

# Vascular injury-related in-hospital mortality in Ontario between 1991 and 2009

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## Abstract

**Objective:** Trauma-related vascular injuries are major contributors to morbidity and mortality worldwide. We conducted a retrospective, population-based, cross-sectional study to examine temporal trends and factors associated with traumatic vascular injury-related in-hospital mortality in Ontario, Canada from 1991 to 2009.

**Methods:** We obtained data on Ontario hospital admissions for traumatic vascular injury, including injury mechanism and body region; and patient age, sex, socioeconomic status, and residence from the Canadian Institute for Health Information Discharge Abstract Database and Registered Persons Database from fiscal years 1991 to 2009. We performed time series analysis of vascular injury-related in-hospital mortality rates and multivariable logistic regression analysis to identify significant mortality-associated factors.

**Results:** The overall in-hospital mortality rate for trauma-related vascular injury was 5.5%. A slight but non-significant decline in mortality occurred over time. The likelihood of vascular injury-related in-hospital mortality was significantly higher for patients involved in transport-related accidents (odds ratio [OR]=2.21, 95% confidence interval [CI], 1.76–2.76), age  $\geq 65$  years (OR = 4.34, 95% CI, 2.25–8.38), or with thoracic (OR = 2.24, 95% CI, 1.56–3.20) or abdominal (OR = 2.45, 95% CI, 1.75–3.42) injuries.

**Conclusions:** In-hospital mortality from traumatic vascular injury in Ontario was low and stable from 1991 to 2009.

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## Keywords

Vascular injury, mortality, trauma, in-hospital mortality, older adults, motor vehicle accidents

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## Introduction

The outcome of a traumatic injury depends on the severity of the injury and the timeliness of early care at the event and transport to the hospital.<sup>1–4</sup> Trauma is a leading cause of disability and mortality in the United States (US),<sup>5</sup> associated with 79,000 deaths annually among individuals younger than 45 years old<sup>6</sup> and even higher death rates among older people.<sup>7</sup> Causes of early death among trauma patients include severe brain damage, hemorrhagic shock, and cardiopulmonary dysfunction.<sup>8</sup> In particular, vascular injuries are responsible for almost 20% of trauma-related deaths in the US,<sup>9</sup> with injury to blood vessels of the chest and abdomen associated with the highest rates of morbidity and mortality.<sup>10</sup>

In Canada, a recent study reported that the annual rate of hospital admissions for vascular trauma in Ontario, Canada has declined in recent decades, from 3.3 per 100,000 in 1991 to 2.7 per 100,000 in 2009.<sup>11</sup> However, the number of trauma-related deaths in Canada overall appears to be increasing, with 8687 deaths following a trauma-related accident in 1994<sup>12</sup> and 13,906 deaths from traumatic injury in 2013.<sup>13</sup> The extent to which trauma-related deaths are caused by vascular injuries is unclear. In this study, we investigated temporal trends in in-hospital mortality owing to vascular injuries in Ontario between 1991 and 2009. Additionally, we performed multivariable logistic regression to evaluate the association between vascular injury-related mortality and patient factors, including mechanism of injury, age,

sex, socioeconomic status, body region of injury, and residence, which have previously been linked to the likelihood of trauma-related death.<sup>14–18</sup>

## Methods

### *Study design and population*

We conducted a retrospective, population-based, cross-sectional study of mortality among patients of all ages admitted to Ontario hospitals with vascular injuries between fiscal years 1991 and 2009. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Research Ethics Board of Sunnybrook Health Sciences Centre. The requirement for informed consent was waived owing to the retrospective nature of the study.

### *Data collection*

Study data were obtained from two Canadian administrative claims databases—the Canadian Institute for Health Information Discharge Abstract Database (CIHI-DAD) and the Registered Persons Database (RPDB)—between 1 April 1991 and 31 March 2010. Using the CIHI-DAD, we identified all patients of any age who were admitted to a hospital with any International Classification of Diseases (ICD) code for vascular injury of the neck (ICD-9 900 or ICD-10 S15), thorax (ICD-9 901 or ICD-10 S25), abdomen (ICD-9 902 or ICD-10 S35), upper limb (ICD-9 903 or ICD-10 S45, S55, or S65), or lower limb

(ICD-9 904 or ICD-10 code S75, S85, or S95). Transport-related injuries were defined as patients with ICD-9 E800-E848 or ICD-10 V01-V99 codes for external causes of injury, whereas patients without these specific codes were considered to have “other” mechanisms of injury. The positive predictive value of ICD-10 codes for vascular injury, as confirmed in a direct chart audit, was previously confirmed to be 95%.<sup>19</sup> Data on patient sex and age at the time of injury were also obtained. Using the RPDB data of the same included patients, we determined patients’ socioeconomic status, based on neighborhood income quintiles using primary residence postal code information. Patients in quintiles 1 or 2 were considered to have low socioeconomic status whereas those in quintiles 3, 4, or 5 were considered to have high socioeconomic status. Patients’ primary location of residence was categorized as rural or urban based on the forward sortation area of Ontario.

### Statistical analysis

Rates of vascular injury-related in-hospital mortality in Ontario were calculated using the total number of vascular injury events for the relevant population and timespan as the denominator. To assess trends in the rates of vascular injury-related in-hospital mortality, we used time-series analysis and exponential smoothing models.<sup>11</sup>

Multivariable logistic regression analysis was used to assess the relationship between in-hospital mortality and the following factors: mechanism of injury (transport-related or other), sex, age group, socioeconomic status (high vs. low), location of residence (rural vs. urban), and anatomical site of injury. For time series analysis, statistical significance was defined as a two-sided  $p < 0.05$ .

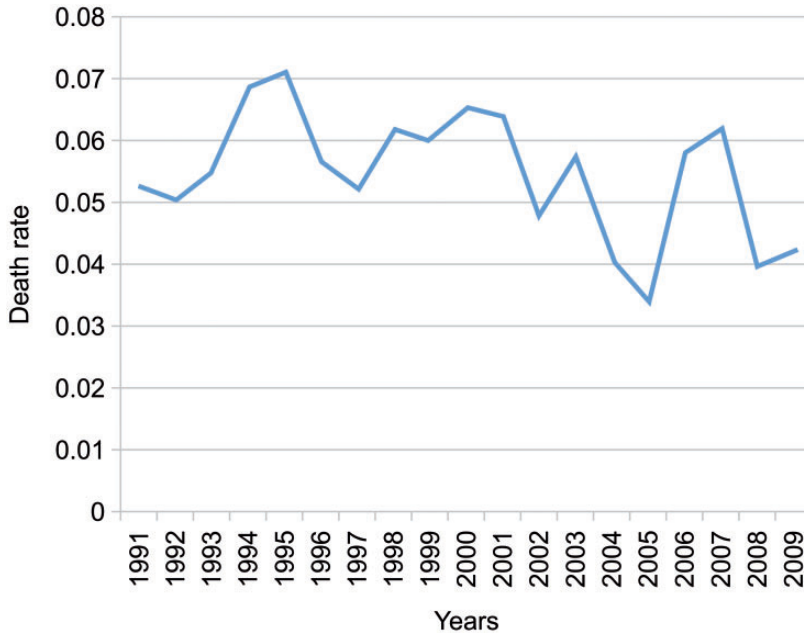
## Results

Of the 8252 patients admitted to Ontario hospitals for traumatic vascular injury between 1991 and 2009, 451 (5.5%) died in the hospital. There was a trend toward a decline in the rate of vascular injury-related in-hospital mortality between 1991 and 2009 (Figure 1), but this did not reach statistical significance.

Vascular injury-related in-hospital deaths and mortality rates according to patient factors are shown in Table 1. Multivariable logistic regression analysis showed that patients who were involved in transport-related accidents, age  $\geq 65$  years, or sustained injuries to the thorax or abdomen had significantly higher odds of in-hospital mortality after adjusting for other factors (Table 2). There was a declining trend of mortality secondary to thoracic, but not abdominal, vascular injuries over the study period. Mortality was not significantly associated with patient sex, socioeconomic status, or location of residence.

## Discussion

We found that 5.5% of all documented traumatic vascular injury-related hospital admissions in Ontario between 1991 and 2009 resulted in in-hospital death. This average mortality rate owing to traumatic vascular injury is somewhat lower but within the range of rates reported in studies from the US (2.4% to 13%)<sup>5,20–22</sup> Britain (15%),<sup>23</sup> and Australia (19%).<sup>24</sup> Furthermore, we observed a stable rate of in-hospital mortality owing to vascular injury over time, with only a slight, non-significant decline. Previous studies have reported inconsistent temporal trends in trauma-related mortality in recent decades. Studies from the United States<sup>25</sup> and Japan<sup>26,27</sup> have reported decreases in overall in-hospital mortality between 2000 and 2013. By contrast, an Australian study



**Figure 1.** Annual rate of overall vascular injury-related in-hospital mortality in Ontario for fiscal years 1991 to 2010.

**Table 1.** Analysis of in-hospital mortality related to vascular injury in Ontario for fiscal years 1991 to 2010.

	Number of deaths	Percent deaths by injury type
Total	451	5.5%
Mechanism		
Transport	255	14%
Other	196	3%
Age, years		
Children (0–14)	11	2.2%
Youth (15–24)	87	4.3%
Adult (25–64)	234	4.8%
Senior (65 and over)	119	14%
Sex		
Male	320	5%
Female	131	7.5%
Socioeconomic status		
Low	204	5%
High	243	5.7%

(continued)

**Table 1.** Continued.

	Number of deaths	Percent deaths by injury type
Body region		
Neck	57	7%
Thorax	135	18.2%
Abdomen	191	18.6%
Upper limb	25	0.5%
Lower limb	43	3%
Residence		
Urban	359	5.3%
Rural	90	6.3%

reports that in-hospital mortality was higher in 2007 than in 2003,<sup>28</sup> and a US study reported that fall-related mortality increased by 46% between 2002 and 2010.<sup>29</sup>

We found that transport-related vascular injuries were associated with a higher rate of mortality than other mechanisms of injury, consistent with a previous study

**Table 2.** Multivariable logistic regression analysis of vascular injury-related in-hospital mortality.

Variable	Odds ratio	95% confidence interval	
<b>Mechanism of injury</b>			
Other	1.00 (reference)	N/A	N/A
Transport	2.21	1.76	2.76
<b>Sex</b>			
Female	1.00 (reference)	N/A	N/A
Male	1.04	0.82	1.32
<b>Age</b>			
Child (0–14)	1.00 (reference)	N/A	N/A
Youth (15–24)	1.34	0.69	2.6
Adult (25–64)	1.55	0.82	2.93
Senior (65 and over)	4.34	2.25	8.38
<b>Socioeconomic status</b>			
High	1.00 (reference)	N/A	N/A
Low	0.96	0.78	1.19
<b>Residence</b>			
Rural	1.00 (reference)	N/A	N/A
Urban	1.07	0.82	1.40
<b>Anatomical site of injury</b>			
Neck	1.00 (reference)	N/A	N/A
Thorax	2.24	1.56	3.2
Abdomen	2.45	1.75	3.42
Upper limb	0.1	0.06	0.16
Lower limb	0.36	0.24	0.56

showing that the likelihood of in-hospital mortality is higher for patients involved in motor vehicle crashes than for fall victims.<sup>30</sup> However, we did not find a difference in mortality rates between patients living in urban versus rural areas. This result is in contrast to findings from Canada and other countries that mortality rates related to motor vehicle accidents are higher in rural areas,<sup>15,20,31–35</sup> perhaps owing to a greater propensity for high-risk behaviors such as speeding, exposure to agricultural machinery, or limited or delayed access to trauma care in rural areas.

We found no significant sex difference in vascular injury-related mortality rates, in agreement with the results of previous studies reporting either no sex difference or a slight tendency toward higher mortality among male individuals with vascular or other types of injury.<sup>18,20,36–38</sup> Moreover,

despite reports of higher rates of injury and resulting mortality among people with lower socioeconomic status or living in low-income areas,<sup>17,39–41</sup> we found no difference in mortality between patients with high versus low socioeconomic status. This might reflect the benefit of universal health care coverage provided to all Ontario residents.

A study from a major trauma center in the United Kingdom reported that patient age and body region of vascular injury are independent risk factors for mortality.<sup>23</sup> Although older individuals experience fewer injuries of all types compared with younger individuals,<sup>36,42</sup> mortality rates increase with each decade of age, which can mainly be explained by a higher risk of complications and associated comorbidities.<sup>43–46</sup> We found that vascular injury-related in-hospital mortality was approximately 3- to 6-fold higher among

people age  $\geq 65$  years (14.0%) than among younger patients (2.2% to 4.8%), consistent with a previous report of a higher trauma-related mortality rate among older patients.<sup>7</sup> We also found that abdominal and thoracic vascular injuries were associated with the highest mortality rates (18.6% and 18.2%, respectively), consistent with previous reports.<sup>10,24</sup> These findings could be expected, as abdominal and thoracic vascular injuries typically result secondary to more advanced trauma, are associated with other complex injuries, and require a greater degree of surgical intervention and longer periods of intensive care. Vascular injury in the upper or lower limbs was associated with the lowest mortality rates (0.5% and 3%, respectively), in agreement with studies showing that vascular injuries of the extremities are associated with mortality rates ranging from 0% to 4%.<sup>47–50</sup> Furthermore, we previously observed that abdominal and thoracic vascular injuries are more frequent among older than younger patients,<sup>11</sup> which suggests that the higher mortality rate among older people is owing to both age and the site of injury.

## Limitations

Because this was a retrospective study using data collected from a coding system, incorrect coding could cause under- or overestimation of injury rates as well as of mortality. Geographic location was based on the patients' place of residence rather than on the location where the injury occurred because the latter was unavailable in the databases. The duration of hospital admission as well as the timing of death was not analyzed.

## Conclusion

The overall in-hospital mortality rate for trauma-related vascular injuries in Ontario was low and remained stable between 1991

and 2009. The mortality rate was higher among patients who were older, involved in transport-related accidents, or who sustained abdominal or thoracic injuries.

## Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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