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ORIGINAL RESEARCH

Trauma system management of adults with severe burns in Victoria, Australia

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Abstract

Objectives: The aim of the present study was to examine the profile, management and outcomes of adult patients with severe burns within the Victorian State Trauma System (VSTS).

Methods: Data from the Victorian State Trauma Registry (VSTR) was analysed to characterise patient and injury characteristics and review prehospital management and clinical outcomes of adult patients with severe burns.

Results: There were 421 cases over 13 years of the study. Approximately 80% of cases were flame burns, and 5% were associated with other significant trauma. Approximately 75% were male; with 83% of patients under 65 years old, 40% of lower socioeconomic status, 25% having pre-existing drug and alcohol involvement, and 36% living with associated comorbidities. All but 11 patients (of 421) were managed definitively at the burns service. Around one-third of patients had interhospital transfer, with median (interquartile range (IQR)) time spent in the primary hospital 3.0 (1.9–4.3) h. Only five patients had multiple interhospital transfers. Nearly 75% of patients were admitted to an ICU. The median (IQR) length of definitive hospital stay was 27.2 (11.2–44.9) days. The mortality rate was 23.8%.

Conclusions: Severe burns are uncommon injuries with high mortality. There is a high rate of adherence to VSTS guidelines for managing patients with severe burns, and a decrease in patients requiring transfer associated with an increase in acceptable time to a trauma-receiving hospital. The VSTS operates to deliver almost all patients with severe burns to the definitive burns service efficiently.

Key words: *burns, quality and evaluation, trauma systems.*

Key findings

- The Victorian State Trauma System was effective in delivering severe burns patients to the specialist burns service.
- An increase in allowable maximum time from scene to hospital was associated with a decrease in the incidence of secondary transfers.
- The high proportion of patients having a secondary transfer reinforces the need for active educational and clinical support outreach by burns service staff.

Introduction

Severe burn injury is a complex injury associated with high mortality and morbidity among survivors.[1–3] Outcomes of complex conditions, including burns, are improved by management in specialist centres, and appropriate transfer of people with severe burn injury to specialist services is a prerequisite for best outcomes.[4,5] Severe burns are defined here as burn injuries involving ≥20% Total Body Surface Area (TBSA).

Trauma systems have the aim of decreasing mortality and morbidity in trauma patients through the implementation of coordinated protocolised prehospital care and transfer to appropriately resourced acute care hospitals according to injury type and severity. Mature trauma systems are characterised by formal networks incorporating accreditation, education, training, and quality assurance programs. Such systems have been associated with improved mortality outcomes; however, they have not generally been focused on burn injury.[6]

The Victorian State Trauma System (VSTS) incorporates burn injury as a specific form of trauma. This contrasts with other jurisdictions where burns services may not be well integrated into a trauma network.[7,8] The present study examined the profile and management of adult

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patients with severe burns within the VSTS.

Methods

Setting

The Australian state of Victoria had an estimated population of 6.6 million in 2022, increased from 5.9 million in 2016. It is a highly urbanised state: most Victorians live in the capital city of Melbourne, which comprised 4.9 million people in 2021.[9]

The VSTS has a state-wide inclusive structure which characterises different levels of acute health services and has a single integrated ambulance service with road and air (helicopter and fixed wing) transfer capabilities. As part of Ambulance Victoria, Adult Retrieval Victoria (ARV) provides system coordination, medical advice regarding critically unwell and injured patients, and patient transport services.

The VSTS has one paediatric and two adult major trauma services (MTS), with two designated specialist burns services: an adult service housed in one of the adult MTS hospitals, and a paediatric service at the paediatric MTS. Indications for referral to specialist burns services are broader than the VSTS definition of severe burns trauma, which constitutes a small proportion of burns service admissions.[10]

The VSTS pre-hospital triage guidelines for adult patients specify that patients with a ≥20% TBSA burn should be transferred to the adult specialist burns service. Current major trauma guidelines state that where transport to an MTS hospital is not possible within 60 minutes, transport to the nearest highest-level trauma-receiving hospital should occur, prior to inter-hospital transfer to the Burns Service.[11]

Victorian State Trauma Registry

The Victorian State Trauma Registry (VSTR) monitors the effectiveness of the VSTS. Data are collected about all major trauma patients managed at 138 trauma-receiving health services in Victoria. The Registry collects data to assess trends in patient characteristics, management and outcomes.[12]

Ethics approval

The VSTR has approval from the Human Research Ethics Committee (HREC) of the Department of Health and Department of Families, Fairness and Housing, and approval from all participating health services and Monash University. The present study received Monash University HREC approval (project #36357).

Patients

Hospitalised major trauma cases aged 16 years and older captured by the VSTR, with a date of injury from 1 July 2009 to 30 June 2022 were included if they had sustained a cutaneous burn injury involving ≥20% TBSA. Burn patients who otherwise fulfilled the criteria for major trauma were excluded if they did not have a cutaneous burn ≥20% TBSA.

Data analysis

Data for analysis were extracted from the VSTR relating to pre-hospital management, ambulance transfers and clinical management and outcomes. The Abbreviated Injury Scale (AIS) and the International Classification of Diseases 10th Edition Australian Modification (ICD-10-AM) diagnoses were used to categorise size of burn into the subgroups <10% TBSA, 10–19% TBSA, 20–29% TBSA, 30–39% TBSA, 40–49% TBSA, 50–69% TBSA, 70–89% TBSA and ≥90% TBSA. Any AIS diagnosis code 919200.2 to 919208.6 was categorised as inhalation injury. Hypothermia was defined as temperature <35°C, and hypotension as systolic BP <100 mmHg.

Descriptive analyses provided an overview of cases. Frequencies and percentages were used for categorical variables, while mean and standard deviation (SD) or median and interquartile range (IQR) were used for continuous variables depending on data distribution. A trend in incidence of severe burns was determined using a negative binomial model to report the incidence rate ratio (IRR) and 95% confidence intervals (CIs) of the IRR. Years were collapsed into 2 years intervals.

Categories of some variables were combined to eliminate potentially statistically disclosive cell count. Intent was categorised as unintentional or intentional. Associations between year and categorical variables were assessed using Chi-square tests, and for continuous variables, Kruskal–Wallis or Mann–Whitney *U* tests. A *P* value <0.05 was considered significant. Analyses were performed using Stata Version 17.0 (StataCorp, College Station, TX, USA) and performed using Monash University Secure eResearch Platform (SeRP).

Results

From 1 July 2009 to 30 June 2022, 1013 adult (16 years and older) cases were identified in the VSTR with a burn injury. Of these, 421 were recorded to have a burn injury ≥20% TBSA. Three-quarters of these patients were male, and 83% were <65 years of age (Table 1). Lower socioeconomic status (quintiles 1 and 2) was documented in 157 (39.4%) cases. More than 80% of burns were because of flame. Significant other trauma (AIS body region with a severity score of 3 or more) occurred in 20 (5%) patients.

A pre-existing drug, alcohol or mental health condition was documented in 100 (24.5%) cases, and intentional self-harm in 73 (17.3%) patients. Associated comorbidities were present in 36.3% of patients. Overall mortality rate was 23.8% (Table 1).

Population incidence decreased by 5% per year (IRR = 0.95, 95% CI = 0.92–0.97) over the time of the study, with large year by year variation and small number of cases (Fig. 1). The percentage of patients who experienced burns involving ≥30% TBSA tended to increase over the study (Table S1).

Trauma system management

Most cases occurred in metropolitan Melbourne (236 cases). Of the 169 burn injuries outside

TABLE 1. *Profile of adult severe burn patients managed in the Victorian State Trauma System, 2009–2022*

Population descriptor	$N = 421$
Age group (years)	
16–24	70 (16.6%)
25–34	78 (18.5%)
35–44	80 (19.0%)
45–54	72 (17.1%)
55–64	50 (11.9%)
65–74	35 (8.3%)
75+	36 (8.6%)
Sex	
Male	315 (74.8%)
Female	106 (25.2%)
Charlson comorbidity index weight	
0	268 (63.7%)
1	78 (18.5%)
>1	75 (17.8%)
Pre-existing mental health, drug or alcohol condition	
No	308 (75.5%)
Yes	100 (24.5%)
Index of Relative Socioeconomic Advantage and Disadvantage quintile	
1 (Most disadvantaged)	84 (21.1%)
2	73 (18.3%)
3	86 (21.6%)
4	88 (22.1%)
5 (Least disadvantaged)	67 (16.8%)
Burn cause	
Fire, flames, smoke	345 (81.9%)
Scald or contact burn	55 (13.1%)
Transport	12 (2.9%)
Other	9 (2.1%)
Intent of injury	
Unintentional	310 (73.6%)
Intentional-self harm	73 (17.3%)
Intentional-other	16 (3.8%)
intent cannot be determined	22 (5.2%)
ISS, median (IQR)	18 (9–29)
% TBSA	
20–29% TBSA	184 (43.7%)
30–39% TBSA	79 (18.8%)
40–49% TBSA	52 (12.4%)

(*Continues*)

Melbourne, 41 were in outer regional or remote geographical locations. All but 11 patients were definitively managed at the specialist burns service hospital: 7 at a metropolitan trauma service hospital and 4 at a regional trauma service hospital.

Information was available for 401 of the 421 patients for mode of arrival to first hospital from the scene: a Victorian road ambulance delivered 63.4% (258 cases) and an air ambulance delivered 22.2% (89 cases – 80 helicopter and 9 fixed wing). All transports involving air ambulance were delivered to the definitive burns service hospital. The remainder self-presented (45 patients) or were transported by interstate ambulance.

Pre-hospital physiology and management

Ambulance Victoria transferred 347 patients from the scene to hospital by air or road. The median (IQR) time spent at the scene was 26 (16–47) min and the time from arrival at the scene to the primary hospital was 63.5 (47–93) min. Systolic BP mean (SD) on arrival was 135.0 (30.9) mmHg. The mean (SD) pulse rate was 103.5 (23.6)/min. Median (IQR) respiratory rate was 20 (18–24)/min and oxygen saturation was 98 (95–100)%. Intubation was performed on 89 (26.3%) patients. Intravenous fluids were administered to 259 (76.4%) patients. Analgesia was given to 312 (92%) patients, and sedatives to 105 (31%) patients.

Inter-hospital transfer

One hundred thirty-seven patients were transferred from a non-burns service hospital. Except for one patient, the definitive hospital was the burns service hospital. Five patients had more than one inter-hospital transfer. Eight patients were admitted to the primary hospital prior to transfer, and one had a surgical debridement before transfer. No escharotomies were recorded before transfer. Regional VSTS hospitals comprised the majority of transferring hospitals (65.0% of transfers – 89 cases). Transfers

TABLE 1. *Continued*

Population descriptor	$N = 421$
50–59% TBSA	24 (5.7%)
60–69% TBSA	29 (6.9%)
70–79% TBSA	11 (2.6%)
80–89% TBSA	14 (3.3%)
90%+ TBSA	28 (6.7%)
Isolated burn injury	
No	24 (5.7%)
Yes	397 (94.3%)
Inhalation injury	
No	285 (67.7%)
Yes	136 (32.3%)
Mode of arrival at first hospital	
Road ambulance	258 (64.3%)
Air ambulance	89 (22.2%)
Self-presentation	45 (11.2%)
Interstate ambulance	9 (2.2%)
Inter-hospital transfer	
No	284 (67.5%)
Yes	137 (32.5%)
Retrieval service activation (transferred patients)	
No ARV documented retrieval	71 (51.8%)
ARV	66 (48.2%)
Definitive care at a burn unit	
No	11 (2.6%)
Yes	410 (97.4%)
ICU stay	
No	110 (26.1%)
Yes	311 (73.9%)
Hospital length of stay, median (IQR) days	27.2 (11.2–44.9)
In-hospital death	
No	321 (76.2%)
Yes	100 (23.8%)

IQR, interquartile range.

from within the Melbourne metropolitan area comprised 17.5% (24 cases).

The time at the primary hospital was known for 114 patients. The median (IQR) time at the primary hospital was 3.0 (1.9–4.3) h, with a maximum of 164 days. The median (IQR) time to arrival at the definitive hospital from arrival at the initial hospital was 4.6 (3.4–7.0) h. This increased to 5.4 (3.8–8.6) h if Adult Retrieval Victoria (ARV) coordinated transfer (Table 2).

Rates of cases requiring inter-hospital transfer, occurring in regional Victoria *versus* Melbourne, and mode and time of transfer did not vary according to time periods. Use of ARV increased during the period of the study (Table S1).

Clinical observations on arrival

Of the 137 transfers, BP data on arrival at the initial hospital were available for 113 patients. Of these, 10 (8.9%) patients were hypotensive. Four patients remained hypotensive on arrival at the definitive hospital. Temperature data were available for 101 transferred patients on arrival at the initial hospital. Twenty-two (21.8%) were hypothermic, and 12 remained hypothermic on arrival at the definitive hospital.

In hospital outcomes

There were 100 deaths (an overall mortality rate of 23.8%). The mortality rate for patients with 70%+ TBSA burns was 90.6% (5 survivors out of 48). No patient with a ≥90% TBSA burn survived (Fig. 2).

Ninety-six deaths occurred in the definitive burns service hospital: most (59%) within 24 h of arrival. There was a trend to increased mortality rate (Table S1). Eighty-eight patients had an inhalation injury, 48 (35.3%) of whom died. In the group with no inhalation injury, 18.3% (52 cases) died.

The hospital average LOS (SD) was 41.2 (27.0) days for survivors and 6.9 (17.0) days for patients who died. The median (IQR) hospital LOS for all admissions was 27.2 (11.2–44.9) days (Fig. 3).

Nearly three-quarters of patients were admitted to ICU (311/421 cases). The median (IQR) LOS in ICU was 8.0 (2.0–19.0) days. Patients with inhalation injury had a median (IQR) LOS of 10.0 (3.0–23.0) days. The median (IQR) ICU LOS was 6 (2–16) days for patients without inhalation injury. Admission to ICU increased over the study time (Table S1).

Discussion

Following a similar VSTR 2001–2009 study conducted on patients with burns, this manuscript reports the management and outcomes of adults with major burns. The number of major burns per year managed within

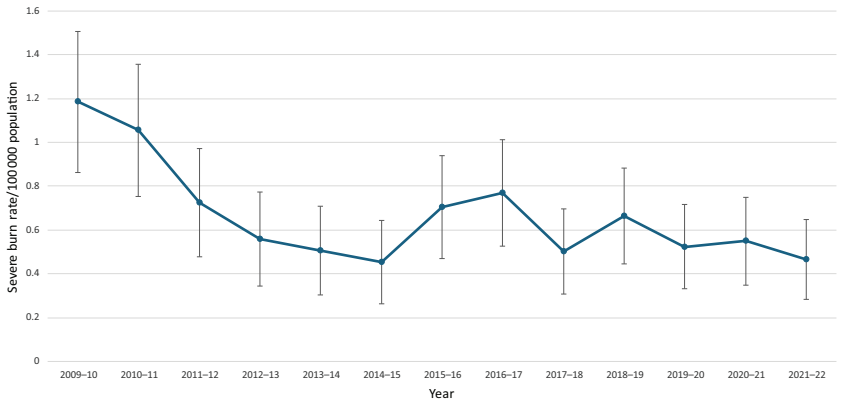

Figure 1. *Incidence of severe burns by year.*

the system over both time periods was low: fewer than 35 patients per year on average. Compliance with transfer guidelines remained high, with 11 patients (2.6%) not transferred to the burns service hospital.

The mortality rate found in the present study was considerable: almost one in five patients died after arrival at hospital. Almost 60% died within 24 h of arrival, indicating a high likelihood of non-survivable injury and no institution, or early withdrawal, of active treatment. Possible or likely non-survivability is not considered a contraindication to transfer. Mortality rates were similar to those reported in other high-income countries.[13] A study of burns patients admitted to Australian and New Zealand specialist burns services found the Victorian service had a lower predicted mortality than other services, but low overall numbers and mortality rates preclude analysis of the association between mortality risk and various individual factors.[14]

During the 2001–2009 period, 52.7% of burn cases occurred in metropolitan Melbourne, and 42.6% in regional Victoria. This compares with 56.1% and 40.1%, respectively, in the current study, in which 33% of patients were transferred from a primary hospital to the burns service, compared with 51% reported in the earlier study. This increase in direct delivery from the scene was associated with acceptable time for delivery to an MTS increasing from 30 to 60 min before mandated transfer to the nearest highest-level trauma receiving hospital. Increased admission rates to ICU over the period of the study to 94% are consistent with a change in hospital policy to mandate that all these patients initially be admitted to the ICU.

Hospital LOS was lower in the current study compared with 2001–2009: 27.2 days (11.25–44.9) compared with 30.7 days (14.7–52.8), although ICU LOS was similar. Other studies have shown varying associations between transfers and in-hospital outcomes. A German study found that directly admitted patients had similar numbers of operations and mortality rates to those transferred via another hospital, although time to first burn excision, ventilation time and ICU and hospital LOS, were shorter in the directly admitted group.[15] In contrast, a US study found no difference between transferred and non-transferred patients, despite higher acuity transferred patients.[16]

In our setting, the highly centralised nature of burn care and regionalisation of ambulance services, necessitated the interhospital transfer of nearly one-third of patients who sustained severe burns. Our study suggests that protocolised, well-resourced ambulance transfers and the co-location of burns with major trauma services support safe and efficient management, in contrast to other trauma systems.[7,8] Ambulance Victoria's Clinical Practice Guidelines provide a burns-specific structured approach to assessment and management of patients with burn injuries.[17]

Patient physiology (BP and temperature) improved on average between arrival at the initial hospital and the definitive burns service hospital, suggesting appropriate clinical interventions; however, available data are limited. No patient was recorded to have had escharotomies at

TABLE 2. *Transfer times: according to Adult Retrieval Victoria (ARV) involved/not involved*

	Overall	No ARV activation	ARV activation
Transfer time (time from arrival at primary hospital to arrival at definitive hospital), median (IQR) h	4.6 (3.4–7.0)	3.8 (2.6–5.3)	5.4 (3.8–7.6)
Transport hours (departure from primary hospital to arrival at definitive hospital), median (IQR) h	1.4 (1.0–2.2)	1.2 (0.7–1.9)	1.9 (1.1–2.5)
Time at primary hospital, median (IQR) h	3.0 (1.9–4.3)	2.2 (1.4–3.8)	3.4 (2.3–5.5)

IQR, interquartile range.

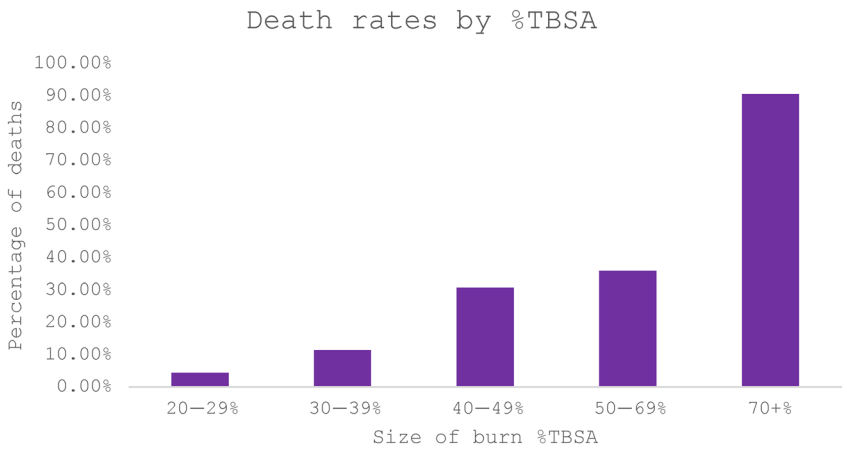

Figure 2. *Mortality rates by size of burn.*

the initial hospital prior to transfer. This may represent a lack of documentation, or else the relatively short time to arrival at the definitive burns service. It may also be indicative of inexperienced staff in primary receiving hospitals. Despite early management of severe burns requiring relatively few specialist resources, incorrect assessment and inadequate management in pre-burn service care are well documented. Our study found that on average, these patients' early (pre-hospital) physiological indicators were not far outside normal limits. Even patients with unsurvivable burns may appear relatively stable for some hours post injury, and clinicians unfamiliar with acute burns presentations may underestimate the need for early active interventions, resulting in delayed resuscitation, and inadequate pain, temperature and airway management.[18]

Telemedicine consultation can assist clinicians to assess and perform interventions such as escharotomy, and also minimise the incidence of inappropriate transfers. This is especially relevant because early transfer (frequently in our setting by aircraft) contributes to a high rate of intubation, which may not otherwise be clinically indicated, and not without risks.[19]

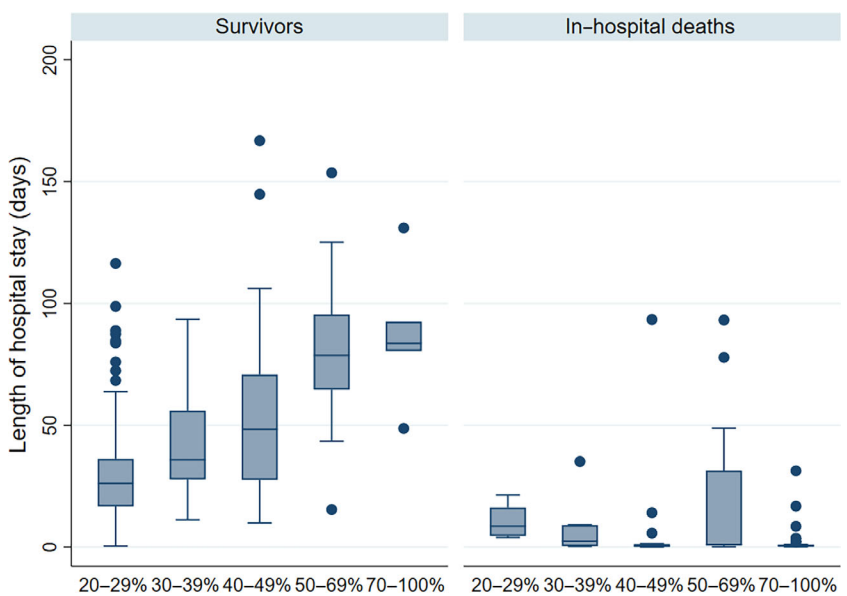

Figure 3. *Hospital length of stay by survival status and size of burn.*

Limitations

This registry-based study did not consider burn depth as an indicator of burn severity. The proportion of missing clinical data on patient physiology during the pre-definitive hospital phase was 18%, and of some clinical concern in so far as it may be indicative of a failure to appreciate the significance of aspects of resuscitation, such as fluid and temperature management. Although the comprehensive nature of the VSTR in collecting data across the trauma system and Victorian population provides a view of integrated management, data is not collected for burns patients who warrant management in a burns service but do not fulfil the criteria for 'major trauma'. There are limitations to the data collected by the trauma registry for burns patients, and elements of interest such as burn size assessment by pre-burns hospital clinicians, geocoding to assess distance transferred, and pre-burns hospital fluid administration were not available.

Conclusions

The study findings demonstrate the efficacy of a protocolised approach incorporated within a comprehensive, mature trauma system in delivering severe burns patients to the specialist burns service. An increase in allowable maximum time from scene to hospital was associated with a decrease in the incidence of secondary transfers. The high proportion of patients having a secondary transfer reinforces the need for active educational and clinical support outreach by burns service staff. The population-based nature of the VSTR supports its use in monitoring the ongoing performance of the state trauma system.

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Competing interests

Prof. Peter A Cameron is an Editorial Board member of *EMA* and a co-author of this article. To minimise bias, he was excluded from all editorial decision-making related to the acceptance of this article for publication. The other two authors have no conflict.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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Supporting information

Additional supporting information may be found in the online version of this article at the publisher's web site:

Table S1. Trends in patient and injury demographics, management and outcomes, by 2 years intervals.