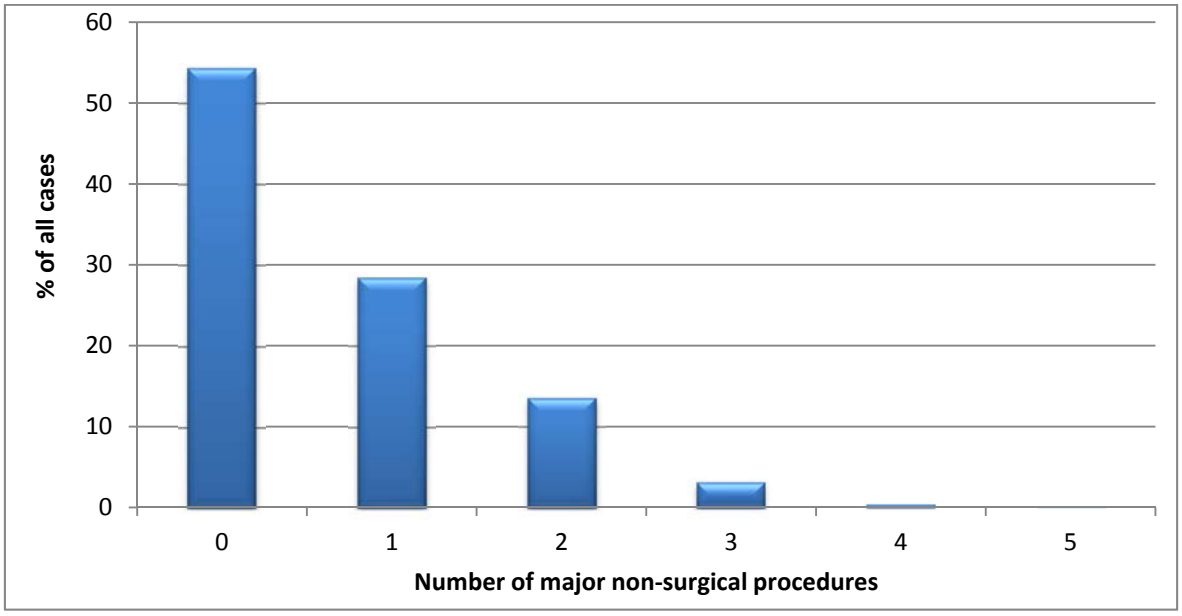


Figure 4-49 Major non-surgical procedures in the ED

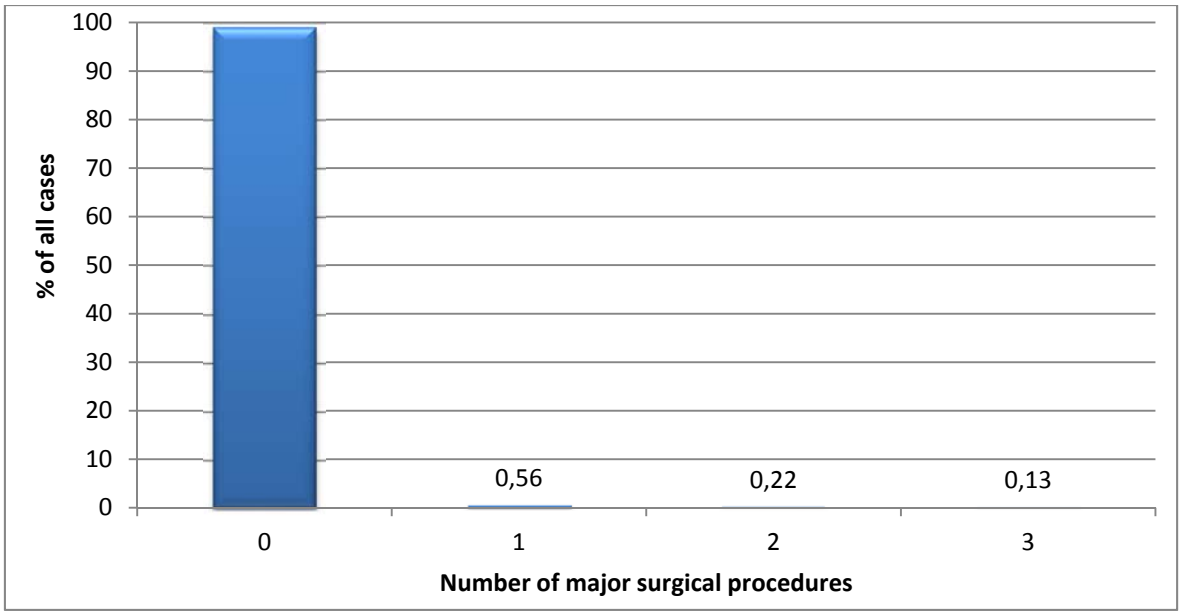


Figure 4-50 Number major surgical procedures in the ED

When analysing surgical and non-surgical procedures in combination, of the patients who required any major procedure, most (45% of all patients) had non-surgical procedures only, while 0.87% had a combination of surgical and non-surgical procedures and 0.04% had surgical procedures only (see Figure 4-51).

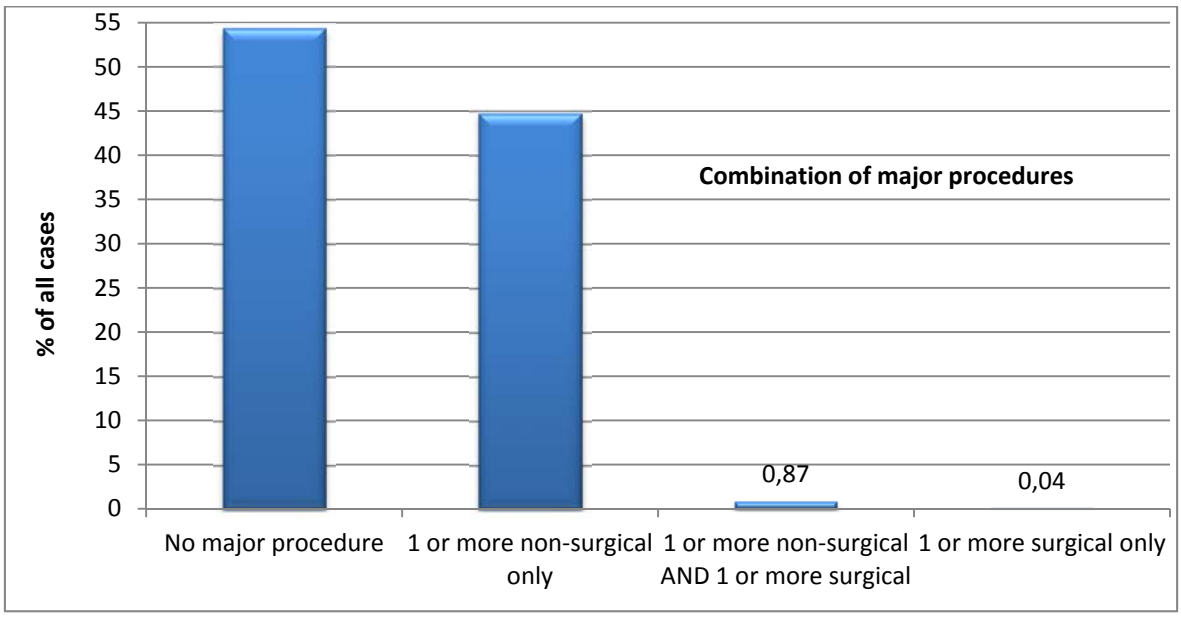


Figure 4-51 Major surgical and non-surgical procedures in the ED

Only 0.91% of patients had one or more surgical procedures. Of these, tracheostomy and thoracotomy were performed most frequently (on 0.49% and 0.36% of patients, respectively) (see Figure 4-52).

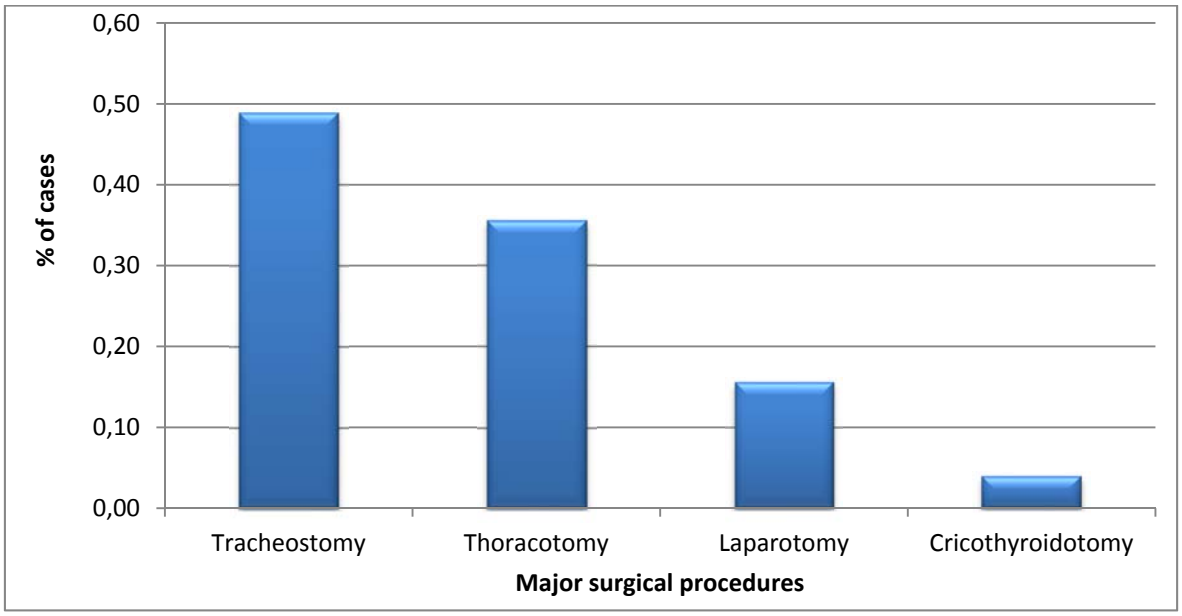


Figure 4-52 Major surgical procedures in the ED

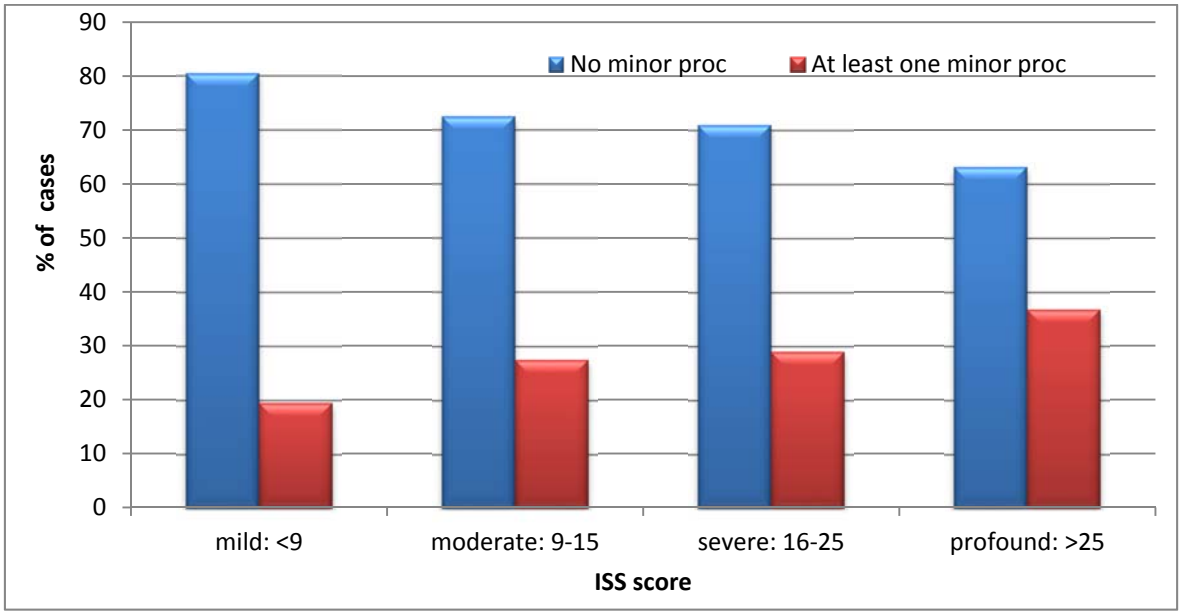


Figure 4-53 Minor procedures in the ED for each category of severity of injury

There was a significant, but weak, association between the ISS score and whether or not patients had one or more minor procedures (Pearson's X^2 test, $p<0.001$; Cramer's V=0.13). As expected, the proportion of patients who needed at least one minor procedure increased with increasing ISS score (see Figure 4-53).

There was a significant, moderate, association between the ISS score and whether or not patients had one or more major procedures (Pearson's X^2 test, $p<0.001$, Cramer's V=0.48). As expected, the proportion of patients who needed at least one major procedure increased with an increasing ISS score (see Figure 4-54).

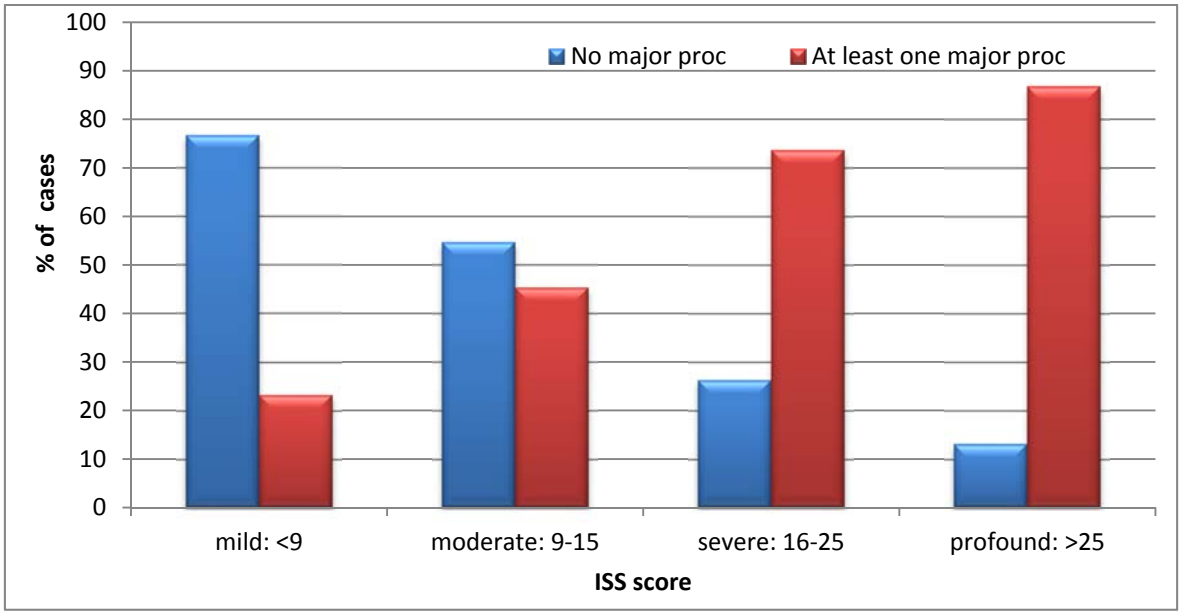


Figure 4-54 Major procedures in the ED for each category of severity of injury

Similar relationships were found for non-surgical and surgical procedures (Pearson's X^2 test, $p<0.001$, Cramer's V=0.48 and Pearson's X^2 test, $p<0.001$, Cramer's V=0.15 respectively) (see Figures 4-55 and 4-56).

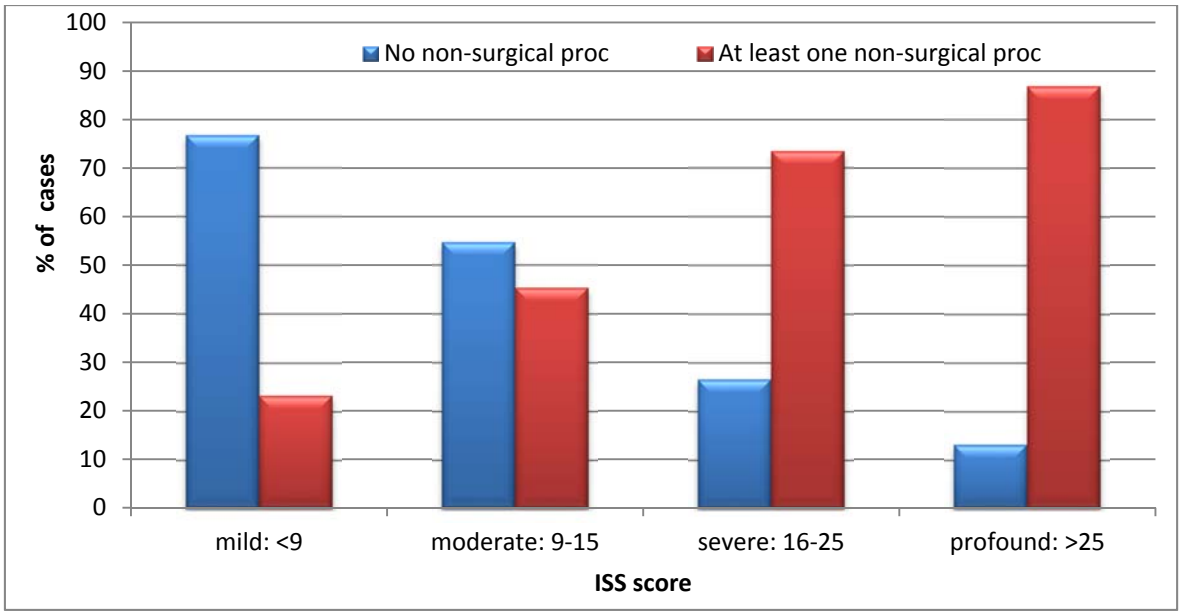


Figure 4-55 Major non-surgical procedures in the ED for each category of severity of injury

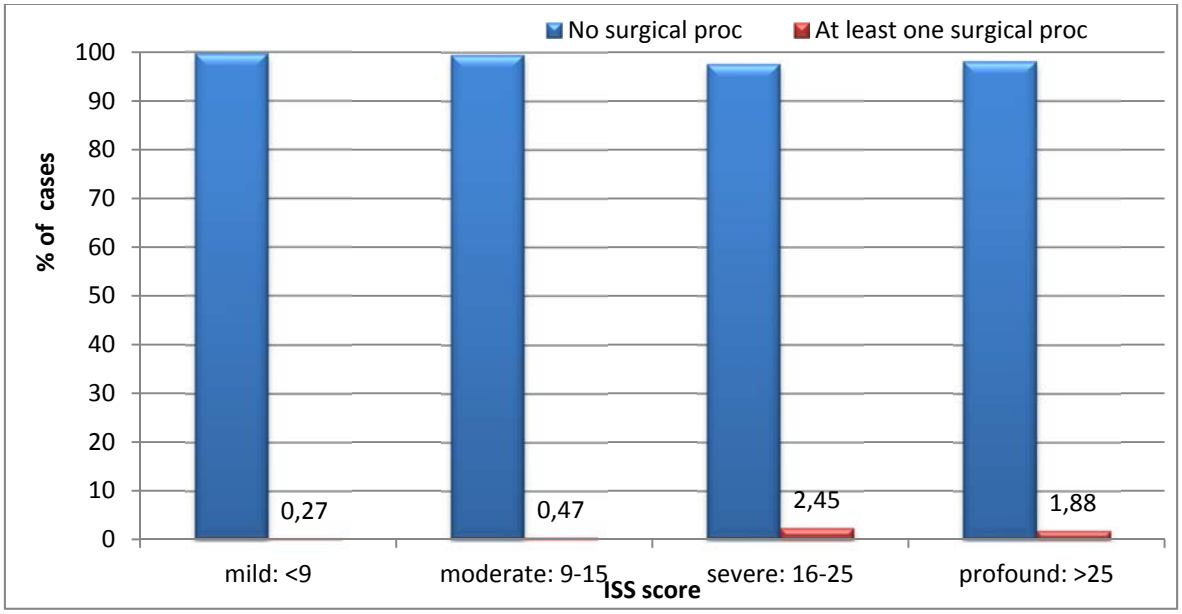


Figure 4-56 Major surgical procedures in the ED for each category of severity of injury

ED disposition

There was a significant, moderate association between disposition and whether or not patients had at least one major procedure (Pearson's X^2 test, $p<0.001$, Cramer's V=0.47). Patients who died or went to ICU or theatre were most likely to have required one or more major procedures, while patients who were discharged or who went to a ward were least likely to have required a major procedure (see Figure 4-57).

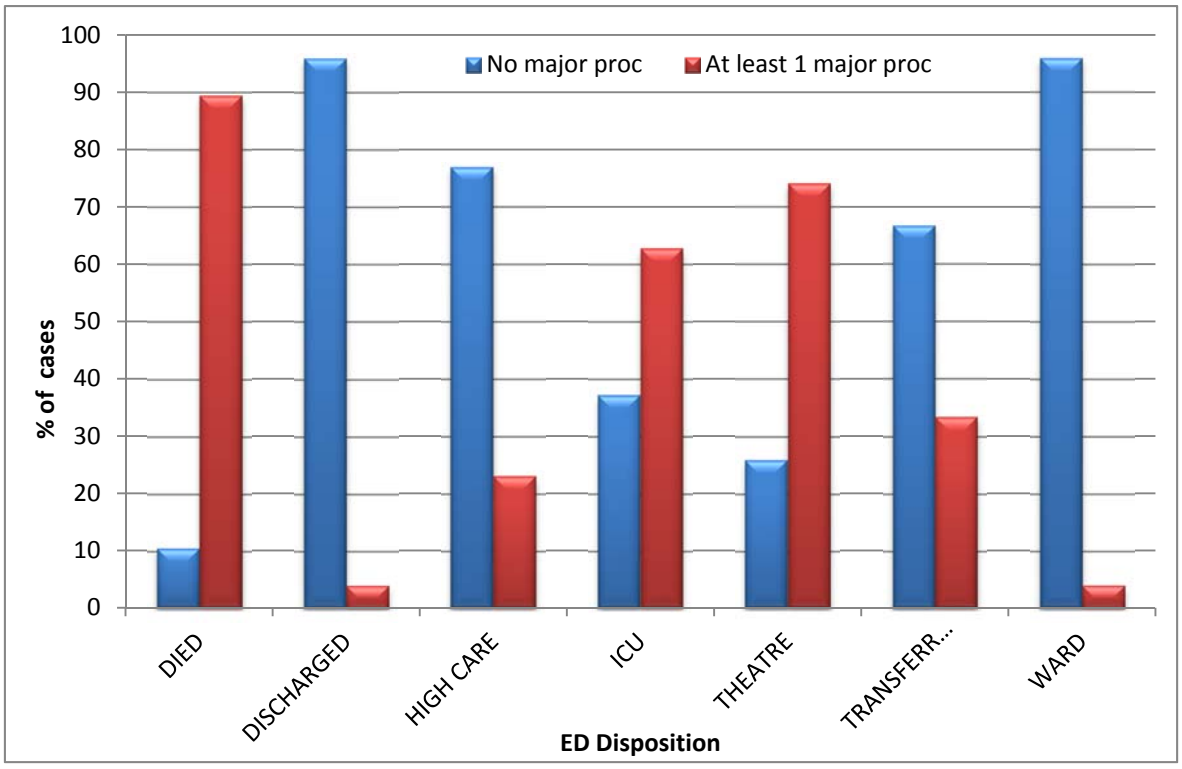


Figure 4-57 Disposition of patients requiring a major procedure

A very similar relationship was found between disposition and non-surgical procedures (Pearson's X^2 test, $p<0.001$; Cramer's V=0.47) (see Figure 4-58).

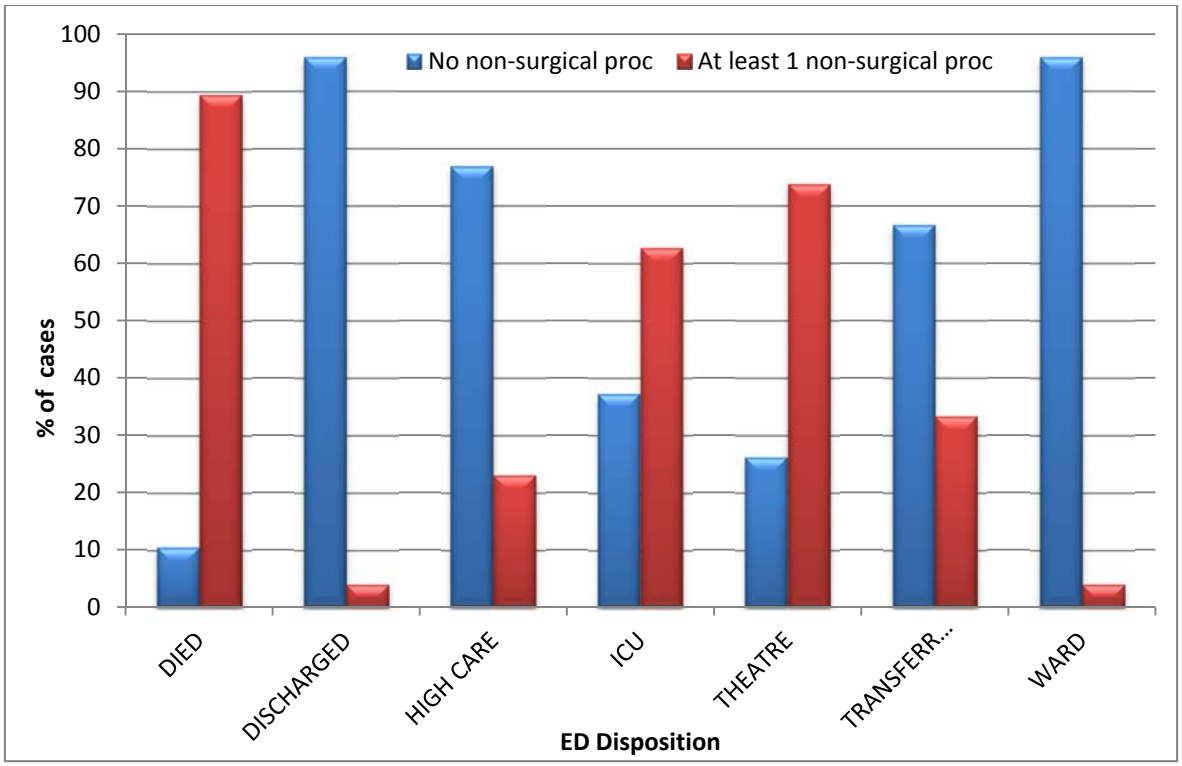


Figure 4-58 Disposition of patients requiring a major non-surgical procedure

The relationship between disposition and surgical procedures could not be quantified due to low cell frequencies (rendering Pearson's X^2 test inappropriate) and precise computations for Fisher's exact test were not possible computationally. However, inspection of the data (see graph) shows that the surgical procedures were associated with only four categories of disposition: death, surgery (theatre), ICU and transfer (one case) (see Figure 4-59).

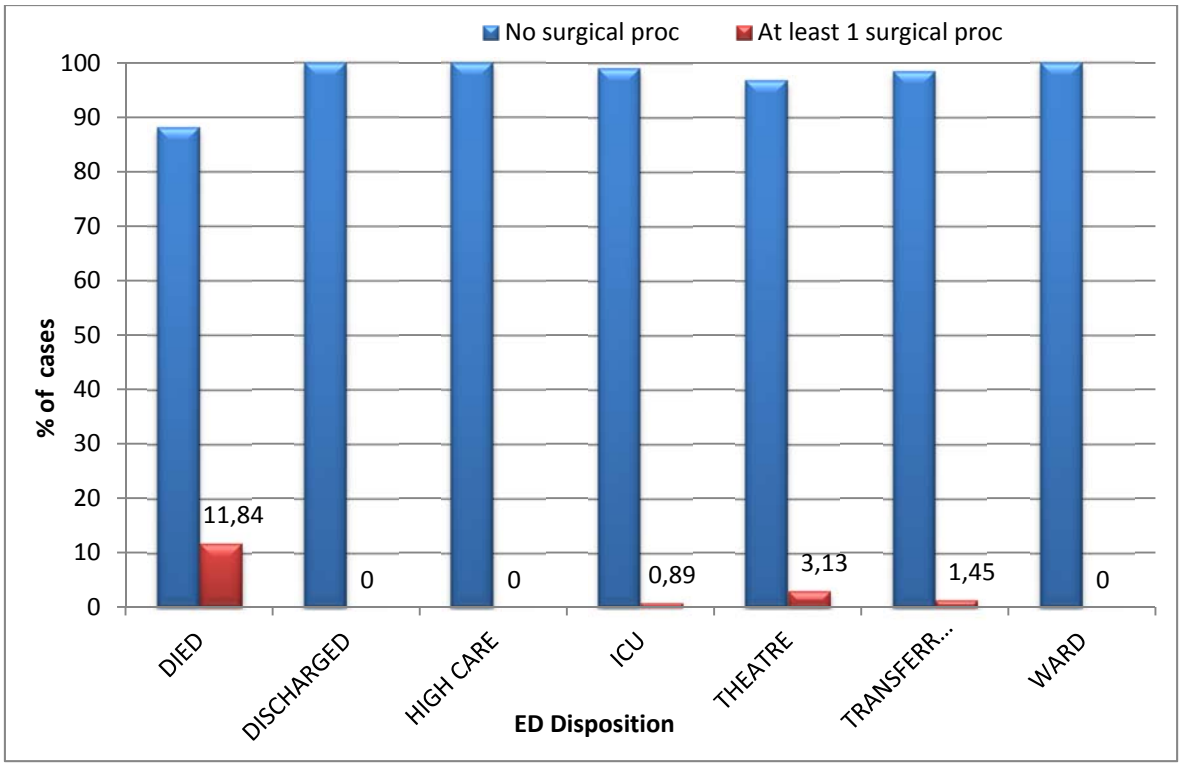


Figure 4-59 Disposition of patients with a major surgical procedure

Chapter 5 DISCUSSION

Overview of findings

Study population

Sample size

The sample size for this study was 4570 patients collected over a five year period. This is a relatively small sample size compared to similar studies which had patient samples of over 20 000 collected over 13 years[160] and another that collected over 8000 samples in seven years.[159] However, it was large enough to allow for detailed statistical analysis and to draw realistic conclusions from the findings.

Demography (age, sex, ethnicity, day of presentation)

The sample was mainly made up of males with an average age of 34 years. The demographic profile was typical of the "average trauma patient" and comparable to that found in similar studies.[160] There were more patients seen on weekends than during the week with Thursday being the quietest day and Saturday the busiest day. This is to be expected, as the weekends are when most social activities occur which, when coupled with the inevitable increase in alcohol consumption at such events, results in an increase of the major causes of trauma (motor vehicle accidents, and inter-personal violence).[166-168]

Source of patients

Over 70% of the patients arrived from the scene of the injury. Approximately 20% of the patients were transferred in from other facilities – these patients would have

been assessed and stabilised at other hospitals. The patients that arrived primarily from the scene experienced a reasonably short time between paramedics arriving at the scene and arrival in the ED, while those transferred in had a much longer delay from accident to arrival. These patients transferred in to the ED would represent a diverse group: some may have been treated and resuscitated well, while others are likely to have been under-resuscitated. This would have affected the treatment they received in the ED which makes it difficult to compare these patients to patients who are transported primarily from the scene. Nonetheless, they have been evaluated in the same group for this study. In the majority of cases these patients arrive with adequate warning as the transfers have been pre-arranged. Based on information provided by the referring hospital, it is possible to decide whether urgent treatment may be required on their arrival in the ED.

Mode of arrival

The majority of patients arrived by ambulance (74%) or helicopter (10%), while 10% arrived via private transport. For the patients arriving via private transport, no prior notice would have been received about the patient and most, but not all, ambulance cases would have given prior notification of patient transport to the ED. It is likely that all patients arriving by helicopter would have had prior notification of arrival. Due to the lack of available data, only speculation is possible as to the exact number of the patients for whom the trauma team was activated prior to the patient's arrival. In addition, some of these patients would have arrived as lower priority patients and been upgraded after secondary triage by the ED staff. This is important, as without prior notification of patient arrival the trauma surgeon cannot be present in the ED when the patient arrives. This leaves the EMP to manage

these patients while activation of the trauma surgeon is delayed. Clearly, it is imperative that the EMP be capable of managing severely injured patients without the presence of a trauma surgeon.

Often there is a poor correlation between the outcome of ED secondary triage and pre-hospital triage.[128-131] This may relate to the qualifications and abilities of the pre-hospital EMS staff attending to patients at the scene. However, activation of the air ambulance service and subsequent air transport of severely injured patients to Level 1 facilities should bring with it better correlation between triage and actual injuries.

Patients flown into the ED via the air ambulance service are subjected to on-scene triage as well as a form of secondary triage by staff at the air ambulance call centre. Medical doctors assess the merits of each request and apply flight authorisation guidelines to establish which patients will receive the most benefit from being flown and when the benefits of a helicopter are warranted.[169] If the call criteria are satisfied, the air ambulance is dispatched with a medical doctor on board. In spite of this, a number of the patients arriving by helicopter are discharged from the ED (as was found in this study).[137, 138] The call centre is exposed to the same poor pre-hospital triage and the helicopter may be despatched to an accident scene where the patients might not actually be severely injured. Such patients are nonetheless flown to Level 1 facilities, as medical insurance companies will not reimburse the service for an aborted helicopter flight.

Precious resources such as the air ambulance need to be conserved. In South Africa, from the early services of Flight For Life (which relied heavily on local provincial administration and government funding), to STAR (Specialised Trauma Air Response) (heavily dependent on sponsorship and donations) and the modern private Helicopter Emergency Medical Services (HEMS) (which operate with funding from corporate sponsorship as well as on a fee-for-service basis for those with medical insurance) – resources are limited and the services are expensive to run.

Cause of injuries

By far the most prevalent cause of injury was road traffic accidents (nearly 35%, but the percentage may be more because of unrecorded data in TraumaBank – road traffic accidents accounted for 45% of trauma cases for which the cause was recorded). This is to be expected as road traffic accidents are predicted to be the third leading cause of death by 2030.[30] This is comparable to the 29%[159] and 46%[160] found in other, similar studies.

Over 45% of the patients in the study group had blunt injuries (27% requiring emergency operative or procedural intervention) and just over 10% had penetrating injuries (28% requiring emergency operative or procedural intervention). This is in contrast to other studies that have reported a prevalence of blunt injuries of 81%[159] and 85%.[160] This is possibly explained by the finding that 34% of the mechanism of injury in this study was not recorded. If we extrapolate by excluding the unrecorded data, this would bring the percentages in line with the other studies, with 70% of cases resulting from blunt trauma.

Time in the ED

Of the patients flown in and transferred in, proportionately more of these spent less time in the ED and went to theatre. Patients arriving from the scene of an accident via ambulance spent more time in the ED (89 minutes) than those arriving as a flight in (74 minutes) or transfer from other hospitals (74 minutes). This can be explained by the fact that the patients arriving via ambulance from the scene of the incident require more management, procedures and investigations than patients who have already been seen at another hospital. These patients who have been transferred may have had the majority of radiological and laboratory investigations performed prior to transfer. They may also be more unstable, with more severe injuries that are unable to be treated at the original facility, and are likely to comprise a population of patients that requires operative intervention by trauma surgeons. For those patients going directly to theatre, the mean time spent in the ED was 77 minutes.

Over 60% of cases that went to theatre directly from the ED spent more than one hour in the ED. Only 34% of the cases (122 patients) went to theatre within one hour of arrival at the ED (the median time in the ED was 46 minutes for these patients). In general, patients with major blunt trauma require more investigations within the ED, often requiring ultrasonography or more advanced radiological procedures such as computed tomography before a diagnosis can be made. Patients with penetrating injuries require surgery more frequently and investigations can be kept to a minimum when the emphasis is on urgent time to theatre for haemorrhage control and appropriate surgical management. Thus, patients with abdominal penetrating injuries were the quickest out of the ED to

theatre. Patients who sustained both blunt and penetrating injuries require the most investigation and the most major and minor procedures while in the ED. These patients quite often are unstable with potential occult trauma. They require the extensive workup of blunt injury patients with simultaneous procedures in the ED to control bleeding, stabilise fractures and manage injuries such as pneumothorax. The longest times in ED were for those patients that were discharged immediately or transferred to another hospital. These patients usually have a full workup of potential injuries, and once all results are available they are discharged if no major injuries are detected. Only desperately ill, physiologically irremediably unstable patients are transferred directly to theatre.

Disposition from ED

Predictably, nearly 90% of patients went to a high acuity environment from the ED (theatre, ICU or High Care). Surprisingly, a small proportion of the patients were sent to the ward or even discharged home. These cases most likely belonged to the group of patients who arrived as Priority 1 activations due to severe mechanism of injury, rather than actual injuries or physiological derangement. Not infrequently, few or no injuries were found in these patients.

Disposition to theatre

A total of 364 patients went from the ED directly to theatre, but only 122 of these were within one hour of arrival in the ED. Constraints (such as unavailability of a theatre, delayed arrival of the anaesthetist, or maintenance of the CT Scanner) within the facility at the time of trauma activation were not recorded. On the other hand, non-urgent patients with relatively minor injuries may have been

accommodated in theatre in less than an hour, simply because the facilities where available at the time – this is often the case late at night when the theatres are not in routine use. These factors affect the validity of the data collected on patients going to theatre within 60 minutes as the numbers would be skewed towards an increased proportion of patients going to theatre who do not actually require urgent surgery. The opposite holds true to the effect on data validity for those patients who require urgent surgery but who are prevented from going to theatre due to staffing constraints in theatre or lack of theatre availability. These factors were beyond the scope of this study as this information was not recorded.

Only 19 patients were transferred to theatre within 30 minutes of arriving in the ED, of which 10 were transfers in from other facilities. These cases (if the transfer to theatre was for urgency rather than expediency) would mandate the surgeon to be present at the time of patient arrival. Patients transferred for the care of the trauma surgeon often have their injuries adequately investigated at the referring hospital and the receiving surgeon's main objective is to get the patient to theatre as soon as possible. Clearly this differs to a patient arriving primarily from the scene – these patients still need investigation to determine whether the unique skills possessed by a surgeon might be required.

Severity of injury (ISS, NISS and POS from ISS)

This study population represented a group of patients with significant injuries, as reflected by the severity scoring systems, with an overall median ISS score in the "moderate" range. Patients from flights in and transfers had higher ISSs than primary cases, which is to be expected. These findings are comparable to other

studies of major trauma presentations,[160] and suggest that the findings from this sample may be generalisable to other trauma systems that receive severely injured patients.

Penetrating truncal injuries

As is expected, a higher proportion (40%) of penetrating abdominal injuries went to theatre as there are limited possibilities for conservative management of these patients. This is because of the high probability of damage to solid organs and hollow viscera, especially in the event of injury due to gunshot wounds. Only 10% of thoracic/neck penetrating injuries went to theatre. Penetrating thoracic injuries can often be definitively managed in the ED. Stab and gunshot wounds to the chest are either rapidly fatal and the patient does not survive to theatre, or they do not involve critical structures and are managed within the ED by means of intercostal drains with subsequent observation in the ICU.

Implementation of major resuscitation rules

This study, like some previous studies, showed that the existing rules for classifying a patient as requiring major resuscitation are not ideal. The major resuscitation rules evaluated in this study showed that, at most, only 45% of patients were classified as requiring major resuscitation, yet all were “Priority 1” cases for which the trauma surgeon would have been summoned. This overtriage rate of 55% to 70% (depending on the rule) is more than what the ACS deems acceptable.[28] Perhaps different endpoints for the rules are needed. Of the patients that truly required surgeon presence (cases that went to theatre or had surgical procedures in the ED) only 50% to 70% (depending on rule) were determined to

require major resuscitation - an undertriage rate of between 25% and 40%. This does not comply with the guidelines of acceptable undertriage rates. [28] Overall, there was only a weak association between patients meeting major resuscitation criteria and interventions required. Penetrating trauma (and specifically abdominal trauma) was most predictive of urgent surgical intervention.

Patients who have been field-triaged and meet ACS major resuscitation criteria may improve after pre-hospital treatment with an amelioration of their physiological parameters. Some of these patients will be “responders”[25] and some will be “transient responders”[25] and this may only become apparent in the ED. Apparent over-triage is therefore important to ensure that the potentially lethal injuries of the “transient responder “ are identified. Early surgical procedures would, however, be unlikely. Similarly, patients who initially appear stable on scene can deteriorate during transport or in the ED. False negatives for major resuscitation rules applied are not necessarily “misses” and probably do not result in delays in appropriate surgical care as most patients quickly develop obvious signs indicating the need for rapid surgeon involvement.

When applied to our study population, The Loma Linda Rule was the most sensitive, while the revised Loma Linda Rule (which includes penetrating injury to the torso and less conservative physiological criteria) resulted in slightly lower sensitivity, but improved specificity compared to the original Loma Linda Rule.

In general, application of ACS rule is problematic and not evidence-based. Modified rules for activation of the trauma team exist and have been derived and

shown to be effective, although they still require additional validation. Our figures support the need for revised activation criteria.

There were no major differences in time spent in the ED, or disposition or ISS between patients defined as requiring major resuscitation or not requiring major resuscitation by the various rules as applied to our study sample. The bottom line is that the rules performed poorly to discriminate between cases that actually needed major resuscitation and those that didn't. The existing system for our units had an even higher over-triage rate than for any of the individual rules. The under-triage rate is unknown as this data was not recorded. The balance between providing appropriate care and not missing injuries is complex and evidence-based systems need to be introduced with appropriate endpoints (outcomes) – at least for defining the need for surgical presence in the front room.

ED procedures

EMPs should be capable of performing all major non-surgical procedures such as all forms of airway management, central venous catheterisation, intercostal drains and so on. Of the ED procedures performed, only a few are clearly better performed by a trauma surgeon such as thoracotomies and diagnostic peritoneal lavages (which are now infrequently used), and possibly tracheostomies (although many EMPs are skilled in this procedure as well). However, patients undergoing ED thoracotomies (16 in this study, at least two of which, ironically, were performed by EMPs) almost invariably demise and the presence of a trauma surgeon is not likely to change this fact.[170-172] ED laparotomies (of which there

were seven) should not be performed and the justification for this procedure would need to be exceptional.[173, 174]

Fasciotomies or escharotomies (14 in this study, all performed on burn patients) can usually be delayed and should be performed in theatre, unless causing respiratory compromise, difficulty in ventilation or neurovascular compromise.

Cricothyroidotomy is routinely taught on many courses (including ATLS), yet there were only six performed in this study of over 4500 patients. In fact, a supraglottic airway device can also be used as an intermediate airway between a failed intubation and a surgical airway, and it forms part of the recommendations in the 8th Edition of the ATLS manual.[25] Likewise, only 16 tracheostomies were performed. Tracheostomies have been listed as a procedure that should only be performed by surgeons, yet many EMPs are comfortable performing percutaneous tracheostomies. Interestingly, the TraumaBank registry reflects procedures which are now considered somewhat outdated. DPLs (20) are no longer widely performed. The ATLS manual still teaches that DPL should be performed by surgeons, but most modern protocols rely on EFAST (Extended Focused Assessment with Sonography for Trauma) examination instead.[175, 176] There are a number of EMPs working in our EDs that are credentialed in EFAST. The use of ED ultrasonography in South Africa is an EMP initiative, driven by EMPs. There are thus EMPs that have skills that are not available to surgeons as there are no South African surgeons with certified skills in emergency ultrasound as yet. This supports the concept of surgeons and EMPs working together with complementary skills to provide a high quality of care to severely injured patients.

Is routine trauma surgeon presence necessary?

The vast majority of patients (over 95%) did not require any urgent attention by a surgeon (to theatre within 60 minutes of arrival in the ED) or major surgical procedures (that could only performed by a trauma surgeon) in the ED.

Patients undergoing emergency surgery or emergency surgical procedures

To summarise the important findings: of the 4544 patients, 123 (2.7%) underwent emergency operative intervention and 38 (0.8%) underwent emergency procedural intervention, resulting in 161 (3.5%) total patients having either emergency operative intervention or emergency procedural intervention. Of the patients who required emergency procedural intervention, 16 (0.35%) underwent thoracotomy, 24 (0.53%) underwent cricothyroidotomy and/or tracheostomy, and seven (0.15%) underwent ED laparotomy.

Based on this study, only 2.7% of the sample required urgent surgery within one hour of their arrival. That is approximately one patient per centre per month. This is similar to findings in other studies.[159,160] Clearly, this casts doubt on the value and feasibility of requiring routine trauma surgeon presence in the ED for every patient triaged as Priority 1 by pre-hospital emergency personnel.

In reality, there are other “rate-limiting” factors which affect the time to theatre for patients requiring emergency surgery. Anaesthetists are often delayed and although they are placed on standby for a pre-activated Priority 1 case, they are only activated (called to come in to the hospital) if the surgeon decides to operate. This in itself suggests that there is limited belief in and only partial adoption of the

ACS-COT guidelines. In our case there is a delayed activation of the anaesthetist and the surgical assistant. On occasion the EMP has had to assist in theatre while the surgical assistant makes a delayed appearance. Essentially the surgical support team are only activated after secondary triage by the trauma surgeon. Based on this, looking at urgent cases to theatre as a standalone dataset – the surgeon and the surgical assist team could just as easily be activated by the EMP. Considering the small proportion of trauma cases that actually require initial trauma surgeon presence, this partial adoption of the ACS-COT guidelines is understandable. Yet the surgeon's oversight of all resuscitation implies a belief that surgeon resuscitation skills are better than those of the EMP. There seems to be an assumption that only a surgeon possesses the skills to perform trauma resuscitation, and that a non-surgical background and training means you cannot provide optimal early trauma care. The truth is that EMPs probably see more critically unstable patients than trauma surgeons and are probably as good in that first hour or two in resuscitating the trauma patient. It is therefore understandable that almost all EMPs would strongly object to this assumption.

Parallels can be drawn to medical Priority 1 cases such as patients presenting with acute ST-segment elevation myocardial infarction. The ED is sometimes alerted to the imminent arrival of such a patient in a similar manner to EMS activation of trauma cases (if brought in by ambulance). After initial assessment and management by the EMP on arrival in the ED, the cardiologist and his "cath lab" team are activated, and they often arrive at the hospital at the same time the patient is being transported out of the ED into the "cath lab". Studies have shown that activation of the "cath lab" by the EMP rather than the cardiologist results in a

reduction of the door-to-balloon times.[177, 178] There is no reason to suspect that this might be any different for the trauma patient and theatre, as long as appropriate protocols are adopted and instituted to activate the callout of the trauma surgeon for cases requiring surgeon intervention. These protocols can be based on the ACS-COT recommendations, but modified to suit the individual facility's unique requirements. For trauma activation, the protocol could be a simple clinical decision rule which includes penetrating truncal injuries, hypotension and tachycardia.

This system can be employed for all Priority 1 cases – both trauma and medical. This is actually how the system currently works. The EMP is responsible for the management of all medical Priority 1 patients that present to the ED, as well as trauma Priority 1 cases where the surgeon is unavailable or there has been no pre-hospital activation to alert the trauma team via trauma team activation.

In this study, the patients that went to theatre were predominantly those with penetrating truncal injuries (mainly abdominal), followed by blunt injuries with unstable vital signs (low BP and tachycardia). This stands to reason as these patients require definitive or damage control surgery.

A higher proportion of transfers-in from other facilities went to theatre within 60 minutes than primary presentations. The patients are expected by the trauma surgeon and it stands to reason that theatre may have been prepared in expectation of patient arrival. Likewise, it is understandable that the surgeon be present on patient arrival. Only those patients that have significant injuries and

require trauma surgery are transferred – patients with uncomplicated injuries are not likely to be transferred from other facilities.

Patients requiring major surgical procedures in the ED

The procedures included in this study were airway procedures, which one would expect EMPs to be able to perform; as well as ED thoracotomies and laparotomies which are virtually always unsuccessful (and were in this study). All other procedures EMPs are expected to be able to perform. Interestingly, at least two of the ED thoracotomies were performed by EMPs, which may further raise the question: is there any difference between the experienced trauma surgeon and the experienced EMP?

A few of the patients required multiple major procedures and these patients would benefit from more than one attending doctor, ideally an EMP and a surgeon. In the USA they have a full trauma team that is activated, including surgeons, anaesthetists, EMPs, physician assistants, technicians and nurses. Although this may not happen all over the world, an important consideration is that someone in the ED needs to be an expert in these procedures. It might be a surgeon or an EMP, but it does mean that both surgeons and EMPs need to be appropriately trained and experienced. In general, EMPs are capable of performing all emergency non-surgical procedures as well as a trauma surgeon. It has been shown that EMPs are better at airway management than trauma surgeons.[179, 180] Insertion of central lines, intercostal drains and similar procedures are a basic set of surgical skills that are required to be able work in any ED. Where multiple

procedures are required, any two doctors will improve the resuscitative process: two EMPs may be suitable or, ideally an EMP and a trauma surgeon.

Patients "triaged" as requiring major resuscitation

While the ACS-COT major resuscitation criteria are acceptable for triage purposes, they do not reflect the realities of the South African situation. The major resuscitative criteria are useful to triage pre-hospital patients to the correct centres, but they are not useful to define when the surgeon is required to see the patient. Triage protocols are designed to over-triage patients, which minimises the risk of missing patients with serious injuries.[17, 82] Of the major resuscitation criteria, gunshot wound to the torso and hypotension appear to be the strongest predictors of emergency operative intervention or emergency procedural intervention, findings confirmed in our study and others.[162, 181]

Of the ACS-COT major resuscitation criteria, the two most common criteria met were "respiratory compromise, obstruction, or intubation" and "GCS < 8" with mechanism attributed to trauma," - conditions in which it has been argued that a trauma surgeon is unlikely to be necessary.[120, 162, 182]

The new 8th edition of the *Advanced Trauma Life Support* (ATLS) course manual contains a small but significant change.[25] The phrase, "trauma is a surgical disease", long a point of contention with other specialties caring for trauma patients, has been removed.[163] As the findings of this study and others confirm, perhaps it is more appropriate to say that the early management of trauma is *occasionally* a surgical disease.[102, 163, 183] Trauma triage and management have

been evolving in ways that emphasise non-operative procedures, but this has been met with energetic opposition.[163]

In our study centres there is daytime presence of trauma surgeons when better qualified EMPs are working in the EDs. While at night when EMPs with lesser experience are working in the EDs there is no trauma surgeon presence in the hospital. Thus, to an extent, we are already working within an ACS-COT guided system, but employing secondary triage and delayed activation of the trauma surgeon. EMPs working outside of Level 1 traumas centres do not necessarily have the availability of surgeons versed in trauma. In fact they may not have access to a surgeon at all, especially in rural facilities. The EMPs are the primary practitioners responsible for the care of seriously injured patients in the ED. Therefore it makes sense that the training of EMPs should include extensive instruction in trauma. In those facilities without trauma surgeons, the general surgeons can perform the role of the trauma surgeon (although a trauma surgeon would be preferred).

With the current system of trauma surgeon cover, it is unavoidable that there will be times when the surgeon is delayed or unavailable. They can be delayed in traffic *en route* to the hospital from home or another medical facility. They might already be in theatre operating when a new trauma patient arrives in the ED, leaving the EMP to take care of the patient in the absence of the trauma surgeon. As mentioned above – in the absence of the trauma surgeon, the EMP needs to be well versed in all aspects of trauma resuscitation so as to ensure optimal trauma care for the severely injured patient.

EMPs are present at all times in the ED. They are perfectly positioned to manage the Priority 1 Trauma patient alongside all the other Priority 1 Medical patients using one uniform system, with the trauma surgeon's assistance as is needed. What is really needed from the trauma surgeon is a rapid response time from activation to theatre. With this in mind, EMPs should have their skills enhanced in order to be *the* experts in all aspects of ED major and minor procedures.

There is still debate as to the best model for assessment and management of unstable patients: in other words, "Trauma Surgeon or Emergency Medicine Physician: Who Is the Best for the Patient?"[184] or "Who Should Be the First Line of Management of Trauma Patients: Trauma Surgeons or Emergency Medicine Specialists?"[185] A more rational approach is that, "Trauma Surgeon or Emergency Medicine Specialist Is the Wrong Question"[186] because both disciplines are required to provide optimal management for the seriously injured patient.

Trauma surgeons in South Africa and especially in the private sector are limited to trauma surgery only; the ACS-COT system ensures on-going work for the surgeon in an environment where they perform no elective non-trauma surgery. General surgeons within the same Level 1 facilities do not support the role of the trauma surgeon as an acute care surgeon. A turf battle between these surgeons would not have a favourable outcome for the trauma surgeons. With surgery limited to trauma patients only, is compliance with the ACS-COT callout criteria a question of conscientiousness and the desire to provide an excellent level of medical care, or is it rather a question of motivation for financial gain or financial self-preservation? If there was full compliance with the ACS-COT guidelines, then the anaesthetist

and assistant should be activated along with the trauma surgeon at the time of initial trauma team activation. This should happen 24 hours a day, not only during normal working hours, leaving EMPs to manage the initial treatment of severely injured patients' alone after normal working hours.

However, strict adherence to the guidelines along this line would have serious financial and manpower implications. Such a small proportion of Priority 1 patients require theatre, and the burden of cost for this service would fall on the individual practitioners concerned. The higher the proportion of callout with no resultant theatre case, the less likely the participants would be to maintain their position on the trauma call roster. The individual practitioners would be responsible for their own wasted time and ancillary costs such as fuel and vehicle maintenance, as well as loss of alternate productivity in other fields of medicine. Besides the EMP, the trauma surgeon would be the only other member of the trauma team able to claim a fee for service on a patient not requiring surgery. Such a system would result in severe difficulties is finding anaesthetic cover for trauma call lists.

Staffing of a Level 1 ED is costly and the EMPs also require remuneration and reward for all their work. This means that there are additional financial factors at play for both trauma surgeon and EMP. The ED demands the presence of the EMP every minute of the day. It is costly to staff the ED with well-trained EMPs 24 hours a day. Such staffing acuities have a financial toll, which needs to be recouped by active participation in the cases with major trauma. It is understood that similar financial challenges confront trauma surgeons who are precluded from general surgical practice in our hospitals.

No decision rule should replace sound clinical judgment on the part of the EMP. At most modern trauma centres, all patients are promptly evaluated by EMPs skilled in initial trauma care and in judging the need for (and urgency of) specialist consultation. Even when surgeons are not present on patient arrival, a vital requisite of any trauma centre is their ability to respond promptly when necessary.[159] However, the facts speak clearly; in reality no clinical decision rule is even necessary: surgeons need not be routinely present at all unless specially summoned by the EMP for unique circumstances (see Figure 5-1).[159]

EMPs do not seek exclusivity in the ED, and neither should trauma surgeons. EMPs and trauma surgeons should work hand in hand and complement each other's skills. "Instead of fighting turf wars based on our differences, we enjoy celebrating our common interest in a fascinating and rewarding field."[186] There is little doubt that critically ill multisystem trauma patients benefit from the expertise and timely availability of a trauma surgeon, and that a team combined of trauma surgeons and EMPs is the best choice to be the first line of management of trauma patients."[187]

The role of the ED Specialist compared to a ED non-specialist in determining the need for trauma surgeon presence

There is no published data on the management of major trauma cases by specialist vs non-specialist EMPs. The most important factor in determining the appropriateness of any doctor managing major trauma cases would be their experience in the field: this would apply to both surgical and emergency medicine disciplines. It is clear that both specialist and non-specialist EMPs can have the

skills required to manage trauma resuscitations, however. Individualised policies in each institution with regard to participation of various disciplines and individuals within those disciplines would ensure the appropriate provision of skills required.

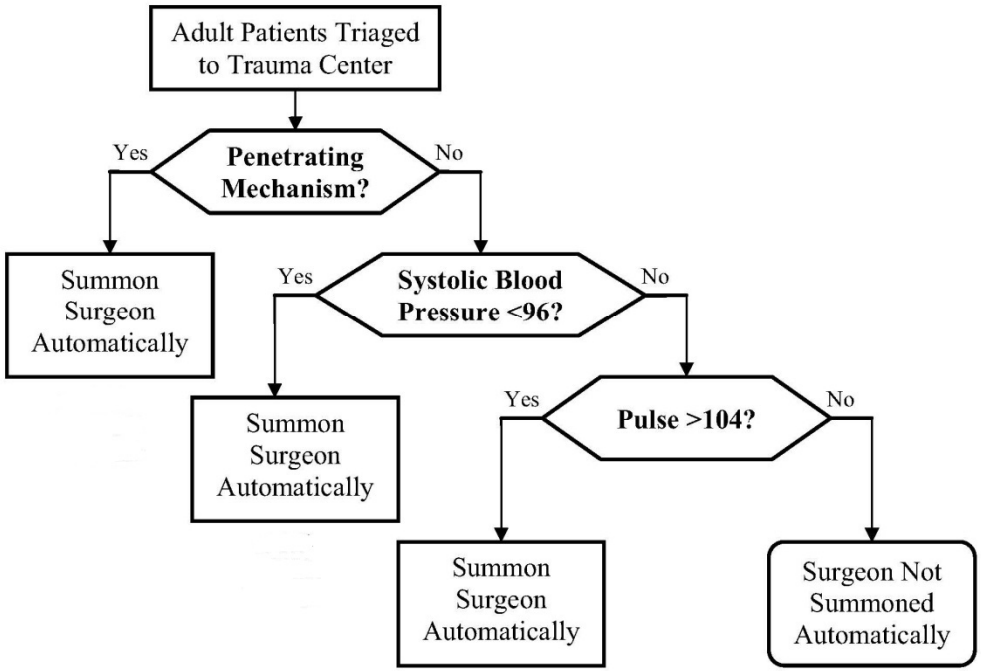


Figure 5-1 An example of an evidence-based surgeon activation algorithm adapted from Steele et al.[159]

Limitations of this study

1. The study was limited by its use of a trauma registry. As is a problem with all registries, the TraumaBank registry does not consistently document all the variables that are of clinical interest.
2. There is no control of the quality of the data entered into TraumaBank and there is no way to confirm the accuracy and authenticity of the data.
3. Variability in how injuries are managed between surgeons (e.g. whether the same spleen laceration would be managed operatively within one hour of patient arrival or managed expectantly) may contribute to the lack of generalisability of the results.
4. We have assumed that all operative interventions were actually necessary. Laparotomies performed due to apparent patient instability may not have yielded findings requiring surgical repair. The TraumaBank registry does not document actual theatre findings.
5. The time from arrival in the ED to transfer to theatre might not reflect clinical acuity: “stable” cases may have had a short stay in the ED because of few required investigations and the immediate availability of a theatre; unstable cases may have had a protracted stay in the ED because of the unavailability of a theatre, theatre staff or members of the surgical team.

Chapter 6 CONCLUSIONS

Routine surgeon presence during the initial phase of trauma management is hard to justify, given that the overall incidence of emergency operative intervention in our trauma centres was low (2.7%) as was the need for surgical procedural intervention (0.8%). In fact, during the study period, emergency operative intervention averaged just one per centre per month. It is clear, however, that the doctors who treat these patients need to be experts in the management of trauma: EMPs fit this description impeccably. However, training and up-skilling is vital.

This study was not intended to evaluate the involvement of the surgeon in trauma cases after the initial period of resuscitation in the ED. There is no doubt that there are fewer missed injuries and late complications when these patients are managed by trauma surgeons.

No clinical decision rule can be expected to be 100% sensitive. Triage policies must instead strike a practical balance between available resources and optimal care. While pre-hospital triage is established, the use of a secondary triage system within the ED needs to be fully verified and validated. To identify those patients that may require emergency operative intervention by trauma surgeons based on pre-hospital triage criteria alone, we need to look primarily at truncal penetrating trauma, persistent shock and unstable patients transferred from other facilities.

Recommendations

- Doctors that work in the ED doctors must be well-trained in acute trauma management. Training programmes in this field and funding for training should be directed towards EMPs as they will be responsible for the majority of acute trauma care across the world.
- There is a need for better activation criteria and secondary triage both at a pre-hospital as well as an ED level. These criteria need to be evidence-based and applicable across a spectrum of populations.
- In any centre where major trauma is managed, someone in the ED needs to be good with trauma resuscitation – the “captain of the ship” may be a surgeon or an EMP, selected on experience and skill rather than discipline.
- The development of the discipline of acute care surgery would be beneficial to overall patient care. With a decreased emphasis on surgical presence in the ED, surgeons’ unique skills (operating) should be put to work where they belong (the operating room).

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APPENDIX 1 Human Research Ethics Committee clearance

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Dr Harry R Nay

CLEARANCE CERTIFICATE	**M10447**
PROJECT	Is Routine Trauma Surgeon Presence in the Emergency Department Necessary for All Priority One Trauma Cases?
INVESTIGATORS	Dr Harry R Nay.
DEPARTMENT	Division of Emergency Medicine
DATE CONSIDERED	30/04/2010
DECISION OF THE COMMITTEE*	Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 03/05/2010 **CHAIRPERSON** .....
(Professor PE Cleaton-Jones)

*Guidelines for written 'informed consent' attached where applicable
cc: Supervisor : Dr Bilieu

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES...

APPENDIX 2 Netcare Research Committee clearance

Netcare Management (Pty) Limited

Tel: + 27 (0)11 301 0000
Fax: Corporate +27 (0)11 301 0499
76 Maude Street, Corner West Street, Sandton, South Africa
Private Bag X34, Benmore, 2010, South Africa

18th August 2010

Dr HR Nay
PO Box 1327
BEDFORDVIEW
2008

E mail: nay@casualty.co.za

Dear Dr Nay

IS ROUTINE TRAUMA SURGEON PRESENCE IN THE EMERGENCY DEPARTMENT NECESSARY FOR ALL PRIORITY ONE TRAUMA CASES

It is with pleasure that we inform you that your application to conduct research on; Is routine trauma surgeon presence in the emergency department necessary for all priority one trauma cases, at Netcare Union, Milpark & Sunninghill Hospitals, has been successful, subject to the following:

i) All information with regards to Netcare will be treated as confidential.

ii) Netcare's name will not be mentioned without written consent from the Academic Board of Netcare.

iii) Where Netcare's name is mentioned, the research will not be published without written consent from the Academic Board of Netcare.

iv) A copy of the research will be provided to Netcare once it is finally approved by the tertiary institution, or once complete.

Directors: E J Brannigan, M S F da Costa, I M Davis, J du Plessis, V Firman, R H Friedland, V L J Litlhakanyane, M B Nkosi, C Pallman, P Warrener
Company Secretary: L Kok Reg. No. 1995/012717/07

v) All legal requirements with regards to patient rights and confidentiality will be complied with.

vi) I will provide a copy of insurance stating the necessary indemnity cover. This cover provided to the researcher must protect both the staff and the hospital facility from potential liability

vii) Netcare will receive a progress report by 30th September annually irrespective of the date of approval from Netcare Research Committee

We wish you success in your research.

Yours faithfully



Prof Dion du Plessis
Full member: Research Committee & Medical Practitioner evaluating research applications as per Management and Governance Policy



Shannon Nell
Chairperson: Research Committee
Network Healthcare Holdings Limited (Netcare)

APPENDIX 3 Letters of Permission from Participating Hospitals

LETTER OF PROVISIONAL PERMISSION TO CONDUCT RESEARCH IN A NETCARE FACILITY

Name and surname of Hospital Manager Johan Holder
Date 19 July 2010

Dear Dr H.R. Nay

Research to be conducted in SUNNINGHILL Hospital

It is with pleasure that we inform you that your application to conduct research on *"Is routine trauma surgeon presence in the emergency department necessary for all priority one trauma cases?"* at SUNNINGHILL HOSPITAL site has been approved in principle, subject to the following:

i) Approval by the Research Committee
ii) All information with regards to Netcare will be treated as confidential.
iii) Netcare's name will not be mentioned without written consent from the Academic Board of Netcare.
iv) Where Netcare's name is mentioned, the research will not be published without written consent from the Academic Board of Netcare.
v) A copy of the research will be provided to Netcare once it is finally approved by the tertiary institution, or once complete.
vi) All legal requirements with regards to patient rights and confidentiality will be complied with.

We wish you success in your research.
Yours faithfully

Signed by Hospital manager
Name of Hospital SUNNINGHILL HOSPITAL
Date 19 July 2010

LETTER OF PROVISIONAL PERMISSION TO CONDUCT RESEARCH IN A NETCARE FACILITY

Name and surname of Hospital Manager **Cobus Venter**
Date July 2010 19

Dear Dr H.R. Nay

Research to be conducted in Milpark Hospital

It is with pleasure that we inform you that your application to conduct research on *"Is routine trauma surgeon presence in the emergency department necessary for all priority one trauma cases?"* at MILPARK HOSPITAL site has been approved in principle, subject to the following:

i) Approval by the Research Committee
ii) All information with regards to Netcare will be treated as confidential.
iii) Netcare's name will not be mentioned without written consent from the Academic Board of Netcare.
iv) Where Netcare's name is mentioned, the research will not be published without written consent from the Academic Board of Netcare.
v) A copy of the research will be provided to Netcare once it is finally approved by the tertiary institution, or once complete.
vi) All legal requirements with regards to patient rights and confidentiality will be complied with.

We wish you success in your research.
Yours faithfully

Signed by Hospital manager
Name of Hospital **MILPARK HOSPITAL**
Date 19 July 2010

LETTER OF PROVISIONAL PERMISSION TO CONDUCT RESEARCH IN A NETCARE FACILITY

Name and surname of Hospital Manager Magriet Holder
Date 19 July 2010

Dear Dr H.R. Nay

Research to be conducted in Union Hospital

It is with pleasure that we inform you that your application to conduct research on *"Is routine trauma surgeon presence in the emergency department necessary for all priority one trauma cases?"* at UNION HOSPITAL site has been approved in principle, subject to the following:

i) Approval by the Research Committee
ii) All information with regards to Netcare will be treated as confidential.
iii) Netcare's name will not be mentioned without written consent from the Academic Board of Netcare.
iv) Where Netcare's name is mentioned, the research will not be published without written consent from the Academic Board of Netcare.
v) A copy of the research will be provided to Netcare once it is finally approved by the tertiary institution, or once complete.
vi) All legal requirements with regards to patient rights and confidentiality will be complied with.

We wish you success in your research.
Yours faithfully

Signed by Hospital manager
Name of Hospital UNION HOSPITAL
Date 19 July 2010

APPENDIX 4 Statistician report

Data Cleaning

Main file (all Priority 1 trauma pts) (file: All Priority 1 patients_for SAS.xls)

- DEM_Age:
  - 1 pt with age=138y was set to age=missing.
  - 4 pts with age=0y but DEM_Age_months > 12m were set to age=1y.
- DEM_Arrival_Date: 1 pt with arrival date = 1958 was set to arrival date=missing.
- DEM_Hospital_Name: Hospital names were standardised.
- EUADMIS_Arrived_from: Spelling was standardised.
- EUADMIS_Time_spent_in_EU: Some durations were very long. The method of calculation of the duration from the clock times in the data set was not clear so recalculation was not an option. There was also considerable missing data and possible data entry error (12-hour clock vs. 24-hour clock) in the clock time data.

  A plot of the EU and Resus times against each other (tab: Main+truncal data prep) showed that a cut-off for realistic values for EU duration could be 7h. Client noted that sometimes times are longer, but we are interested primarily in times < 1h and want to exclude ridiculously long times due to data entry error. Then we see that (1) in many cases the values correlate exactly which means we can use the EU time, (2) in many cases the resus time is less than EU time which makes sense, (3) in some cases resus time is greater than EU time which does not make sense and (4) there are cases for which only one of the times exists and which are therefore not shown on the plot – see listing of EU times with no resus times.

  EU time was thus cleaned as follows:
  If EU time ≤ 7h, keep EU time,
  else if resus time ≤ 7h and resus time < EU time, replace EU time by resus time,
  else set EU time to missing.
  If EU time = missing and resus_time ≤ 7h, replace EU time by resus time.

- EUDATA_BP and PREH_BP: values of 1, 13- (and similar) and >= 200 were set to missing.
- EUDATA_Pulse_Rate: Values of 'l', 'm', 'u', 'x' and 1-39 were set to missing.
- PREH_Pulse_Rate: Values of 1-39 were set to missing.
- PREH_Pulse: Values of 'nil' set to 0; values of 'unk' and 'NA' set to missing.
- PREH_GCS_score: values of 0 set to missing.
- PREH_RTS_score: values of 0 set to missing.
- ISS and NISS EU_POS scores: if these were 0 AND the corresponding ISS or NISS values were missing, the EU_POS scores were set to missing.
- EUADMIS_Arrived_From: 1 case of "Not Recorded" recoded as "Other/Not Recorded" to collapse categories. Spellings were standardised.
- 1 duplicate record was deleted.

Pts with truncal injuries (file: Truncal penetrating for SAS.xlsx)

- NISS: Value of 7.6 changed to 7.
- SBP: Values >= 200 were set to missing.
- No duplicate records were found.

Priority 1 trauma pts requiring surgery (file: Theatre cases for SAS.xls)

- The file provided contained 361 cases, while the main file contained 364 cases where EUDATA_Disposition=THEATRE, so given that the Theatre Cases data set is an extract from the Main data set, 3 cases were lost. The data set was used as provided.

- DEM_Age: 1 pt with age=0 was set to age=1 based on correction made in main data set.
- DEM_Hospital_Name: Hospital names were standardised.
- EUADMIS_Time_spent_in_EU: Unlike the main data file, these values appeared to have been cross-checked against records (var: ED_time) although data is sparse. Assume data is clean.
- EUDATA_BP: one value of >= 200 set to missing.
- Variables in hidden columns were assumed not to be needed and were not cleaned. If we DO need these, then we should merge this file back into the main data file, otherwise we are duplicating data cleaning.
- No duplicate records were found.

Priority 1 pts - ED procedures: (file: All Priority 1 EU procedures for SAS.xls)
- Hospital_Disposition: spelling was standardised.
- HAEMORRHAGE_CONTROL: 2 cases with values=H replaced by 1.
- ISS_Score: scores of 0 were set to missing.
- 13 duplicate records were deleted (1 case was present 12 times).

Following this data cleaning, the truncal injury file was merged into the main data file.
- Merged by pt number and then by surname.
- Before merge, main data set had 4556 cases (and truncal injury data set had 274 cases).
- After merge, main data set initially gained 44 new cases from truncal injury file. Of these,
    - 19 cases were subsequently merged – initially did not merge due to spelling errors in surnames or use of pt_numbers suffixes of .5 in truncal injury file which then did not match exactly with pt_numbers in main file. Pt numbers and/or surnames in truncal injury file were corrected to match those in main file so that the records would merge.
    - 11 further cases matched on pt_number AND SBP, NISS, time in EU, etc. but NOT on surname. Dodgy data somewhere in TraumaBank extracts? Client advised that these could be accepted as duplicates. Surnames in truncal injury file were changed to match those in main file so that the records would merge.
    - 14 appear to be genuine additional cases and were retained as such – representing a 14/4556=0.3% increase in the main data set.
- Backfill of data from Truncal data set variables into matching Main data set variables was carried out on the assumption that the main data set's data takes preference and only missing data in the main data set was replaced by data from the truncal data set (if it existed).
    - 8 injuries from Truncal data (Injury) set filled into missing values from Main data set (INC_How_it_happened). New variable: How_it_happened.
        - Categories 'sports' and 'sport injury' combined.
    - 2 modes of arrival from Truncal data set (Arrival) filled into missing values from Main data set (EUADMIS_Transport).
    - 1 pre-hospital BP from Truncal data set (prebp) filled into missing values from Main data set (PREH_BP).
    - 8 values of BP from Truncal data set (sbp) filled into missing values from Main data set (EUDATA_BP).
    - 1 NISS score from Truncal data (NISS) filled into missing values from Main data set (ISS_NISS_score).
    - 7 Dispositions from Truncal data (Disposition) filled into missing values from Main data set (EUDATA_Disposition).
    - 3 values of time in EU from Truncal data (EU_time) filled into missing values from Main data set (EUADMIS_Time_spent_in_EU).