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PREHOSPITAL AND RETRIEVAL MEDICINE

Factors involved in intensive care unit mortality following medical retrieval: Identifying differences between intensive care unit survivors and non-survivors

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Abstract

Objective: The study aimed to determine factors related to ICU mortality in critically ill patients transferred by Adult Retrieval Victoria (ARV) medical staff. Patients who died in ICU after interhospital transfer were compared against those who survived.

Methods: This was a retrospective cohort study of ARV cases between 1 January 2009 and 30 June 2010. Retrieval data were linked with data from the ANZICS CORE APD (Australia and New Zealand Intensive Care Society Centre for Outcome and Resource Evaluation Adult Patient Database). Victoria Data Linkage (VDL) performed linkage of data. Data included demographic and clinical data obtained during transfer and clinical data recorded in ICU.

Results: Of the 601 cases transferred by ARV during the study period, 549 cases were eligible for linkage to 25 543 ANZICS APD case records for the same period. VDL matched 460 of these cases (83.8%). Mortality rate in the matched sample was 13.9%. Variables associated with mortality were: advanced age (odds ratios [OR] 1.02, 95% confidence interval [CI] 1.00–1.04, $P = 0.02$), principal referral problem cardiac (OR 1.84, 95%CI 1.02–3.32, $P = 0.04$), lower mean arterial blood pressure (OR 0.97, 95% CI 0.95–0.99, $P = 0.005$) and tachycardia (OR 1.02, 95% CI 1.00–1.03, $P = 0.008$) on arrival at destination hospital.

Conclusions: Advanced age, lower mean arterial blood pressure and tachycardia towards the completion of transfer were associated with increased ICU mortality in this population. Clinicians should be aware of the additional risk for cardiac patients.

Key words: *aeromedical transport, critical care, intensive care, mortality, retrieval, transfer.*

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Introduction

Background

Interhospital transfer (IHT) of critically ill patients has been associated with an increased mortality rate and length of stay in the intensive care unit (ICU) and hospital when compared with patients admitted to ICU from the ED.[1–4] Patients with multi-trauma, respiratory infection, sepsis, intracranial haemorrhage, head injury and cardiac arrest have statistically significant worse outcomes than patients in other diagnostic categories.[2]

IHT exposes patients to additional factors that may have an adverse impact on patient outcome and delay access to definitive care.[1,5] Some researchers have advocated for the early transfer of patients to mitigate this risk.[3] However, previous studies have reported limited access to data describing the referral centre, transfer team, transfer mode and physiological status during the transfer. Similarly, outcomes for these patients have been poorly reported. Therefore, little is known about the transfer-specific process on patient outcomes.[2,4,6–8] Such findings could provide useful information to all stakeholders in the critical care community to heighten awareness of the vulnerabilities of this specific population.

The aim of the present study was to determine factors related to ICU mortality in critically ill patients transferred by Adult Retrieval Victoria (ARV) medical staff through linkage of ARV and ICU datasets. Patients who died in ICU were compared with those surviving ICU admission to identify independent predictors of mortality following retrieval. Analysis of the datasets aimed to identify transfer specific factors, patient factors or system factors related to mortality, with an expectation of more in-depth future analysis of a larger dataset and more comprehensive clinical data elements.

Methods

Study population

This is a retrospective cohort study of ARV cases transferred by a retrieval physician with subsequent ICU admission at the destination hospital over an 18 month period. Retrieval physicians were consultant and registrar grade medical practitioners from anaesthetic, emergency medicine and intensive care disciplines with training and experience in retrieval medicine. Medical crewing of retrieval missions occurs in cases of higher complexity and acuity compared with paramedic-only crewed cases. De-identified ARV data were linked with de-identified data from the Australian and New Zealand Intensive Care Society Centre for Outcome and Resources Evaluation Adult Patient Database (ANZICS CORE APD) to determine predictors of death in ICU following retrieval. Ethics approval for the project was obtained through Monash University Human Ethics Research Committee (MUHREC). The Ambulance Victoria Research Committee also approved the study.

The study was performed in the state of Victoria, Australia. The state covers an area of over 225 000 km^2 with a population of 5.5 million including the metropolitan area of Melbourne (4.1 million). ARV provides a range of services to this population 24 h per day including critical care and major trauma advice by specialist medical staff, management of statewide critical care bed access systems and adult retrieval services. ARV provides a single statewide contact point, a central communication and coordination hub, and telehealth outreach and support.

The study period was between 1 January 2009 and 30 June 2010. This period was selected on the basis of convenience. ARV was established in November 2007. The ARV administrative database was established in mid 2008 and provides logistic and process data on retrieval cases, clinical classification of illness types and some limited physiological data. The information system and dataset reached a level of stability and quality required for research by January 2009. Thus, although clinical data were limited and reflect the early phases of a retrieval service, it was considered worthy of examination in relation to the broad study question proposed. There were 601 medical-crewed cases transferred by ARV in the 18 month study period. Fifty-two of these cases were excluded from the process of data linkage because they had incomplete data or did not meet study inclusion criteria (Fig. 1).

The ANZICS APD data are collected as part of quality management systems and receives de-identified data from participating ICUs where strict data definitions are applied and standardised software is used to collect data at all sites.[9] Data audit is conducted routinely, and estimates relating to missing or erroneous data are known.[10] There were 25 543 case records available for data linkage from the ANZICS APD for the defined study period.

Data linkage

Victorian Data Linkages (VDL) performed linkage of these de-identified datasets using age, sex, postcode of

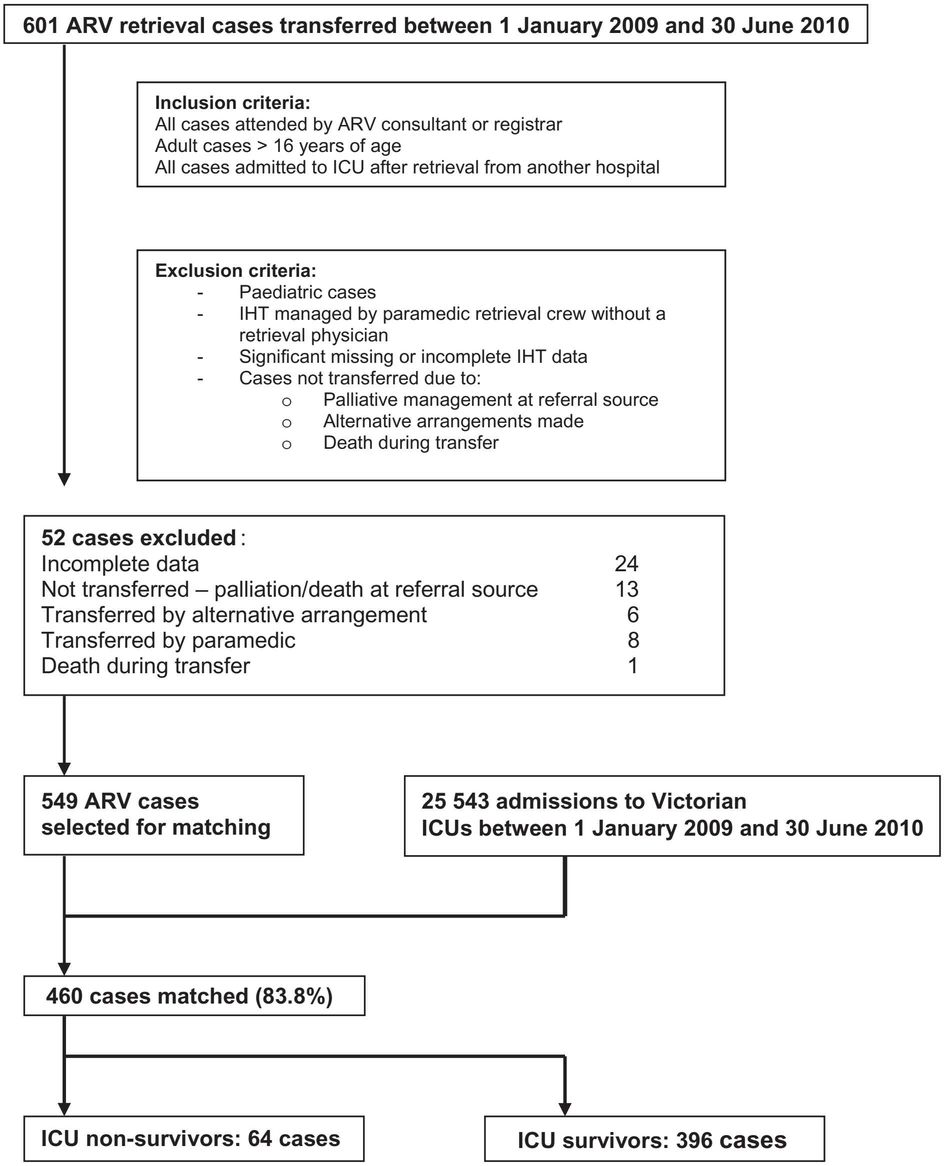

Figure 1. Selection process for cases used in the ARV/ANZICS mortality study from 1 January 2009 to 30 June 2010.

residence, hospital admission date and time. Both datasets contained 100% age, sex, hospital admission date and time. Postcode was available for 98% of ANZICS APD cases and for 80% of ARV cases. Because both datasets were de-identified, linkage was performed through a previously validated stepwise deterministic process.[11] These stepwise deterministic processes are known to have lower sensitivity but higher specificity than other linkage methods.[12] Previous work has validated the high precision of our linkage method using the ANZICS APD dataset, so we can be confident that all matched cases are likely to be 'true matches'.[13]

Baseline demographic and risk factors

Demographic data analysed included patient age, sex, referral unit, destination unit, principal problem, time of arrival at destination and retrieval intervals: time for retrieval physician to reach patient, time retrieval physician spent at referral hospital and time taken to transfer patient to destination hospital.

Clinical parameters analysed included endotracheal intubation, intubation in transit, intercostal catheter in situ, patient weight >120 kg and recorded hypo- or hyperthermia during transfer. Systolic and diastolic blood pressure, heart rate, oxygen saturation and inspired fraction of oxygen (FiO_2), Glasgow Coma Score (GCS) at beginning and end of transfer were also analysed.

Statistical analysis

Comparison was made between the matched and unmatched patient groups to assess population characteristics and any sample bias associated with the matching process. Matched cases were classified as ICU survivors if they were discharged from ICU and as nonsurvivors if they died in ICU.

All data were analysed using STATA 9.2 (Stata Corp., College Station, TX, USA). Univariate analyses were conducted using a Student's *t*-test for variables with a normal distribution, χ^2 test of equal proportions for binary categorical variables or two-sample Wilcoxon rank-sum (Mann–Whitney) test for variables with a non-parametric distribution. Univariate logistic regression was used to estimate odds ratios (OR) and their 95% confidence intervals and a two-sided *P*-value of 0.05 was considered to be statistically significant. Due to the large number of potential variables, univariate logistic regression analysis was performed only for variables of interest including selected hospital variables such as time of admission to hospital and ICU. Logistic regression was not performed on some variables of interest (GCS and FiO_2) due to incomplete data or insufficient numbers.

Results

Of the 549 ARV cases eligible for linkage, 460 cases (83.8%) could be matched by the VDL. Table 1 compares the characteristics of the matched and unmatched groups. The matched group represented a group of older male individuals. Retrieval physicians spent more time (5 min) at the referral hospital in the matched group. A significantly higher proportion of trauma patients were not matched. The matched group had a higher intubation rate and a lower initial GCS and FiO_2. The matched group therefore represented patients at the more 'unwell' end of the spectrum of medical-crewed retrieval patients. Mortality rate in the matched sample was 13.9%.

Table 2 compares the characteristics of 64 cases surviving ICU admission to 396 controls not surviving. In univariate analyses of the available demographic variables, higher ICU mortality rates were evident in cases with advanced age, longer times at scene, cardiac principal referral problems and lower mean arterial blood pressure at the end of the transfer. Similarly, the Acute Physiology and Chronic Health Evaluation (APACHE) III scores and predicted risk of death was higher in the non-survivor group. Trauma cases had lower rates of ICU mortality compared with other principal referral types.

Table 3 provides a univariate logistic regression analysis of all variables considered of interest. Variables associated with mortality were advanced age, principal referral problem cardiac, lower mean arterial blood pressure and tachycardia on arrival at destination hospital. Cases with a principal referral problem of trauma were associated with lower mortality.

Discussion

The analysis of the linked datasets aimed to identify factors related to mortality by comparing survivors to non-survivors following IHT. The principal factors associated with increased mortality were advanced age, cardiac conditions as the principal referral problem, tachycardia and a lower mean arterial blood pressure at the end of transfer.

The present study had several strengths. Data from the ANZICS CORE APD are collected and subject to strict quality control procedures.[10] The ARV administrative data were of high quality and provided excellent logistic and demographic information about retrieval patients. A high linkage rate between the two datasets was a further strength. This was achieved by use of a validated method performed by an independent party.[11] Outcomes of transferred patients could therefore be clearly determined.

The study group represents an entire population of medical-crewed retrieval patients within a specified time frame. As a large number of variables were available for analysis and the exact impact of each on the outcome unknown, a larger study population would have been beneficial. Given the large number of potential variables in this population, and the lack of comprehensive previously published data, pre-analysis sample size calculations were problematic. Variables of interest such as GCS and FiO_2 were unable to be used because of incomplete data, which was a limitation of the database at the time of analysis. The data were retrospective and extracted from a largely administrative dataset, so similarly, interventions to correct haemodynamic instability, which would have better informed our findings, were not within the scope of this initial study.

Table 1. Characteristics of 549 patients transferred by ARV retrieval physicians (1 January 2009–30 June 2010) according to linkage status†

Characteristics	Unmatched (*n* = 89)	Matched (*n* = 460)	*P* difference
Demographic and diagnostic information			
Age (years)	51.2 (23.1)	56.6 (17.7)	0.01
Sex, men (%)‡	43 (48.3)	279 (60.7)	0.03
Time to patient (min)§	67 (55, 90)	70 (55, 97)	0.40
Time at scene (min)§	50 (25, 67)	55 (40, 85)	0.003
Transfer time (min)§	114.5 (65, 149)	120 (75, 148)	0.19
Arrival time at destination hospital (%)‡			
07:00–09:00	62 (69.7)	335 (72.8)	0.54
08:00–09:00	60 (67.4)	299 (65.0)	0.66
21:00–09:00	42 (47.2)	216 (47.0)	0.97
22:00–08:00	39 (43.8)	185 (40.2)	0.53
22:00–09:00	39 (43.8)	189 (41.1)	0.63
00:00–08:00	26 (29.2)	141 (30.7)	0.79
Destination unit (%)‡			
ICU	37 (42.6)	315 (68.5)	<0.001
ED	33 (37.1)	99 (21.5)	0.002
CCU	14 (15.7)	34 (7.4)	0.01
HDU	2 (2.3)	8 (1.7)	0.74
OR	0 (0.0)	2 (0.4)	0.53
Other	1 (1.2)	1 (0.2)	0.19
Ward	2 (2.3)	0 (0.0)	0.001
Cardiac Cath Lab	0 (0.0)	1 (0.2)	0.66
Referral unit (%)‡			
ED	56 (62.9)	267 (58.0)	0.39
ICU	15 (16.9)	101 (22.0)	0.28
Ward	9 (10.1)	34 (7.4)	0.38
Other	4 (4.5)	17 (3.7)	0.72
HDU	0 (0.0)	19 (4.1)	0.051
Theatre	2 (2.3)	14 (3.0)	0.68
CCU	3 (3.4)	7 (1.5)	0.23
Principal referral problem (%)‡			
Cardiac	23 (25.8)	93 (20.2)	0.23
Respiratory	16 (18.0)	83 (18.0)	0.99
Neurological/Neurosurgical	7 (7.9)	60 (13.0)	0.17
Trauma	20 (22.5)	43 (9.4)	<0.001
Sepsis	4 (4.4)	50 (10.9)	0.07
Gastrointestinal	6 (6.7)	47 (10.2)	0.31
Toxicological	7 (7.9)	21 (4.6)	0.20
Multi-organ failure	2 (2.3)	12 (2.6)	0.84
Vascular (not neuro)	2 (2.3)	8 (1.7)	0.74
Renal	0 (0.0)	9 (2.0)	0.18
Endocrine	0 (0.0)	7 (1.5)	0.24
Other	1 (1.1)	6 (1.3)	0.89
Haematological	0 (0.0)	6 (1.3)	0.28
ENT	0 (0.0)	4 (0.9)	0.38
Immune/allergy	1 (1.1)	3 (0.7)	0.63
Gynaecological	0 (0.0)	3 (0.7)	0.45
Shock (cause unknown)	0 (0.0)	2 (0.4)	0.53
Genitourinary	0 (0.0)	1 (0.2)	0.66
Oncology	0 (0.0)	1 (0.2)	0.66
Clinical information			
Systolic blood pressure at start (mmHg)§	123.6 (24.7)	120.2 (28.9)	0.31
Systolic blood pressure at end (mmHg)§	124.5 (21.6)	122.2 (23.7)	0.42
Diastolic blood pressure at start (mmHg)§	68.0 (14.8)	66.5 (16.0)	0.43
Diastolic blood pressure at end (mmHg)§	66.7 (12.4)	65.9 (13.3)	0.61
Heart rate at start (/min)§	93.6 (26.1)	96.5 (61.7)	0.68
Heart rate at end (/min)§	88.3 (22.9)	93.7 (67.5)	0.36
Endo tracheal (ET) tube (%)‡	38 (42.7)	287 (62.4)	0.001
ET intubation in transit (%)‡	1 (1.1)	5 (1.1)	0.98
Oxygen saturation at start (%)§	99 (97, 100)	99 (97, 100)	0.67
Oxygen saturation at end (%)§	100 (98, 100)	100 (98, 100)	0.47
Fractional inspired oxygen at start (%)§	40 (30, 100)	60 (40, 100)	0.008
Glasgow coma score at start§	14 (3, 15)	3 (3, 15)	0.01
Intercostal catheter in situ (%)‡	4 (4.5)	19 (4.1)	0.88
Recorded hypothermia <35°C (%)‡	2 (2.3)	18 (3.9)	0.44
Recorded hyperthermia >38°C (%)‡	2 (2.3)	19 (4.1)	0.40
Patient weight >120 kg (%)‡	5 (5.6)	23 (5.0)	0.81

†*ARV, Adult Retrieval Victoria. Stepwise deterministic linkage was used to match ARV records with Australia and New Zealand Intensive Care Society (ANZICS) records. Values are mean (standard deviation), unless otherwise stipulated.* P *difference by unpaired t-test.* ‡*Binary categorical data presented as n (%).* P *difference using Pearson's* χ^2 *statistic.* §*Values are median (interquartile range).* P *difference using the two-sample Wilcoxon rank-sum (Mann–Whitney) non-parametric test.*

Table 2. Characteristics of 460 patients transferred by ARV retrieval physicians (1 January 2009–30 June 2010) aged 16–90 years, according to survival status in ICU†

Characteristics	Overall (*n* = 460)	Survivors (*n* = 396)	Non-survivors (*n* = 64)	*P* difference
Demographic and diagnostic information				
Age (years)	56.6 (17.7)	55.8 (18.2)	61.4 (14.0)	0.02
Sex, men (%)‡	279 (60.7)	243 (61.4)	36 (56.3)	
Time to patient (min)§	70 (55, 95)	70 (55, 94)	70 (50, 105)	
Time at scene (min)§	55 (40, 85)	55 (40, 80)	63 (50, 92)	
Transfer time (min)§	120 (75 148)	120 (79, 146)	120 (70, 150)	
Arrival time at destination hospital (%)‡				
00:00–08:00	141 (30.7)	124 (31.3)	17 (26.6)	
08:00–16:00	99 (21.5)	85 (21.5)	14 (21.9)	
16:00–00:00	220 (47.8)	187 (47.2)	33 (51.6)	
08:00–20:00	212 (46.1)	179 (45.2)	33 (51.6)	
20:00–08:00	248 (53.9)	217 (54.8)	31 (48.4)	
ICU admission time (%)‡				
00:00–08:00	127 (27.6)	105 (26.5)	22 (34.4)	
08:00–16:00	117 (25.4)	102 (25.8)	15 (23.4)	
16:00–00:00	216 (47.0)	189 (47.7)	27 (42.2)	
08:00–20:00	219 (47.6)	18 (47.5)	31 (48.4)	
20:00–08:00	241 (52.4)	208 (52.5)	33 (51.6)	
Principal referral problem (%)‡				
Cardiac	93 (20.2)	74 (18.7)	19 (29.7)	0.04
Respiratory	83 (18.0)	74 (18.7)	9 (14.1)	
Neurological/Neurosurgical	60 (13.0)	54 (13.6)	6 (9.4)	
Trauma	43 (9.4)	42 (10.6)	1 (1.6)	0.02
Sepsis	50 (10.9)	43 (10.9)	7 (10.9)	
Gastrointestinal	47 (10.2)	39 (9.9)	8 (12.5)	
Toxicological	21 (4.6)	20 (5.1)	1 (1.6)	
Multi-organ failure	12 (2.6)	10 (2.5)	2 (3.1)	
All other	50 (10.9)	40 (10.1)	10 (15.6)	
Clinical information				
Systolic blood pressure at start (mmHg)	120 (29)	121 (28)	116 (32)	
Systolic blood pressure at end (mmHg)	122 (24)	123 (24)	117 (22)	0.04
Diastolic blood pressure at start (mmHg)	66 (16)	67 (16)	64 (16)	
Diastolic blood pressure at end (mmHg)	66 (13)	67 (13)	61 (12)	0.002
Mean arterial pressure at start (mmHg)	85 (19)	85 (19)	81 (19)	
Mean arterial pressure at end (mmHg)	85 (15)	86 (15)	80 (12)	0.005
Heart rate at start (/min)	94 (24)	93 (24)	99 (24)	
Heart rate at end (/min)	91 (23)	90 (22)	98 (25)	0.008
Fractional inspired oxygen at start (%)§	60 (40 100)	60 (40 100)	100 (55 100)	0.008
Oxygen saturation at start (%)§	99 (97, 100)	99 (97, 100)	99 (96, 100)	
Oxygen saturation at end (%)§	100 (98, 100)	100 (98, 100)	100 (97, 100)	
Glasgow coma score at start§	3 (3, 15)	3 (3, 15)	3 (3, 15)	
Recorded hypothermia <35°C (%)‡	18 (3.9)	15 (3.8)	3 (4.7)	
Recorded hyperthermia >38°C (%)‡	19 (4.1)	17 (4.3)	2 (3.1)	
Endo tracheal (ET) tube (%)‡	287 (62.4)	242 (61.1)	45 (70.3)	
ET intubation in transit (%)‡	5 (1.1)	4 (1.0)	1 (1.6)	
Patient weight >120 kg (%)‡	23 (5.0)	18 (4.6)	5 (7.8)	
Hospital length of stay (h)§	240 (106, 451)	274 (139, 493)	61 (20, 186)	<0.0001
APACHE III score§	57 (39, 81)	52 (38, 71)	105 (81, 131)	<0.0001
APACHE III risk of death (%)§	13 (4, 39)	10 (3, 27)	73 (44, 86)	<0.0001

†*ARV, Adult Retrieval Victoria. Stepwise deterministic linkage was used to match ARV records with Australia and New Zealand Intensive Care Society (ANZICS) records. Values are mean (standard deviation), unless otherwise stipulated.* P *difference by unpaired* t-test. ‡*Binary categorical data presented as n (%).* P *difference using Pearson's* χ^2 *statistic.* §*Values are median (interquartile range).* P *difference using the two-sample Wilcoxon rank-sum (Mann–Whitney) non-parametric test.*

Table 3. Odds ratios (OR [95% CI]) using univariate logistic regression for death in ICU, among 460 patients (279 males) aged 16–90 years, transferred by ARV retrieval physicians (1 January 2009–30 June 2010)†

Characteristics	Univariate analysis‡		
	OR	(95% CI)	*P*-value
Demographic/diagnostic information			
Age (years)	1.02	(1.00–1.04)	0.02
Sex, men (%)	0.81	(0.47–1.38)	0.44
Time to patient (min)	1.00	(0.99–1.01)	0.48
Time at scene (min)	1.00	(0.99–1.01)	0.16
Transfer time (min)	1.00	(0.99–1.01)	0.90
Arrival at destination 00:00–08:00 (%)	0.79	(0.44–1.44)	0.45
ICU admission time 00:00–08:00 (%)	1.45	(0.83–2.55)	0.19
Principal referral problem (%)			
Cardiac	1.84	(1.02–3.32)	0.04
Respiratory	0.71	(0.34–1.51)	0.37
Neurological/neurosurgical	0.66	(0.27–1.59)	0.35
Trauma	0.13	(0.02–0.99)	0.05
Sepsis	1.01	(0.43–2.35)	0.99
Gastrointestinal	1.31	(0.58–2.94)	0.52
Toxicological	0.30	(0.04–2.26)	0.24
Multi-organ failure	1.25	(0.27–5.82)	0.78
Clinical information			
Mean arterial pressure at start (mmHg)	0.99	(0.97–1.00)	0.13
Mean arterial pressure at end (mmHg)	0.97	(0.95–0.99)	0.005
Heart rate at start (/min)	1.01	(0.99–1.02)	0.06
Heart rate at end (/min)	1.02	(1.00–1.03)	0.008
Oxygen saturation at start (%)	0.96	(0.90–1.03)	0.26
Oxygen saturation at end (%)	0.98	(0.94–1.02)	0.29
Recorded hypothermia <35°C (%)	1.25	(0.35–4.44)	0.73
Recorded hyperthermia >38°C (%)	0.72	(0.16–3.19)	0.66
Endo tracheal (ET) tube (%)	1.51	(0.85–2.67)	0.16
ET intubation in transit (%)	1.56	(0.17–14.14)	0.70
Patient weight >120 kg (%)	1.78	(0.64–4.98)	0.27

†ARV, Adult Retrieval Victoria. Stepwise deterministic linkage was used to match ARV records with Australia and New Zealand Intensive Care Society (ANZICS) records. ‡Univariate analysis using logistic regression. OR, odds ratio (95% confidence interval).

IHT of critically ill patients increases mortality risk.[1–4] Our findings confirmed older patients with cardiac conditions are at higher risk. These factors may be relevant in consideration of appropriateness of transfer or in determining response methods and crew skill mix and capability.

Analysis of the principal referral problem revealed a survival benefit in the trauma group. Univariate comparison between survivors and non-survivors indicated a low mortality rate in this group. The finding is statistically significant but interpretation of clinical significance is difficult considering the small sample size and potential sample bias. The vast majority of major trauma patients in Victoria are transferred directly from a scene to a major trauma service and are therefore not exposed to secondary interhospital retrieval. The high number of unmatched patients in the trauma group is likely because of the fact that patients transferred to major trauma centres are often subsequently discharged to wards instead of ICU.

After hours and overnight admission to ICU has been associated with worse outcomes in some studies.[14] However, it remains a contentious point, and meta-analysis has not been able to refute this claim.[15] Our study was unable to find an association between ICU admission time and mortality. Further investigation and review of critical care organisational systems is warranted.

Conclusion

In this population where IHT of critical patients was managed by retrieval physicians, mortality was associated with advanced age, cardiac conditions, lower mean arterial blood pressure and tachycardia on arrival at the destination hospital. These findings are based on a small dataset only; however, they support both optimised cardiovascular support for these patients and a heightened awareness of those retrieval patients at greatest risk. Our study was underpowered and as such was unable to identify other clinical factors that may be associated with mortality. Although not surprising, the results presented in the present paper validate the importance of supporting the collection and maintenance of high quality clinical and administrative data such as ours. Further analysis of transfer and clinical factors is recommended as more data are acquired over time and between different retrieval systems.

Author contributions

MK, PV, LRH, GKH, MB conceived the study and its design. LS performed data linkage. LRH conducted the statistical analysis. PV, LRH and MK developed the first draft of the manuscript. All authors contributed to the final version.

Competing interests

None declared.

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