Impact of the introduction of an integrated adult retrieval service on major trauma outcomes

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Received 4 October 2014
Revised 2 August 2015
Accepted 30 August 2015
Published Online First 18 September 2015

ABSTRACT

Objectives The primary aim of this study was to examine the impact of the introduction of an integrated adult critical care patient retrieval system in Victoria, Australia, on early clinical outcomes for major trauma patients who undergo interhospital transfer. The secondary aims were to examine the impact on quality and process measures for interhospital transfers in this population, and on longer-term patient-reported outcomes.

Methods This is a cohort study using data contained in the Victorian State Trauma Registry (VSTR) for major trauma patients >18 years of age between 2009 and 2013 who had undergone interhospital transfer. For eligible patients, data items were extracted from the VSTR for analysis: demographics, injury details, hospital details, transfer details, Adult Retrieval Victoria (ARV) coordination indicator and transfer indicator, key clinical observations and outcomes.

Results There were 3009 major trauma interhospital transfers in the state with a transfer time less than 24 h. ARV was contacted for 1174 (39.0%) transfers. ARV-coordinated metropolitan transfers demonstrated lower adjusted odds of inhospital mortality compared with metropolitan transfers occurring without ARV coordination (OR 0.39, 0.15 to 0.97). Adjusting for destination hospital type demonstrates that this impact was principally due to ARV facilitation of a Major Trauma Service as the destination for transferred patients (OR 0.41, 0.16 to 1.02). The median time spent at the referral hospital was lower for ARV-coordinated transfers (5.4 h (3.8 to 7.5) vs 6.1 (4.2 to 9.2), p<0.0001).

Conclusions In a mature trauma system, an effective retrieval service can further reduce mortality and improve long-term outcomes.

Key messages

What is already known on this subject?
Multiple studies have determined that trauma systems improve patient outcomes. Further observational studies identify that the interhospital transfer of trauma patients within trauma systems is complex and high risk. Yet to date, there has not been any data published that evaluates the implementation of any model of interhospital patient retrieval within an integrated trauma system to help health services plan and develop their trauma systems.

What might this study add?
This retrospective study demonstrated that severely injured patients who have their interhospital transfer coordinated by a centralised and specialised patient retrieval service have reduced risk-adjusted odds of inhospital mortality and improved long-term functional outcomes when compared with patients who are transferred between hospitals without retrieval service contact. The principal impact of retrieval coordination lies in the determination of a major trauma service as the destination. The uses of highly skilled staff overseeing the retrieval process improved logistical coordination, central coordination of destination choice and appear to contribute to the benefit.

INTRODUCTION

Integrated trauma systems have been shown to improve patient outcomes.[1–3] These systems are comprised of various elements, including development and designation of hospital trauma services, systems for triaging patients to the appropriate trauma service as well as retrieval of patients from lower to higher level centres of care. The interhospital retrieval of trauma patients to definitive trauma care is an important aspect of a trauma system, and is in itself a complex operation. There is little published data to define the impact of patient retrieval systems or to support a particular model as best practice within an integrated and functioning trauma system.

The definition and models of care in retrieval medicine vary significantly by jurisdiction. However, for the purposes of this paper, it is defined as the coordinated interhospital transfer and clinical care of critical patients using specialised clinical staff, transport platforms and equipment.[4] Typically, retrieval services receive case information from a referrer who is seeking assistance with clinical management and/or transfer of a patient to a hospital with greater capability. The case coordinator is generally a medical practitioner of senior status and from a critical care or other relevant specialty. Coordination aims to move the patient to the destination most appropriate for the clinical need and in a safe and time-efficient way.

The Victorian State Trauma System (VSTS) was established in Victoria, Australia, following a ministerial review of emergency and trauma services,[5] resulting in a 37% reduction in risk-adjusted mortality for hospitalised patients with severe trauma.[2] The proportion of all major trauma patients directly transported from the scene of injury to a major trauma service (MTS) increased from 59% in

To cite: Kennedy MP, Gabbe BJ, McKenzie BA. *Emerg Med J* 2015;**32**:833–839.

2001–2002 to 67% in 2005–2006, and the proportion of road trauma major trauma patients transferred from the scene of injury directly to an MTS hospital increased from 55% in 2001–2002 to 77% in 2010–2011.[6]

Secondarily transferred trauma patients are perceived as higher risk in terms of morbidity and mortality, although accurate data is scant.[7 8] The Victorian major trauma transfer study[9] examined the interhospital transfer of 451 major trauma patients during 2003–2004. It was a descriptive study undertaken prior to the introduction of Adult Retrieval Victoria (ARV), and showed a mortality rate of 6.1% for patients secondarily transferred, with highest mortality rates associated with transfer by referring hospital junior medical staff (resident and registrar grade). The study predated the introduction of the current retrieval system, and neither it nor other published papers have reviewed risk-adjusted short-term and long-term outcomes for major trauma retrieval patients.

This study examines the impact of the introduction of an integrated retrieval system in Victoria on early clinical outcomes for major trauma patients who undergo interhospital transfer.

METHODS

Setting

Prior to 2007, the Victorian Adult Emergency and Retrieval Coordination Service delivered retrieval services in Victoria under the auspices of St Vincent's Hospital. Following a review published in 2006 by the Victorian Department of Human Services,[10] Victoria moved to optimise its adult retrieval services. The principles identified by that report were to adopt a retrieval model with standard operating procedures, a 'one-stop shop' for referrers using a single phone call, improved central governance, operational integration, a comprehensive system with state-wide accessibility and promotion of health-service participation and early warning and activation of the system. While the overall distribution of major trauma cases originating in regional versus metropolitan settings was similar, ARV was commissioned with a primary goal of narrowing the service gap and 'tyranny of distance' for rural and regional patients. Rural patients face greater transfer times to definitive care, and often are initially cared for in smaller hospitals with lower levels of resource and staffing compared with metropolitan patients; both factors potentially leading to different clinical outcomes. Consequently, the early focus of the service was on coordination of retrieval for non-metropolitan patients, both major trauma and general critical care. The result was the establishment of ARV in 2007 as an operational department within Ambulance Victoria (AV), providing a comprehensive, integrated adult critical care retrieval service that is staffed by medical practitioners.

Interhospital transfers, not coordinated by ARV, are managed using disparate methods; transport platforms varying from non-emergency (contracted private provider) ambulance to emergency state ambulance, and crews ranging from nurse and/or basic ALS paramedic to intensive care paramedic, including junior medical staff with limited or no training or experience in retrieval medicine.

The Victorian State Trauma Registry (VSTR) is a population-based trauma registry, capturing data about all major trauma patients in Victoria. The registry has been operating since July 2001, and collects data from the prehospital and acute hospital settings, as well as following up patients to 2 years' postinjury to collect long-term functional and health-related quality-of-life outcomes.[11 12] The VSTR operates using an opt-off consent process to ensure complete capture of all cases in the state. The VSTR and ARV coordinate data each quarter to ensure that all cases involving ARV are identified in the registry, and accurate and complete data are provided.

Participants

All adult (>15 years of age) major trauma patients with at least one interhospital transfer recorded, a date of injury from 1 January 2008 to 31 December 2013 and a total transfer time <24 h were extracted for analysis. Transfer time was the time from arrival at the primary hospital to arrival at the destination hospital. Major trauma patients injured overseas were excluded. Paediatric major trauma patients were also excluded as the retrieval of paediatric cases is coordinated by other services in the state.

Procedures

For eligible patients, the demographic, preinjury characteristics, injury event details, injury type, Injury Severity Score (ISS), hospital details, transfer details, clinical observations, inhospital outcomes and 6-month postinjury outcomes were extracted from the VSTR for analysis.

Data analysis

Summary statistics were used to compare cases coordinated by ARV and cases without ARV coordination. Frequencies and percentages were used for categorical variables, and the mean and SD or median and IQR for continuous variables. χ^2, Mann–Whitney U tests and independent t tests were used to test for an association between covariates and whether the case was coordinated by ARV. Data from 2008 were excluded from the analysis because this year was an establishment year where new service processes were not yet established. Due to the multiple comparisons, a Bonferroni correction was used, and a p value <0.002 was considered significant.

Multivariable binary logistic and ordinal logistic models were performed to quantify the association between mode of transfer coordination, and each outcome, adjusted for variables demonstrating a potentially important ($p<0.10$) difference in case-mix between the groups on preliminary analyses (ie, potential confounders). ARV coordination (yes/no) was considered the exposure of interest. The outcomes of interest were inhospital mortality, admission to intensive care unit (ICU) and 6-month outcome functional scores (Glasgow outcome scale (extended) (GOS-E)) and return to work. The GOS-E rates the patient's level of function on a scale from 1 (death) to 8 (upper good recovery), and was analysed as an ordinal variable. The death and vegetative state categories of the GOS-E were merged into a single category for analysis due to the low number of cases classified as vegetative state. For all return to work analyses, only patients confirmed as working prior to injury were included.

Adjusted ORs (95% CI) were reported for binary logistic and ordinal regression analyses to provide an estimate of the strength of association, and the precision, between ARV coordination and outcome. An interaction term between the region of the transfer (metropolitan Melbourne or regional Victoria) and ARV coordination was included to establish whether the association between coordination source and outcome differed depending on whether the transfer was from a health service based in metropolitan Melbourne or regional Victoria. Model fit was assessed using the Hosmer–Lemeshow statistic, as well as standardised residuals and leverage to check for influential

observations. Where continuous predictor variables (ie, age, ISS and shock index) were shown not to have a linear relationship with the outcome of interest, log transformation or categorisation was used to include these in the models. The Brant test was used to test the assumption of proportional odds for the ordered logistic regression model. All analyses were performed using Stata SE V.13.0.

Ethics approval was provided for all VSTR research by all trauma-receiving hospitals in the state of Victoria and by the Monash University Human Research and Ethics Committee.

RESULTS

ARV was contacted in 36% (n=1261) of major trauma interhospital transfers <24 h, and transported 30% (n=1045) of cases to the definitive care hospital. The proportion of cases where ARV was contacted and provided case coordination increased from 17% (n=87) in 2008 to 48% (n=308) in 2013 (p<0.001, figure 1). The proportion of major trauma cases directly crewed by ARV retrieval teams increased from 17% (n=87) in 2008 to 33% (n=208) in 2013 (p<0.001).

From 2009 to 2013, there were 3009 major trauma interhospital transfers in the state with a transfer time <24 h. In this timeframe, ARV was contacted for 1174 (39.0%) transfers. Cases coordinated by ARV were younger, had a higher prevalence of comorbidities and were more commonly transport-related (table 1).

The majority of ARV-coordinated transfers were from regional Victoria and transferred from regional trauma services, compared with non-ARV transfers that were predominantly from metropolitan areas and metropolitan trauma services (MeTS) (table 2). Most ARV-coordinated transfers were transported to a (level 1) MTS, while a higher proportion of non-ARV transfers were to a (level 2) MeTS. The time spent at the referral hospital was lower for ARV-coordinated transfers, but the transport time was higher, reflecting the prevalence of regional patients transferred by ARV (table 2).

Although the majority of patients had a final destination of MTS, there were differences in destination type based on the region of origin. A higher proportion of patients transferred from a regional hospital were transported to an MTS (X^2_3=59.80, p<0.001) (table 3).

The mean shock Index was higher in patients coordinated by ARV on arrival at the definitive hospital and at arrival at the referral hospital. There was a higher prevalence of burn and head injury multitrauma cases transported by ARV, while cases not coordinated by ARV involved a higher proportion of spinal cord injury, orthopaedic and isolated head injury cases (table 4). The ISS of ARV cases was higher, and a greater proportion of ARV cases were admitted to ICU. Consistent with the overall greater injury severity, the hospital length of stay for ARV-coordinated cases was higher; however, the inhospital death rate was consistent with the non-ARV-coordinated cases (table 4).

Of the 3009 major trauma cases transferred from 2009 to 2013, 2660 (88.4%) had a valid GOS-E score at 6 months (including inhospital deaths). Fifty-three per cent were studying or working for income prior to injury. Table 5 shows the longer-term outcomes for ARV-coordinated and non-coordinated transfer cases. A higher proportion of major trauma patients transferred by ARV were living independently (GOS-E score of lower moderate disability or higher) at 6 months, but there was no association between the source of transfer coordination and functional recovery (GOS-E upper good recovery) or return to work.

The association between ARV coordination of interhospital transfer and the risk of inhospital mortality was different for cases transferred from regional hospitals compared with metropolitan hospitals (table 6). ARV-coordinated metropolitan transfers demonstrated lower adjusted odds of inhospital mortality compared with metropolitan transfers occurring without ARV coordination (table 6). ARV-coordinated metropolitan transfers also demonstrated better risk-adjusted functional (GOS-E) outcomes at 6 months postinjury when compared with metropolitan transfers occurring without ARV coordination (table 6). Analysis in the model of whether the patient was managed at an MTS hospital only partially explained the difference in outcomes. There was no association between ARV coordination and return to work.

DISCUSSION

System redesign as occurred in the establishment of ARV was intended to alter both practices and outcomes. When adjusted for age, gender, comorbidity, injury type and severity, GCS, and

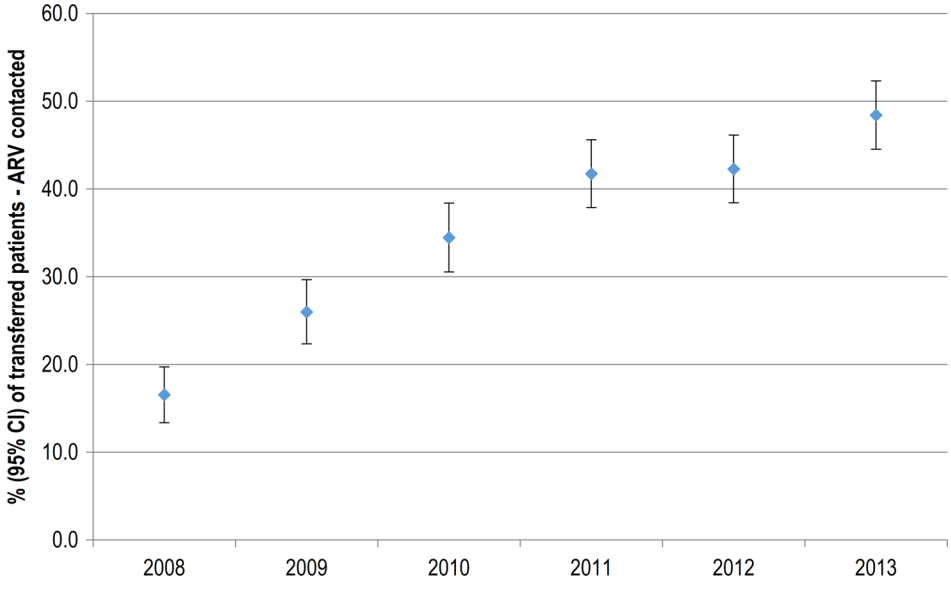

Figure 1 Proportion of transferred major trauma cases where Adult Retrieval Victoria (ARV) was contacted.

Table 1 Profile of cases by source of transfer coordination

Descriptor	ARV coordination (n=1174)	No ARV coordination (n=1835)	p Value
Age group (years)			
N (%)			
16–24	220 (18.7)	261 (14.2)	<0.001
25–34	153 (13.0)	207 (11.3)	
35–44	180 (15.3)	209 (11.4)	
45–54	156 (13.3)	220 (12.0)	
55–64	140 (11.9)	224 (12.2)	
65–74	153 (13.0)	225 (12.3)	
75–84	131 (11.2)	308 (16.8)	
85+	41 (3.5)	181 (9.9)	
Sex			
N (%)			
Male	894 (76.2)	1315 (71.7)	0.007
Female	280 (23.8)	520 (28.3)	
CCI weighting			
N (%)			
0	649 (55.3)	1183 (64.5)	<0.001
1	381 (32.4)	452 (24.6)	
≥2	144 (12.3)	200 (10.9)	
*Injury intent**			
N (%)			
Unintentional	1012 (86.9)	1595 (87.2)	0.12
Intentional self-harm	32 (2.7)	32 (1.8)	
Intentional—other	100 (8.6)	175 (9.7)	
Intent cannot be determined	21 (1.8)	23 (1.3)	
Cause of injury†			
N (%)			
Low fall (<1 m)	239 (20.4)	677 (37.1)	<0.001
Motor vehicle	276 (23.6)	229 (12.5)	
Motorcycle	129 (11.0)	165 (9.0)	
High fall	111 (9.5)	221 (12.1)	
Struck by/collision with person	75 (6.4)	136 (7.4)	
Struck by/collision with object	70 (6.0)	104 (5.7)	
Pedal cyclist	56 (4.8)	95 (5.2)	
Pedestrian	42 (3.6)	43 (2.3)	
Cutting/piercing object	19 (1.6)	33 (1.8)	
Other	152 (13.0)	123 (6.7)	

*Data missing for n=16 cases.
†Data missing for n=14 cases.
ARV, Adult Retrieval Victoria; CCI, Charlson Comorbidity Index.

Table 2 Transfer and transport details by source of transfer coordination

Descriptor	ARV coordination (n=1174)	Non-ARV coordination (n=1835)	p Value
*Region of injury event**			
N (%)			
Metropolitan Melbourne	179 (16.2)	1014 (60.5)	<0.001
Regional Victoria	914 (82.5)	648 (38.7)	
Interstate	15 (1.3)	14 (0.8)	
Referral hospital region			
N (%)			
Metropolitan trauma service	112 (9.5)	1214 (66.2)	<0.001
Regional trauma service	1062 (90.5)	621 (33.8)	
Destination VSTS level			
N (%)			
Level 1/ MTS	1082 (92.2)	1342 (73.1)	<0.001
Level 2/MeTS	47 (4.0)	309 (16.8)	
Austin (spinal)	36 (3.1)	133 (7.2)	
Regional trauma service	8 (0.7)	29 (1.6)	
Metropolitan primary care service	1 (0.1)	22 (1.2)	
Time at referral hospital†			
Median (IQR) hours	5.4 (3.8–7.5)	6.1 (4.2–9.2)	<0.0001
Transport time‡			
Median (IQR) hours	1.7 (1.2–2.4)	1.0 (0.7–1.6)	<0.0001
Total transfer time			
Median (IQR) hours	7.4 (5.5–9.8)	7.4 (5.3–10.6)	0.49

*Data missing for n=225 cases.
†Data missing for n=88 cases.
‡Data missing for n=115 cases.
ARV, Adult Retrieval Victoria; MeTS, metropolitan trauma service; MTS, major trauma service; VSTS, Victorian State Trauma System.

shock index, cases managed by referral into this new system have demonstrated improved process management (time at referral hospital) and in metropolitan patients have demonstrated better clinical outcomes in both short and longer term (death, GOS-E). After adjusting for destination type, it is clear that an important component of the impact of retrieval coordination lies in the determination of an MTS as the destination, an intervention known to improve clinical outcomes. In addition to this, there appear to be other retrieval-related factors (undefined) that also demonstrate benefit.

Similar outcome impacts associated with retrieval systems have been described in other jurisdictions and in patient populations with a broader range of clinical presentations than the major trauma group we have studied.[13] The weakness of ad hoc approaches to critical patient transfer has also previously been highlighted, as has the preference for coordinated, organised retrieval systems.[14 15]

The VSTS has demonstrated growing confidence in the retrieval service, with approximately 50% of major trauma transfers now coordinated via ARV, whereas pre-2008, the retrieval service coordinated <15% of major trauma transfers. Despite the ARV-coordinated group being more unstable and more severely injured, overall mortality of retrieval patients was comparable or less than mortality rates in non-retrieval patients.

Significant differences in system process and structure exist between retrieval-service-coordinated cases and the remainder,

Table 3 VSTS destination level by source of transfer coordination and region of initial hospital

	Regional		Metro	
Destination VSTS level	ARV coordination (n=1062)	Non-ARV coordination (n=621)	ARV coordination (n=112)	Non-ARV coordination (n=1214)
N (%)				
MTS	990 (93.2)	509 (82.0)	92 (82.1)	833 (68.6)
MeTS	36 (3.4)	55 (8.9)	11 (9.8)	254 (20.9)
Austin (spinal)	27 (2.5)	28 (4.5)	9 (8.0)	105 (8.7)
Other	9 (0.8)	29 (4.7)	0 (0.0)	22 (1.8)

ARV, Adult Retrieval Victoria; MeTS, metropolitan trauma service; MTS, major trauma service; VSTS, Victorian State Trauma System.

Table 4 Injuries and inhospital outcomes by source of transfer coordination

Descriptor	ARV coordination (n=1174)	Non-ARV coordination (n=1835)	p Value
*Trauma type**			
N (%)			
Blunt	1060 (90.5)	1737 (94.5)	<0.001
Penetrating	28 (2.4)	45 (2.5)	
Burn	70 (6.0)	45 (2.5)	
Other	13 (1.1)	8 (0.5)	
ISS†			
N (%)			
1–12	193 (16.5)	309 (16.9)	<0.001
13–15	185 (15.8)	367 (20.1)	
16–17	249 (21.2)	456 (24.9)	
18–24	217 (18.5)	243 (13.3)	
25+	329 (28.0)	455 (24.9)	
Injury group‡*			
N (%)			
Other/multitrauma (except neuro)	458 (39.1)	483 (26.4)	<0.001
Isolated head injury	257 (21.9)	550 (30.1)	
Head and associated injuries	298 (25.4)	360 (19.7)	
Spinal column/extremity injuries	108 (9.2)	282 (15.4)	
Spinal cord injury	31 (2.6)	96 (5.2)	
Chest/abdominal injuries only	21 (1.8)	59 (3.2)	
Shock index on arrival at definitive hospital§*			
Mean (SD)	0.67 (0.44)	0.61 (0.26)	<0.0001
Shock index on arrival at referral hospital¶*			
Mean (SD)	0.67 (0.22)	0.62 (0.19)	<0.0001
*GCS on arrival at definitive hospital***			
N (%)			
3–8	498 (42.9)	239 (13.3)	<0.001
9–12	15 (1.3)	44 (2.5)	
13–15	648 (55.8)	1513 (84.2)	
GCS on arrival at the referral hospital††			
N (%)			
3–8	114 (10.0)	61 (3.4)	<0.001
9–12	87 (7.6)	74 (4.2)	
13–15	940 (82.4)	1650 (92.4)	
ICU admission?			
N (%)			
No	502 (42.8)	1295 (70.6)	<0.001
Yes	672 (57.2)	540 (29.4)	
ICU length of stay (days)‡‡*			
N (%)			
1	45 (6.7)	53 (9.8)	0.01
2–3	228 (33.9)	214 (39.6)	
4–7	217 (32.3)	134 (24.8)	
8+	182 (27.1)	139 (25.7)	
Ventilation time‡‡,§§*			
Median (IQR) hours	35 (11–110)	19 (0–75)	<0.0001
Length of stay			
Median (IQR) days	8.7 (4.7–15.7)	6.8 (3.9–12.5)	<0.0001
Discharge destination§§*			
N (%)			
Home	552 (47.0)	943 (51.4)	0.11
Inpatient rehabilitation	454 (38.7)	625 (34.1)	
Death	83 (7.1)	135 (7.4)	
Other	85 (7.2)	131 (7.1)	

*Data missing for n=3 cases.
†Data missing for n=6 case.
‡Data missing for n=6 cases.
§Data missing for n=48 cases.
¶Data missing for n=34 cases.
**Data missing for n=52 cases.
††Data missing for n=83 cases.
‡‡If admitted to ICU.
§§Data missing for n=1 case.
ARV, Adult Retrieval Victoria; ICU, intensive care unit; ISS, Injury Severity Score.

which are managed and transferred using ad hoc systems. The differences are illustrated in figure 2 below:

From inception, the retrieval service has predominantly directed its attention to the rural subpopulation of patients on the basis that local responses, regional hospital capabilities and distance and logistic factors all posed additional risk for such patients. As a department of AV, ARV developed or adopted effective internal ambulance systems and consistent processes for managing these transfers, employing principally air, but also road transport options. As noted above, metropolitan transfers coordinated via the retrieval service had significant survival and functional outcome benefits compared with non-metropolitan patients. Processes for interhospital transfers from regional centres in Victoria that are not coordinated by ARV are generally managed directly by the ambulance air transport department, which is collocated with the retrieval service. There is, therefore, considerable similarity and overlap between these departments, their clinical practice guidelines and their processes. In contrast, metropolitan transfers not managed by ARV may be facilitated by many pathways without the levels of process consistency or structure seen in rural and regional transfers. In such circumstances, patients are managed without reference to or clinical support from the ARV medical coordinator (who has

Table 5 Six-month outcomes by source of transfer coordination

Descriptor	ARV coordination	Non-ARV coordination	p Value
Functional recovery?			
N (%)			
No	848 (80.3)	1270 (79.2)	0.48
Yes	208 (19.7)	334 (20.8)	
Independent living?			
N (%)			
No	280 (26.5)	506 (31.6)	0.005
Yes	776 (73.5)	1098 (68.5)	
*Return to work?**			
N (%)			
No	202 (35.9)	232 (31.3)	0.08
Yes	360 (64.1)	509 (68.7)	

*If working prior to injury.
ARV, Adult Retrieval Victoria.

Table 6 Association between ARV coordination and outcome

Outcome	Model excluding level of definitive care in the system Adjusted OR (95% CI)	Model including level of definitive care in the system Adjusted OR (95% CI)
ICU stay†		
Not ARV and metropolitan hospital (reference)	1.00	1.00
Not ARV and regional hospital	0.82 (0.61 to 1.11)	0.83 (0.62 to 1.12)
ARV-coordinated and regional hospital	1.22 (0.93 to 1.59)	1.28 (0.98 to 1.68)
ARV-coordinated and metropolitan hospital	1.50 (0.79 to 2.83)	1.54 (0.81 to 2.94)
Inhospital death‡		
Not ARV and metropolitan hospital (reference)	1.00	1.00
Not ARV and regional hospital	0.83 (0.52 to 1.33)	0.87 (0.55 to 1.39)
ARV-coordinated and regional hospital	0.69 (0.45 to 1.05)	0.73 (0.48 to 1.39)
ARV-coordinated and metropolitan hospital	0.39 (0.15 to 0.97)	0.41 (0.16 to 1.02)
Return to work at 6 months§		
Not ARV and metropolitan hospital (reference)	1.00	1.00
Not ARV and regional hospital	0.91 (0.63 to 1.30)	0.87 (0.61 to 1.25)
ARV-coordinated and regional hospital	1.06 (0.76 to 1.48)	1.00 (0.71 to 1.39)
ARV-coordinated and metropolitan hospital	1.03 (0.48 to 2.23)	0.98 (0.45 to 2.16)
GOS-E score at 6 months¶		
Not ARV and metropolitan hospital (reference)	1.00	1.00
Not ARV and regional hospital	1.03 (0.86 to 1.23)	1.00 (0.83 to 1.19)
ARV-coordinated and regional hospital	1.17 (0.99 to 1.38)	1.08 (0.91 to 1.27)
ARV-coordinated and metropolitan hospital	1.47 (1.01 to 2.14)	1.41 (0.97 to 2.05)

†Model adjusted for age group, gender, CCI, cause of injury, ISS group, injury group, GCS on arrival at definitive hospital of care, natural log shock index and source of referral.
‡Model adjusted for age, gender, CCI, cause of injury, natural log of ISS, injury group, GCS on arrival at definitive hospital of care, shock index and source of referral.
§Model adjusted for age, gender, CCI, cause of injury, ISS, injury group, GCS on arrival at definitive hospital of care, shock index and source of referral, and only in patients who were working prior to injury.
¶Model adjusted for age group, gender, CCI, cause of injury, ISS, injury group, GCS on arrival at definitive hospital of care, shock index and source of referral.
ARV, Adult Retrieval Victoria; CCI, Charlson Comorbidity Index; ICU, intensive care unit; ISS, Injury Severity Score.

advanced training and experience in retrieval medicine), and may be transferred by junior staff, with little training or exposure to transport medicine, and inconsistent equipment, monitoring and interventions. These fundamental differences may, in part, explain the less significant outcome differences seen in rural retrieval patients compared with metropolitan retrieval patients.

Other factors associated with professional case coordination such as clinical advice, logistic efficiency and in-transit clinical care standards that cannot be adjusted for in the analysis may also affect outcomes.

Decisions regarding the pattern of use of the retrieval service differ considerably between regional referral hospitals and metropolitan referrers. These decisions appear to impact patient outcome, and may be due to a range of factors. Penetration of the ARV service message and establishment of service has been more targeted and effective in rural settings. ARV has limited resource to provide retrieval staff for transfers in the metropolitan setting; therefore, referrers are less likely to engage the service (including for advice and destination planning); prior to 2010, ARV offered very limited metropolitan retrieval support. Persistence of local culture and network preference for transfer within a local health service rather than transfer to a central MTS may also be a factor. Finally, there may be lack of awareness of major trauma transfer guidelines, which specify destination hospital type (MTS) and of the impact on outcomes of care provided in different settings (eg, MTS vs MeTS).

These factors may be addressed with additional resource, communication and education strategies; some of which have been implemented such as a whole of system trauma guideline education programme.[16] It is likely that there would be additional gains to be made if the remainder of major trauma transfer cases were coordinated via the retrieval service. Triage of higher proportions of major trauma patients to MTS destinations does require appropriate concentration of resource in these centres; however, benefits of associated outcomes are well established.[2 17–19] It is also plausible that the benefits seen in the retrieval trauma patient population would be mirrored in other patient populations, and since trauma represents approximately 20% of retrieval practice in Victoria, those gains may be significant, and are worthy of further investigation.

Limitations

This study reflects a single retrieval service in a single setting (mature and effective trauma system)—it may, therefore, have limited external validity. However, the VSTS is certainly typical of regionalised systems, and the geography and demography of Victoria is analogous to many situations. The impacts seen in the typical metropolitan setting could be considered transferrable.

Missing data constitutes <5% of the population, and although noted, is not considered a significant limitation. Finally, the study was observational in nature, and therefore, any causal relationship could not be confirmed.

CONCLUSION

In a mature trauma system, introduction of an effective retrieval service was associated with further reductions in mortality and improved long-term outcomes. A key factor in this finding was case coordination facilitated delivery of patients to an MTS rather than to a lower designated service.

	VAERCS < 2008	ARV ≥ 2008	Non retrieval service (ad hoc) transfers
Call taking	Via host general hospital switchboard	24/7 on base call centre with specifically trained staff, monitored and recorded for quality improvement	Referral hospital to receiving hospital direct
Coordinator	On call, off base, mobile phone, paper records	On base 12-16 hours/day, extensive formal training, contemporary IT supported, all cases peer reviewed.	No formal coordinator role.
Governance	Part time director and admin staff, limited governance framework, basic database	Full time director, support staff, clinical advisors, extensive policy and guideline framework, contemporary quality systems. Web-based advanced IT systems including decision support software and mobile clinical information systems.	Variable, depending on in-house incident and case review processes. No IT systems for retrieval.
Equipment	Some central coordination plus ad hoc systems (e.g. individual doctors' 'personal' drug kits)	Fully standardised kit, maintained centrally, with state-of-art monitoring, ventilation and general contents. Regulated drug kit. Immediate access to blood, plasma, platelets.	Ad hoc or local kit, often not transport-specific, often assembled 'per case'.
Retrieval response clinicians	Part time, consultant based, on-call. Variable training. 150 cases per year.	Full time senior registrars (on-base), Consultants on-base and on-call, formal training and specialist qualification, annual skills and procedural and general credentialing. More than 1200 cases per year.	Variable, often nursing or junior medical staff (especially out of hours). Untrained in retrieval medicine.
Transport Platform Access	Off-base, outbound leg by taxi, return leg ambulance, limited helicopter access, fixed wing	On base, 'ambulance-embedded'. Immediate access to ambulance platforms including road, fixed wing and helicopter	Non emergency or emergency road ambulance
Major Trauma destination coordination	Within guideline: transfer to MTS	Within guideline: transfer to MTS	Variable – local referral patterns to non MTS are common.

Figure 2 Illustration of differences between ARV, pre-existing retrieval services and ad hoc transfer practices in Victoria. ARV, Adult Retrieval Victoria; IT, information technology; MTS, major trauma service; VAERCS, Victorian Adult Emergency and Retrieval Coordination Service.

Contributors All authors contributed equally to the study design and manuscript preparation. BJG provided statistical analysis.

Competing interests None declared.

Provenance and peer review Not commissioned; externally peer reviewed.

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