Vascular Injury Hospitalization Trends in Ontario: A Population-based Study

By

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Abstract

A retrospective, population-based, cross-sectional time series analysis was performed utilizing Ontario’s administrative claims database to examine vascular injury temporal trends between 1991 and 2010. The overall trend in the annual rate of vascular injury-related hospitalizations in Ontario shows a slight but statistically significant decline over the study period (p<0.01). Vascular injury events were higher among young males and rural areas with low-income population. The upper limb was the most common site of injury. Transport associated vascular injuries accounted for only 22%, leaving the majority with other mechanisms of injury. However, hospital mortality was 5.5% for all vascular injury admissions with high rates among seniors with thoracic and abdomen blunt injuries. Vascular injuries were highest during June, July, and August in a regular pattern over the study period. Such findings provide a broad image with important preliminary and supplementary public health and clinical oriented implications for injury management and prevention strategies.
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• Abdulmajeed Altoijry (student): composition of the project.

• Dr. Thomas F Lindsay (supervisor): ideas, study supervision and critical review of the entire project.

• Dr. Muhammad Mamdani (committee member): participated in study conception, design and statistical expertise.

• Dr. K. Wayne Johnston (committee member): critical revision.
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CHAPTER 1

LITERATURE REVIEW

The objectives of this chapter are to:

1. Review the epidemiology of trauma in general.
2. Review the epidemiology of transport-related injuries.
3. Review the epidemiology of vascular injuries.
4. Review the epidemiology of some specific vascular injuries.
5. Summarize the mechanisms of vascular injury.
6. Review the pathophysiology of vascular injuries.
7. Describe the clinical presentation of vascular injuries.

1.1 Trauma

1.1.1 Epidemiology

1.1.1.1 Frequency

Trauma remains a leading cause of death as it accounts for 9% of total mortality worldwide.¹ It is a leading cause of death among children, adolescents, and young adults.¹,² According to the World Health Organization, nearly 6 million people die annually due to trauma-related injuries. A large proportion of survivors are left with either temporary or permanent disability. Studies suggest that up to one quarter of disabilities may result from trauma-related injuries.¹,³ Disability-
adjusted life year (DALY) methodology, developed by WHO and the World Bank, can assess the impact of diseases and injury in terms of years of life lost (YLL) in fatal diseases and years lived with disability (YLD) in non-fatal diseases. By using this methodology in the Netherlands, the mean number of YLL per patient after fatal trauma was found to be 32, while the mean number of YLD per patient was almost 12. A mean of 25 DALYs lost were found for each trauma patient and intentional injuries resulted in substantially more DALYs per patient than did unintentional injuries (34 vs 21 DALYs). Road-traffic injuries were the major contributor to DALYs (40%), due to the high numbers of both fatal and nonfatal cases. Applying the DALY method reflects a shift in the trend from mortality to disability among trauma patients.

In Canada, traumatic injuries are considered the sixth leading cause of death for all age groups; the crude annual rate is approximately 30 per 100,000 people. It represents the leading cause of death among people under 35 years of age and is among the top four reasons for hospitalization in this age group. In 2007, the age-adjusted rate of death secondary to trauma in the United States was reported as 59.3 per 100,000. In addition, 2.6 million patients are hospitalized annually with 30 to 40 million visits to the emergency department each year due to accidental injuries in the United States.

1.1.1.2 Biological Sex

With respect to differences between males and females, males are at higher risk for all types of traumatic injuries compared to females, perhaps due to their propensity to
engage in high-risk activities, including motor vehicle driving. According to data from the National Centre for Injury and Prevention, nearly 70% of all trauma-related deaths between 1999 and 2007 occurred in males. Moreover, mortality secondary to motor vehicle collision were higher among males than females in Canada – this risk of death was almost three times higher among males relative to females globally. Even among children, traumatic injuries were found to be more common in males relative to females in Canada. In a published study, the relationships between socioeconomic status, demographics, and types of childhood injuries in the province of Alberta, Canada were examined using administrative health care data provided by Alberta Health and Wellness on all children aged 0 to 17 years, who had injuries treated by a physician, either in a physician's office, outpatient department, emergency room and/or as a hospital inpatient, between April 1st 1995 and March 31st 1996. While 24% of Alberta children had an injury treated by physicians during the one-year period with peak injury rates occurred among ages 2 and 13–17 years, all injury types except poisoning were found to be more common among males.

1.1.1.3 Economic Status

With respect to socioeconomic status, previous studies have indicated that an inversely proportional relationship exists between trauma and economic status. Over 90% of all types of injury occur in low and middle income countries and the incidence of motor vehicle collision injuries is higher in those countries as well. Data from developing countries indicate a steady increase in the number of road traffic accidents and in road traffic injuries and fatality rates over the past few decades. For example, the number of deaths as a result of road traffic injuries increased by nearly
6 times and non-fatal casualties by more than 5 times between 1962 and 1992 in Kenya.

In one published study in the United States, both individual and neighborhood correlations of injury mortality between 1987 and 1995 were examined in order to better understand the contribution of socioeconomic status in causing specific injury mortality. The principal sources of data were Census tract data (measuring small area socioeconomic status, racial concentration, residential stability, urbanisation and family structure), the National Health Interview Survey (NHIS) and files that link the respondents to subsequent follow up of vital status and cause of death. Residence in neighborhoods with low family incomes, high poverty, high proportions of poorly educated persons, low housing values, and high proportions of crowded housing, were each factors found to significantly increase a person’s risk of death attributable to homicide. Residents of neighborhoods with lower socioeconomic status were at higher risk for motor vehicle fatalities as well\(^1\).

In the aforementioned study in Alberta, injuries were more frequent in urban areas of Alberta and in urban children with lower socioeconomic status, in particular superficial wounds and open wound injuries. The results show a major health concern especially among males, children living in urban centers, and those living on welfare or having treaty status\(^7\).

**1.1.1.4 Geographical Variation**

From a geographic standpoint, unintentional injuries are more common in urban settings due to the increasing complexity of urban life, crowdedness and higher use of motor vehicles. In the US, for example, more than half of the fatal work-related
highway crashes between 1992 and 2000\textsuperscript{11} occurred in urban areas. However, traumas that take place in rural areas are usually associated with longer hospital stays and greater mortality rates. Less hospital resources in rural areas and the need to transfer patients to more advanced or tertiary trauma centers is the traditional explanation for these statistics\textsuperscript{12, 6}.

1.1.2 Transport Injuries

Within civilian populations in peaceful nations, most injuries are unintentional and motor vehicle collisions remain an important source driver of injury as rates of trauma admission continue to increase over time. Worldwide, over 1.2 million people die each year secondary to road traffic injuries or motor vehicle collision and 20 to 50 million people suffer non-fatal injuries\textsuperscript{13}. Motor vehicle collisions are identified as the second leading cause of death among people between age 14 and 45 years globally\textsuperscript{9} and the main source for hospitalization for this age group in Canada\textsuperscript{5}. However, deaths related to motor vehicle collisions have decreased in Canada by around 32\% over the past twenty years\textsuperscript{14}.

1.2 Vascular Injuries

1.2.1 Epidemiology

1.2.1.1 Military

Vascular trauma has been studied in the military environment. It has special significance and due to the similarity of the injury type, commonly guns and explosions, almost all military vascular injury mechanisms are penetrating in nature.
Combat-related injuries to major vessels present unique technical challenges and result in hemorrhage which is responsible for 80% of potentially preventable deaths on the battlefield. The most lethal vascular injuries are those to the torso, which includes the chest and abdomen. Torso injury is reportedly the cause of half of potentially survivable hemorrhagic deaths, followed by extremity vascular injuries, which are responsible for one third. The front lines of a battleground are chaotic, located in harsh environments, and vary widely, depending on the goal and the scope of military operations.

Several studies describe the features of vascular injuries and the principles of management. Available data from World War I demonstrate a total of 443 vascular injuries but little information is available about the mechanism and the anatomical site of the injuries.

A classic paper by DeBakey and Simeone illustrates the challenge of vascular repair, revealing only 81 repairs of a total of 2471 vascular injuries during World War II. Total peripheral vascular injuries accounted for 97.5% of all vascular trauma cases and almost all of the injuries were penetrating. The total amputation rate was 60% for the extremity vascular injuries during World War II, with highest rate for popliteal artery injuries.

During the Korean War in 1952, the total number of extremity vascular injuries was 286, which represents 94.1% of the total number of vascular trauma cases (304 cases). Penetrating injury was almost the only main mechanism. Frank Spencer and a team from the US introduced arterial repair of vascular injuries during this war.
and amputation rate was significantly reduced from 49% in World War II to 13% in the Korean War among vascular repaired limbs. In the Vietnam War, vascular injuries accounted for 2% to 3% of battle-related injuries. Penetrating injuries were predominant (98%) and 91% (n= 910) of the reported 1000 vascular injuries affecting the extremities. Forward surgical capabilities and advances in Casualty Evacuation Aircraft CASEVAC continued to reduce ischemic time and commonly led to successful arterial reconstruction during the Vietnam War. The Vietnam Vascular Registry is considered as a reference standard for vascular surgery application during the modern conflicts of the 21st century.

Published reports from the Global War on Terrorism-Operation (GWOT) and Operation Iraqi Freedom (OIF) demonstrate that the contemporary rate of vascular injuries is considerably higher than during the Vietnam War, at 4% to 6% of battle-related injuries. Additionally, early data from the GWOT Vascular Initiative suggest that the rate of vascular injuries may be as high as 10% among those injured in combat.

Recently, the United States Army Institute of Surgical Research has analyzed the epidemiological characteristics of vascular injuries in the wars of Iraq and Afghanistan, including the categorization of anatomic patterns, mechanisms, and management of casualties where the Joint Theater Trauma Registry was interrogated (2002-2009) for vascular injury in US troops to identify specific injury and operative interventions. These data show a total of 13,076 battle-related injuries and the main mechanism of these injuries was explosions (73%), followed by gunshots (27%).
Most of the injuries affected the major or proximal vessels (60%) while minor or distal vascular injuries represented 40%. These data demonstrate a five-fold increase in the rate of vascular injuries in modern combat compared to what was reported in previous wars\textsuperscript{30}. The increased incidence of vascular injuries may have several explanations, including the change of War Theater, mechanism of injury and operational tempo as well as the increased awareness of and attention to recording such injuries. Certainly, the effectiveness of tourniquets and modern body armor and the strategic forward placement of surgical capabilities also allow the treatment of vascular injuries that would have been fatal in past wars.

1.2.1.2 Civilian

Given the nature of and variety in the injury type, injury biomechanics affecting the anatomical place of injury, as well as the severity and mortality associated with vascular trauma in the military, findings from these studies may not be generalized to a civilian population. However, the principals of care and repair do have a direct impact on similar injuries in a civilian population.

Vascular injuries have increased steadily in the civilian population as a result of the increase in motor vehicle collisions worldwide as well as criminal violence in certain countries. There is a variation in the incidence rate and the injury biomechanics depending on the geographic location\textsuperscript{31-34}. Among major trauma cases, severe vascular injuries range between 2 and 6\%\textsuperscript{31,35}. In a civilian population in Australia\textsuperscript{31}, vascular injuries represent only 1-2\% of total trauma patients, although they account for 20\% of all trauma-related deaths.\textsuperscript{36}
Vascular injuries are considered one of the leading factors that result in traumatic death. One third of in-hospital trauma deaths have been directly related to the hemorrhage however tissue ischemia also contributes to death, secondary to its role in the induction of multisystem organ failure.

Deaths from vascular injuries vary considerably in anatomic location and mechanism of injury. Thoracic and abdominal injuries routinely have death rates between 30-50%; vascular injuries to extremities are significantly lower, in the range of 5%. In an unparalleled large study from Vietnam, Rich reported a total death of only 1.7% for all vascular injuries. It may be that life-threatening vascular injuries were pre-selected by their failure to survive transport. As mentioned earlier, in the warfare conditions of the American intervention in Iraq and Afghanistan vascular trauma represents 7% of total battle injuries, of which 88% were extremity injuries. The amputation rate was only 8% after vascular repair. The mechanism or biomechanics of injury vary by country. Penetrating injuries occur at a lower frequency in Europe and Australia relative to the US. In contrast to the military setting where penetrating vascular injuries that mainly affect the extremities are predominant, the relative incidence of blunt injuries is higher in the civilian population.

In North India, with a low risk of personal violence, blunt injuries, mostly motor vehicle accidents, account for 84% of vascular injuries whereas in Medellin, Colombia 93% of vascular injuries are penetrating and in Georgia they represent 85% of the total. Surprisingly, in the European experience, up to 40% of vascular injuries are iatrogenic, as a result of vascular and other surgical interventions. Kuwait strikes a middle ground with 41% penetrating, 23% a result of motor vehicle
collisions and 22% iatrogenic\(^46\). In Malaysia,\(^35\) over 50% of vascular injuries occur as a result of motor vehicle collisions. As far as the anatomic site of injury is concerned, there is less variability. In Australia\(^31, 36\) injuries are split almost equally between thorax, abdomen and upper and lower extremities, with cervical injuries being less common. In Latin America\(^47\), extremity injuries are twice as common as thoracic and abdominal, although the later result in a higher mortality. As far as extremities are concerned, upper and lower injuries occur with similar frequency and the brachial, femoral and popliteal arteries are the most commonly injured vessels. Within the same survey\(^47\), 68% of the cases could be managed on a clinical basis alone, meaning without arteriography, and 78% were managed within 6 hours of injury.

This variation in the mechanism of injury and anatomical location is reflected in the severity and mortality of vascular trauma as death rates of thoracic and abdominal vascular injuries, which range from 30-50%. In contrast, the death rates for extremity-related vascular injuries are significantly lower at approximately 5%\(^36, 47, 48\). Survival following trauma is also driven by the mechanism and location of vascular injury. While the mortality rate of blunt carotid artery injury varies from 20% to 40%\(^49, 50\), the hospital mortality rate for abdominal aortic injury varies from 30% to 80% and many patients die before reaching hospitals\(^51, 52\).

**1.2.2 Epidemiology of Specific Vascular Injuries**

Although the neck is rarely injured during trauma, the most commonly injured structures in the neck are the blood vessels\(^48\). Neck penetrating vascular injuries are more common than neck blunt vascular injuries, with an incidence of 20% of major
vascular trauma\textsuperscript{53}. Blunt carotid artery injury accounts for 3\% to 10\% of all carotid injuries\textsuperscript{54} and injury of the internal jugular vein occurs in 20\% of penetrating neck trauma cases\textsuperscript{55}.

Trauma to the great vessels of the thorax such as the aorta and pulmonary artery is secondary to blunt or penetrating injury. Thoracic aortic injury is considered the second most common cause of death in blunt trauma patients\textsuperscript{56,57} and responsible for approximately 8000 deaths each year in the US\textsuperscript{58}. Venous thoracic injuries, superior or inferior vena cava injury, are less common but can be lethal with mortality rates reaching up to 50\%\textsuperscript{48}.

In the abdomen, major vascular injuries are common, particularly within civilian settings. Abdominal vascular trauma represents almost 30\% of all vascular traumas with little difference in incidence between arterial and venous trauma\textsuperscript{59}.

Despite the lower incidence of extremity vascular trauma in the civilian setting compared to the military setting, the number of peripheral vascular injuries is still high\textsuperscript{33,36,47}. Brachial, femoral and popliteal arteries are the most frequent injured vessels of the extremity\textsuperscript{33,60}, however, the vessels of the upper extremity are often more affected in civilian studies\textsuperscript{48}. Furthermore, the majority of blunt trauma peripheral vascular injuries are associated with bone fractures and dislocation\textsuperscript{61}.

\textbf{1.2.3 Injury Mechanism}

The mechanism of vascular injury is primarily divided into the categories of penetrating or blunt. In penetrating injury, the injury is produced by separation and crushing of tissue along the path of the object, leading to the arterial wall being
disrupted and bleeding. Blunt trauma is produced by rapid deceleration and local compression and leads to deformation of the vascular wall and causes damage to the vessels by avulsion or intimal tear. Deceleration injuries usually occur in high-speed motor vehicle accidents or falls from heights, whereas local compression results from direct blows.$^{48}$

Severity of the vascular injury is proportional to the amount of kinetic energy at the time of injury and the velocity transferred to the tissue in both mechanisms.$^{48, 62, 63}$ For example, high impact frontal motor vehicle collisions are associated with thoracic aortic injury and injury to abdominal aorta, iliac and femoral vessels may also occur with blunt injury of sufficient force.$^{64}$ In penetrating injuries, the highest risk of serious vascular injury is associated with high-energy gunshot wounds. Explosives are also a frequent cause of vascular injuries in military combat and the rate of vascular injuries in modern combat (ie, the wars in Iraq and Afghanistan) is 5 times greater than in the past, due to the improvement of velocity and energy.$^{30}$ However, the likelihood of serious vascular injury is lower in patients who sustain low-energy wounds such as those produced by handguns and knives.

Each mechanism has its associated pathological correlates. Penetrating trauma always results in varying degrees of vessel laceration or transaction. Retraction and spasm followed by thrombosis of the injured vessel may occur with complete transaction except with large vessels where thrombosis rarely occurs. In partially transected vessels, various degrees of bleeding and hemorrhage occur depending upon spasm and thrombosis. On the other hand, blunt trauma results in disruption of the layers of the vascular wall, transmural damage, extravasations into the wall and frequently
thrombosis\textsuperscript{48, 65}. The external bleeding that is more common with penetrating injuries allows for earlier diagnosis in the case of vascular penetrating injury relative to vascular blunt injury. 

In addition, any blunt or penetrating trauma resulting in extremity fractures also has a high incidence of concomitant vascular injuries, even in the absence of clinical signs. 

1.2.4 Pathophysiology 

Vascular injuries can result in rupture, occlusion or both rupture and occlusion\textsuperscript{48, 65}. Rupture leads to bleeding that could be contained within a body cavity or the skin or could result in external blood loss. Depending on the circumstances and the vessel involved, the resultant blood loss can be lethal, or threaten the organ or limb. Traumatic aneurysms or pseudoaneurysms may develop secondary to partial damage to the arterial wall. Less common but well described are situations when the adjacent artery and vein are both injured and ruptured and which result in traumatic arteriovenous fistula development. Depending on the size of the vessels involved and the size of the communication, high-output heart failure can result secondary to the arteriovenous fistula formation \textsuperscript{66}. 

Occlusive vascular injuries vary with the extent and type of injury. The occlusion can be intrinsic to the vessel wall by intimal flap development with dissection that results in vessel thrombosis or secondary to spasm and thrombosis after complete transaction. Arterial or venous extrinsic compression and thrombosis can develop secondary to a bone fracture. Acute arterial occlusion frequently results in ischemia of the tissues distal to the thrombosed vessel. The degree of ischemia is dependent on
pre-existing collateral vessels and their patency and freedom from injury. Organ or limb recovery from ischemia secondary to traumatic acute arterial occlusion will depend on organ sensitivity to ischemia and the duration of the ischemic event. Permanent tissue loss can result in organ failure or amputation if a limb vessel is involved.

In the upper extremity, the axilla, medial and anterior upper arm, and antecubital fossa are considered particularly high-risk areas for vascular injuries because of the superficial location of the axillary and brachial arteries in these regions. Wounds distal to the bifurcation of the brachial artery are less likely to result in serious limb ischemia, as long as the ulnar and radial arteries remain intact. Injuries to a single distal artery can often be managed by ligation alone if the palmar arches are complete and no prior injury is present.

In contrast, the area of greatest concern in the lower extremity extends from the top of the leg marked by the inguinal ligament anteriorly and by the inferior gluteal fold posteriorly, across the knee inferiorly to the level of the mid calf. The inguinal region, medial thigh, and popliteal fossa in particular are considered high-risk locations. Arterial wounds affecting a single vessel distal to the popliteal artery trifurcation are unlikely to produce serious limb ischemia. If distal collateralization is adequate, injuries to a single branch may therefore be managed by ligation.

With improvement of arterial repair in terms of quality and timing, the amputation rate has been reduced following civilian vascular injuries\(^{67}\). Further, the injured limb vessel is considered an important factor in determining rate of amputation. Injury of the popliteal or common femoral artery is always associated with highest amputation
rate, which can reach up to 85% with complete arterial ligation. However, amputation rates range from 45-60% after ligation of the axillary and brachial artery. Compartment syndrome (compartmental hypertension) is an important complication and frequent manifestation of reperfusion of previously ischemic extremities. The incidence and prognosis of compartment syndrome varies and depends on several factors. These include presence of associated orthopedic or soft tissue injuries, time between onset of tissue ischemia and arterial repair and the artery injured. Certain arteries such as the popliteal are associated with an increased the incidence of compartment syndrome. The prognosis of compartment syndrome also depends on early recognition and use of fasciotomy following extremity vascular trauma.

1.2.5 Clinical Presentation

Clinical presentations of vascular injuries are based on the anatomic location and type of injury. Essentially, external bleeding, internal bleeding accompanied by signs of shock, end organ or extremity ischemia or pulsatile hematoma manifest clinical evidence of vascular trauma. Decisions regarding the need for surgical repair are dependent upon the clinical presentation of vascular injuries, which are further divided into hard and soft signs. Active or pulsatile hemorrhage, pulsatile or expanding hematoma, bruit or thrill, diminished or absent pulses and any sign of limb or organ ischemia are considered indications for intervention with sensitivity of 92-95%. Soft signs such as hypotension or shock, nonpulsatile or small hematoma, neurological deficit secondary
to nerve injury and proximity of injury to a major vessel are much less useful in predicting major vascular injuries that require intervention.

Hemorrhagic shock from intra-abdominal hemorrhage, for example, often leads to metabolic acidosis accompanied by coagulopathy and hypothermia (lethal triad of trauma). Acidosis increases the fatality risk of preexisting injuries primarily by depression of myocardial contractility and by impairment of coagulation. Furthermore, hypothermia inhibits platelet function and slows coagulation factor activation. These factors, the lethal triad, are responsible for 80% of deaths in patients with major vascular injuries and must be rapidly corrected to prevent a negative outcome.
CHAPTER 2
RATIONALE

The objectives of this chapter are to:

1. Present the rationale of the study.
2. Present the study objectives.
3. Present the hypothesis of this study.

2.1 Rationale

Trauma is a major public health concern. Trauma-related injuries, in aggregate, are responsible for enormous disability and premature death\(^1\). Trauma is considered the fourth leading cause of death worldwide, with 5.8 million deaths reported in 2006.\(^8, 65\)

Further, it is the most frequent cause of death occurring during the first four decades of life as almost 80% of injuries affect people younger than 45 years.\(^2, 70\)

In the United States, approximately 2.6 million people are hospitalized each year secondary to trauma, and more deaths can be attributed to trauma for Americans under 35 years of age than all other illnesses combined.\(^2, 48\) Moreover, injury-related deaths result in more years of productive life lost than deaths from cancer and cardiovascular disease. In terms of cost, trauma accounts for more than $200 billion lost annually in United States.\(^2, 65\)

Vascular injuries account for a significant proportion of trauma cases and represent a critical element in the trauma patient. Vascular injuries immediately threaten patients’
lives secondary to bleeding and the morbidity secondary to limb dysfunction can be devastating. Vascular injuries induce downstream tissue ischemia that impairs muscle and nerve viability leading to impaired limb function even in the salvaged extremity. Together with traumatic brain injuries, vascular injuries comprise the leading cause of traumatic death either directly, as caused by acute hemorrhage, or secondarily due to ischemia and organ failure. Aortic injury is the second most common cause of death in blunt trauma patients after brain injuries\textsuperscript{56, 57}.

The clinical impact of vascular trauma depends on many elements such as the mechanism of injury, the site of the injured vessel – artery or vein, central or peripheral – and time to receive medical care. Biomechanics of vascular injuries are primarily divided into penetrating trauma and blunt trauma. Penetrating injuries involve laceration or transaction of the vessels, which leads to perfuse bleeding. Blunt injuries cause vascular wall disruption leading to bleeding and transmural damage, in turn resulting in thrombosis with resultant acute tissue ischemia\textsuperscript{48, 65}.

Multiple publications have described the features of vascular trauma in the military population beginning with the experience of military surgeons in the two World Wars, Korea and the Vietnam War\textsuperscript{16, 17, 22}. There are fewer epidemiological studies of traumatic vascular injuries in the civilian population. The available evidence does document, however, wide geographic variation in the incidence, biomechanics and mortality of vascular injuries depending on the local conditions of each study\textsuperscript{33, 35, 36, 45, 47}. Further, it is evident that the incidence of vascular injuries in the civilian population worldwide has steadily increased over time, with an increase in motor vehicle collisions\textsuperscript{1} and criminal violence in some countries\textsuperscript{34, 71, 72}. 

\textsuperscript{1}
Clearly, trauma is a global health problem and requires a greater understanding of its epidemiology in order to build comprehensive, effective prevention and medical management programs. It is with this intent that this thesis topic was developed. A population-based study of vascular trauma in Ontario will provide a fundamental understanding of the epidemiology of vascular injuries in Ontario. In addition, it may serve as a basis for establishing hypotheses and generating new ideas for future studies in the field of vascular trauma, both locally and globally.

2.2 Study Aims and Objectives

The aim of this thesis is to examine and analyze the patterns of vascular injuries in Ontario.

**Primary Objective:**

To examine temporal trends in the annual rates of vascular injury-related hospital admissions in Ontario over the past two decades (1991 through 2010).

**Secondary Objectives:**

1. To stratify and examine the temporal trends in the rate of hospital admissions related to vascular injury by:
   a. Mechanics of injury (transport/other)
   b. Age
   c. Biological sex
   d. Economic status
   e. Geographical setting (urban vs. rural place of residence)
2. To examine temporal trends in vascular injury-related in-hospital mortality in Ontario over the past two decades.

3. To examine temporal (quarterly) variation in the rate of hospital admissions related to vascular injury in Ontario.

4. To examine the geographic distribution of hospital admissions related to vascular injury in Ontario between 2007 and 2010.

2.3 Hypothesis

Given previous studies showing an increase in the incidence of vascular injuries in the civilian population worldwide over time, with an increase in motor vehicle collisions\(^1\) and criminal violence in some countries\(^34,71,72\), it is hypothesized that trends of vascular injury have increased over the past two decades in Ontario, Canada.
CHAPTER 3

METHODS

The objectives of this chapter are to:

1. Provide an overview of the study methodology.
2. Describe the databases used.
3. Describe the methods used to identify the cases.
4. Describe the method used for data validation.
5. Outline the statistical methods used for data analysis.

3.1 Overview

3.1.1 Study Design

A retrospective, population-based, cross-sectional time series study utilizing Ontario’s administrative claims databases was conducted for the fiscal years 1991 to 2010 (April 1\textsuperscript{st} of the indicated year to March 31\textsuperscript{st} of the following year).

3.1.2 Population

The study population was composed of males and females, all ages, admitted to hospital in relation to vascular injury exposure of the neck, thorax, abdomen, and upper and/or lower extremities, in the province of Ontario.

3.1.3 Endpoints

The main endpoints of interest were divided into primary and secondary endpoints.
Primary Endpoint

Annual rate of hospital admissions related to vascular injury per 100,000 populations in Ontario between 1991 through 2010.

SecondaryEndpoints

1. Annual rate of hospital admissions related to vascular injury in Ontario stratified by the mechanism of injury (transport/other).
2. Annual rate of hospital admissions related to vascular injury in Ontario stratified by age.
3. Annual rate of hospital admissions related to vascular injury in Ontario stratified by biological sex.
4. Annual rate of hospital admissions related to vascular injury in Ontario stratified by economic status.
5. Annual rate of hospital admissions related to vascular injury in Ontario stratified by geographical setting.
3.1.4 Unit of Analysis

For the rate calculation, each vascular injury (arterial and/or venous injuries) event was used as one unit of analysis. An event was defined as the number of hospital admissions for vascular injury (including transfers) one injury for one admission, which approximated the number of injuries since only 1.5% of injuries are a second vascular injury for the same admission. The event rate was calculated as the number of vascular injury events as the numerator per 100,000 populations in Ontario as the denominator per year. The total number of people in the province for each year and yearly population estimated by total, age groupings, gender, urban/rural status and economic status were used as denominators and are based on the contact files. The contact files identify all Ontario residents who have accessed the healthcare system and correspond well with actual census data.

3.2 Data Source

The study was conducted using population-based administrative claims databases housed at the Institute for Clinical Evaluative Sciences in Ontario (ICES).

3.2.1 The Canadian Institute for Health Information (CIHI)

All vascular trauma events were obtained from the Canadian Institute for Health Information hospital discharge abstract database (CIHI-DAD). This database records discharges from all Ontario acute care hospitals. Patient chart information is abstracted, coded and input locally into hospital databases by trained personnel, then included in summaries sent to several central CIHI databases, including the DAD.
The diagnostic codes are based on the International Statistical Classification of Diseases and Related Health Problems. During our study period (1991 – 2010), both the Ninth Revision (ICD-9)\textsuperscript{73} and Tenth Revision (ICD-10)\textsuperscript{74} were used, as Canada hospitals implemented the ICD-10 coding system by the fiscal year of 2001-2002.

The main data elements are categorized into four groups: 1) demographic information, such as age, sex, and area of residence; 2) the disease: both the primary diagnosis (most responsible diagnosis) and the secondary diagnosis and complications (up to 16 diagnoses); 3) the procedures provided by the physician (up to 10 procedures), and 4) the hospital services provided: information on admission category, length of stay and special care unit stay. In a large re-abstraction study to review the clinical coding practices of Ontario’s ten case-costing hospital corporations\textsuperscript{75}, the agreement rates for matching were high – up to 97\% of the non-medical data and 85\% of diagnosis codes were found to be valid. In an older study, the level of agreement between the database and patients’ charts for the most responsible diagnosis was 81\%\textsuperscript{76}. In addition, demographic information were found to be complete and reliable in Ontario’s administrative health databases with less than three percent of Ontario records having missing demographic data\textsuperscript{77}. Transport accidents codes for the external cause of injury in ICD-9 and external causes of morbidity and mortality in ICD-10 were used as well. Trauma-related injuries associated with transport accident codes for the external cause of injury on the same discharge abstract were defined as transport associated injuries, otherwise the mechanism of injury was considered others.
3.2.2 Registered Persons Database (RPDB)

This database records personal information that describes people who are, or were, entitled to medical services under the Ontario Health Insurance Plan. The Ministry of Health inputs all of this information. The main data elements include name, birth date, gender, address, death indicator, and the date of death if applicable. The RPDB is used to identify individuals who have accessed the Ontario healthcare system (i.e. the contact files) – population estimates based on contact files correspond well with actual population census estimates.

Each unique patient in any of these databases has a unique ICES key number (IKN) that serves as a unique encrypted identifier. Using the IKN, these databases can be linked.

ICES, where the study was conducted, has strict privacy policies which deny access to any identifiable data and limit access to anonymous data in order to assist in keeping patient confidentiality. In addition, all staff working with the databases are required to sign a pledge of confidentiality.

3.3 Identification of Cases

3.3.1 Vascular Injury Cases

Using the CIHI database, we identified all patients of any age who were admitted to hospital between April 1, 1991 and March 31, 2010 with any diagnosis code for vascular injury of the neck (ICD-9 900 and ICD-10 code S15), thorax (ICD-9 901 and ICD-10 code S25), abdomen (ICD-9 902 and ICD-10 code S35), upper extremity
(ICD-9 903 and ICD-10 code S45, S55 and S65) and lower extremity (ICD-9 904 and ICD-10 code S75, S85 and S95) (Table 1).

3.3.2 Transport-Related Vascular Injury

Among the vascular injury cases identified in 3.3.1, cases with any transport accident code of the external cause of injury in ICD-9 (ICD-9 codes E800-E848) and external causes of morbidity and mortality in ICD-10 (ICD-10 codes V01-V99) were considered cases with transport-associated vascular injuries (Tables 2 and 3). Individuals without such codes were defined and classified as other injuries. Duplicate records, which are defined as multiple records with the same IKN, admission date, procedure codes and diagnosis codes, were excluded, as were records with missing IKN.

3.4 Data Validation

The validity of vascular injury coding using ICD-10 in the administration was assessed in a separate study. To validate the coding for vascular injury, 380 CIHI discharge abstract records with vascular injury codes at the two main trauma centers in Toronto, Ontario, Canada – St. Michael’s Hospital and Sunnybrook Health Sciences Centre – were randomly selected between April 1, 2002 and March 31, 2010 using ICD-10 codes. These database records were compared with the corresponding patient charts from St. Michael’s Hospital and Sunnybrook Health Sciences Centre to assess the level of agreement for procedure coding. Chart confirmation of vascular injury was considered the gold standard to determine the accuracy and validity, which
refer to how closely a CIHI record of having or not having a certain vascular injury corresponds with the presence or absence of such injury (diagnosis). Ethical approval was obtained from the research ethics boards of both St. Michael’s Hospital and Sunnybrook Health Sciences Centre for this validation project (Appendix 1 and 2).

3.5 Statistical Analysis

3.5.1 Data Validation

Using patient charts as the gold standard, overall accuracy with positive predictive value and sensitivity were calculated to describe the validity of vascular injury diagnosis coding. Positive predictive value (PPV) refers to the proportion of diagnostic codes for vascular injury identified in the CIHI database among those identified using patient chart data. The PPV was calculated in total and for each injured body region (group). Overall sensitivity for vascular injury codes was not calculated since the patient chart data was limited to only those with vascular injuries. However, sensitivity within each subgroup of vascular injury was calculated and refers to the proportion of vascular injury diagnoses that appeared in the patient chart and also in the CIHI database within same subgroup among all vascular injury cases.

3.5.2 Trends and Rate Calculation

Time series methodology was conducted to assess temporal trends in the primary and secondary endpoints.

Temporal trends in the annual rate of any vascular injury-related hospital admissions in Ontario for the fiscal years 1991-2010 for both sex and all age groups were
examined. The overall vascular injury rate per 100,000 populations was calculated annually by using as the denominator the Ontario population through the contact files (defined above) for the relevant.

Temporal trends in rates of vascular injury-related hospital admissions in Ontario for fiscal years 1991-2010 were also obtained according to mechanism of injury, age, gender, geographic site of principal residence and economic status, independently. Transport and other vascular injury rates were calculated per 100,000 inhabitants on an annual basis, using as the denominator the population of Ontario for the relevant year.

The age of the patients at the time of injury was divided into four age groups (children 0-14 years, youth 15-24 years, adults 25-64 years and seniors 65 years and over). The age-specific rates of vascular injury were calculated and the age-stratified population of Ontario for the relevant period was used as the denominator. For gender, vascular injury rates for women and men were calculated by using the Ontario sex-stratified population estimates for the relevant interval. Patients’ economic status was divided into two groups; high and low. Economic status was determined based on neighborhood income quintile using postal code information. For those in income quintile 1 or 2 were considered low income whereas quintiles 3 to 5 were considered high income. Vascular injury rates for each economic group were calculated using the respective province population estimates for each interval in the denominator. The geographical site-specific rates of vascular injury were assessed using location of primary residence data using the Ontario urban or rural population estimates for the relevant period as the denominator. The geographical location of primary residence of
vascular injury-related hospital admission patients was determined based on the forward sortation area (FSA) of Ontario, which is a geographical region in which all postal codes start with the same three characters.

Ontario population estimates for each year were obtained using the contact file information of the Ministry of Health, which define the population based on the number of people accessing health services in Ontario in each year.

In addition, temporal trends of vascular injury-related hospital admissions in Ontario according to the injured anatomical site were obtained by calculating the rate of vascular injuries for each anatomical site (neck, thorax, abdomen, upper extremity and lower extremity).

Temporal trends in vascular injury-related in-hospital mortality in Ontario among injury events over the study period were also examined by using the total number of vascular injury events as the denominator.

### 3.5.3. Temporal Variation

Spectral analysis\(^{79}\) was used to detect statistically significant seasonality of hospital admission related to vascular injury over the study period. Spectral analysis detects seasonal variation and periodicity in time series, by plotting the periodogram or spectral density of the series against the period or frequency. The data series will be de-trended using moving averages prior to conducting spectral analysis. Two tests for the null hypothesis that the series is strictly white noise will be conducted. The Fisher Kappa (FK) Test is designed to detect one major sinusoidal component buried in
white noise, whereas the Bartlett Kolmogorov Smirnov (BKS) Test accumulates departures from the white noise hypothesis over all frequencies.

### 3.5.4 Geographical Distributions

Descriptive statistics were used to assess the variation in vascular injury admission rate distributions geographically based on Local Health Integration Networks (LHIN) between April 1, 2007 and March 31, 2010.

### 3.5.5 Additional Analyses

Differences in proportions were assessed using the chi-square test. We also conducted multivariable logistic regression analysis to assess the relationship between in-hospital mortality and the following variables: transport injury status, gender, age group, economic status, geographical residency status and anatomical site of injury. All the p-values calculated with time series analysis and chi-square tests reflect two – sided statistical tests.
Table 1: International Classification of Disease, ninth and tenth revision (ICD 9 and 10) codes used to identify vascular injury cases.

<table>
<thead>
<tr>
<th>ICD-9 code</th>
<th>ICD-10 code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>900</td>
<td>S15</td>
<td>Injury of the neck vessels</td>
</tr>
<tr>
<td>901</td>
<td>S25</td>
<td>Injury of thoracic vessels</td>
</tr>
<tr>
<td>902</td>
<td>S35</td>
<td>Injury of abdominal and pelvic vessels</td>
</tr>
<tr>
<td>903</td>
<td>S45, S55 or S65</td>
<td>Injury of upper limb vessels</td>
</tr>
<tr>
<td>904</td>
<td>S75, S85 or S95</td>
<td>Injury of lower limb vessels</td>
</tr>
</tbody>
</table>
Table 2: International Classification of Disease, ninth revision (ICD 9) codes used to identify transport accidents.

<table>
<thead>
<tr>
<th>Ecode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>800-807</td>
<td>Railway accidents</td>
</tr>
<tr>
<td>810-819</td>
<td>Motor vehicle traffic accidents</td>
</tr>
<tr>
<td>820-825</td>
<td>Motor vehicle non traffic accidents</td>
</tr>
<tr>
<td>826-829</td>
<td>Other road vehicle accidents</td>
</tr>
<tr>
<td>830-838</td>
<td>Water transport accidents</td>
</tr>
<tr>
<td>840-845</td>
<td>Air and space transport accidents</td>
</tr>
<tr>
<td>846-848</td>
<td>Vehicle accidents not elsewhere classifiable</td>
</tr>
</tbody>
</table>
Table 3: International Classification of Disease, tenth revision (ICD 10) codes used to identify transport accidents.

<table>
<thead>
<tr>
<th>Ecode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V01-V09</td>
<td>Pedestrian injured in transport accident</td>
</tr>
<tr>
<td>V10-V19</td>
<td>Pedal cyclist injured in transport accident</td>
</tr>
<tr>
<td>V20-V29</td>
<td>Motorcycle rider injured in transport accident</td>
</tr>
<tr>
<td>V30-V39</td>
<td>Occupant of three-wheeled motor vehicle injured in transport</td>
</tr>
<tr>
<td>V40-V49</td>
<td>accident</td>
</tr>
<tr>
<td>V50-V59</td>
<td>Car occupant injured in transport accident</td>
</tr>
<tr>
<td>V60-V69</td>
<td>Occupant of pick-up truck or van injured in transport accident</td>
</tr>
<tr>
<td>V70-V79</td>
<td>Occupant of heavy transport vehicle injured in transport accident</td>
</tr>
<tr>
<td>V80-V89</td>
<td>Bus occupant injured in transport accident</td>
</tr>
<tr>
<td>V90-V94</td>
<td>Other land transport accidents</td>
</tr>
<tr>
<td>V95-V97</td>
<td>Water transport accidents</td>
</tr>
<tr>
<td>V98-V99</td>
<td>Air and space transport accidents</td>
</tr>
<tr>
<td></td>
<td>Other and unspecified transport accidents</td>
</tr>
</tbody>
</table>
CHAPTER 4

RESULTS

The objectives of this chapter are to present:

1. Baseline characteristics of the vascular injury patients.

2. Results of the data validation study.

3. Temporal trends and annual rates of hospital admissions related to vascular injury.


5. Temporal variation in the rate of hospital admissions related to vascular injury.


4.1 Baseline Characteristics

4.1.1 Eligible Records for Analysis

Figure 1 summarizes the number of eligible records with vascular injuries that we identified from CIHI database, which were used for the analysis.

4.1.2 Characteristics of Vascular Injury Events

8252 vascular injuries were identified in Ontario for fiscal year 1991 to 2010. Twenty two percent (n=1819) of these injuries were associated with transport trauma and were classified as transport associated injuries (Table 4). The distribution by
anatomical region of all vascular-related injuries that required admission was as follows: neck 10% (n=826), thorax 9% (n=741), abdomen 12.4% (n=1025), upper limbs 52% (n=4287) and lower limbs 16.6% (n=1373). The proportion of injuries that were classified as transport associated injuries for each of the anatomical regions were distributed as follows: neck 26.4% (n=218), thorax 54.4% (n=4.3), abdomen 45.3% (n=464), upper limbs 5.8% (n=249) and lower limbs 35.3% (n=485).

4.2 Data Validation

380 records were selected from two Toronto trauma centers: St. Michael’s Hospital and Sunnybrook Health Sciences Centre. At St. Michael’s Hospital, 189 charts were reviewed with one chart missing. 174 patient charts were identified with the same diagnosis codes in the administrative data whereas 15 charts were matched but with different codes of vascular injury within the administrative data coding. At Sunnybrook Health Sciences Centre 190 charts were reviewed. Of these, 186 patient charts were matched for the same diagnoses as in the administrative data; three charts were matched but with other codes of vascular injury and one chart suggested no evidence of vascular injury (figure 2). Using our chart review as the gold standard, the positive predictive values for the entire study sample (380) and each code group as well as the sensitivity estimates among the individual code groups are reported in tables 5 and 6.
4.3 Temporal Trends in the Annual Rates of Vascular Injury

4.3.1 Overall Vascular Injuries

The trend in the annual rate of vascular injury-related hospital admissions in Ontario for fiscal years 1991-2010 per 100,000 populations is illustrated in Figure 3. The overall vascular injury event rate shows slight but statistically significant decline over the study period from 3.3 per 100,000 populations in 1991 to 2.7 in 2009 (p<0.01).

4.3.1.1 Injury Mechanism

The percentage and number of vascular injury-related hospital admissions in Ontario for both transport and non-transport (others) injuries for fiscal years 1991-2010 are noted in table 7. Transport-associated vascular injury accounted for 22% of vascular injuries. Significant variation in the distribution of injury sites by injury mechanism was observed (p<0.01). The most common sites of transport vascular injury in the admitted patients were lower limb (26.7% n=485), abdominal (n=464, 25.5%) and thoracic (n=403, 22%) vascular injuries. Among other injuries, the upper limb was the most common site of vascular injury (62.8%, n=4038,).

An analysis of the mechanism of vascular injury-related hospital admissions in Ontario (Figure 4) over the study period demonstrates the rate of non-transport (other) vascular injury (average rate of 2.8 events per 100,000 populations) was approximately three-fold higher than that of transport vascular trauma (average rate of 0.8 events per 100,000 populations). The trend in the rate of transport associated vascular injuries was stable over the study period (p=1.00) while the trend in the rate
of other vascular injuries declined slightly after 2003 from 2.8 to 2.1 per 100,000 populations (p<0.01).

As stated in the methods chapter, among the vascular injury cases identified, cases with any transport accident codes of the external cause of injury in ICD-9 or ICD-10 were considered cases with transport-associated vascular injuries. However, individuals without such codes were defined and classified as non-transport (other) vascular injury.

**4.3.1.2 Gender**

An analysis of gender-specific rates of vascular injury-related hospital admission in Ontario for males and females for fiscal years 1991-2010 demonstrated that nearly 80% of all vascular injury events occurred in men (Table 8). Significant variation in the injured site was observed between males and females (p<0.01). Among males, 55% of all vascular injuries took place in the upper limb compared to 42% for women (p<0.01). Abdominal vascular injuries represented 11% of all vascular injuries in men compared to 17% for women (p<0.01).

The different rates of vascular injury-related hospital admissions in Ontario by gender during this study period are seen in Figure 5. The trend in the rate of vascular injury among the male population (average annual rate = 5.7 per 100,000 population) was nearly 4-fold higher than in the female population (average annual rate = 1.5 per 100,000 population). Subtle but statistically significant decreases in overall rates of hospital admission related to vascular injury were observed during the study period for both male (p<0.01) and female populations (p=<0.01).
Analysis of vascular injury events by gender and determination of vascular trauma rates for women and men were based on sex-stratified Ontario population estimates for the relevant interval.

### 4.3.1.3 Age

The analysis of age group at the time of vascular injury-related hospital admission in Ontario is noted in Table 9. The patients were grouped as follows: children 0-14 years, youth 15-24 years, adult 25-64 years and seniors 65 years and over. Significant variation was observed across age groups with respect to sites of vascular injury (p<0.01). Adults (25-64) had the highest incidence of vascular injuries (59.2%, n=4888) followed by youth aged 15-24 (24.5%, n=2018). Seniors had the highest rates of thoracic (n=109, 13%) and abdominal (n=143, 17%) vascular injuries and less upper limb vascular injuries (n=290, 34%) relative to other age groups. The distribution of injury sites was relatively similar in the children, youth and adults except for thoracic and abdominal injuries, which were less frequent among children.

The age group-related temporal trends in the annual rates of vascular injury-related hospital admissions in Ontario for fiscal years 1991-2010 was highest among the youth age group at an average rate of 6.6 per 100,000 population compared to the other age groups (3.8, 2.9 and 1.1 per 100,000 population for adult, senior, and child groups respectively), as seen in Figure 6. The lowest annual rate of vascular injury was among children aged 0-14(average rate of 1.1 per 100,000), followed by seniors (average rate of 2.9 per 100,000). The temporal trends in hospital admissions related to vascular injury decreased significantly over time for children from 1.3 to 0.5 per
100,000 population (p=0.04), youth from 5.9 to 4.7 per 100,000 population (p=0.03), and adults from 3.7 to 2.9 per 100,000 population (p<0.01) but not seniors (p=0.82). The Ontario age-stratified population for the relevant period was used here as the denominator to determine all of the age-specific rates of vascular injury.

4.3.1.4 Economic Status

An analysis of economic status and vascular injury-related hospital admission in Ontario for fiscal years 1991-2010 demonstrates that the number and percentage of vascular injuries were similar for both groups (Table 10). The slight variation observed in the distribution of injury sites by economic status was not statistically significant (p=0.11). However, the annual rates of vascular injury-related hospital admissions were higher in the low economic status population (average rate of 4.2 per 100,000 population) relative to the high economic status population (average rate of 3.1 per 100,000 population). The trends in the rate of vascular injury-related hospital admission in Ontario declined slightly over the study period for both high economic status (p<0.01) and low economic status (p<0.01) populations (Figure 7).

Economic status was determined based on the neighborhood income quintile using postal code information. Those in income quintile 1 or 2 were considered low income whereas quintiles 3 to 5 were considered high income. Vascular injury rates for each economic group were calculated using the respective provincial population estimates for each interval in the denominator.
4.3.1.5 Geographical Variation

The analysis of vascular injury-related hospital admissions by site of principal residence location in Ontario for fiscal years 1991-2010 is noted in table 11. Significant variation in the distribution of injury sites by geographical residency was observed (p<0.01). While the vascular injury-related hospital admissions in the urban setting accounted for approximately 82% (Table 11), the vascular injury event rate was higher among the rural area population (Figure 8) – the average annual rate for vascular injury events was 4.6 per 100,000 for the rural population as compared to 3.4 per 100,000 population for the urban population. The overall trend in the rate of vascular injury-related hospital admission in Ontario declined among the urban population (p<0.01). Among the rural population the overall trend did not show such a decline (p=0.62), although the rates in the rural population did decline from 5.3 in 2003 to 3 per 100,000 population in 2009.

This analysis was based on geographical site-specific rates of vascular injury. These rates were assessed using the location of primary residence data using the Ontario urban or rural population estimates for the relevant period as the denominator. The geographical location of primary residence of vascular injury-related hospital admission patients was determined based on the forward sortation area (FSA) of Ontario, which is a geographical region in which all postal codes start with the same three characters.
4.3.2 Body Regions of Vascular Injuries

Temporal trends in the annual rates of vascular injury-related hospital admissions in Ontario for fiscal years 1991-2010 for each affected anatomical body region are demonstrated in Figure 9. The rate of upper extremity vascular injuries was highest, with an average rate of 1.8 per 100,000 populations whereas the rates of vascular injuries of other body regions were approximately 4-fold lower and similar to each other (average rate of 0.43 per 100,000 of total population). Overall, the rate of vascular injury-related hospital admission in Ontario declined slightly over time for the following sites: neck from 0.34 to 0.26 per 100,000 population (p=0.03), thorax from 0.32 to 0.26 per 100,000 population (p=0.03), upper limb from 1.7 to 1.34 per 100,000 population (p=0.02), and lower limb from 0.57 to 0.4 per 100,000 population (p<0.01) body regions but abdominal injury rates did not decline (p=0.67).

All of the temporal trends of vascular injury-related hospital admissions in Ontario according to injured anatomical site were obtained by calculating the rate of vascular injuries for each anatomical site (neck, thorax, abdomen, upper extremity and lower extremity) based on the corresponding injury code.
4.4 In-Hospital Mortality

4.4.1 Overall

Vascular injury-related in-hospital mortality rate of all vascular injury-related admissions in Ontario for fiscal years 1991-2010 is shown in table 12. The temporal trends in the annual rate of overall vascular injury-related in-hospital mortality in Ontario for fiscal years 1991-2010 are illustrated in figure 10. The overall trend in the rate of overall vascular injury-related in-hospital mortality suggested a trend in decreasing rates over time (p=0.08).

4.4.2 Injury Mechanism

The analysis of vascular injury-related in-hospital mortality in Ontario for fiscal years 1991-2010 for both transport associated and other injuries demonstrated that vascular injury-related in-hospital mortality was approximately fourfold higher among transport-associated vascular injuries (Table 12). On average, approximately 14% of patients with transport-associated trauma died in hospital as compared to 3% of patients with other injuries. Transport-associated vascular trauma was associated with more in-hospital mortality (adjusted odds ratio, 2.21; 95% confidence interval [CI], 1.76 to 2.76) (Table 13). The temporal trends in the annual rate of vascular injury-related in-hospital mortality in Ontario for the study period according to biomechanics of injury are illustrated in figure 11.
4.4.3 Gender

Women experience vascular injury less frequently than men, however the data in table 12 indicates that women have a higher rate of in-hospital vascular injury-related mortality during the fiscal years 1991-2010. Conversely, the difference of in-hospital mortality was not significant according to the gender-adjusted multivariable logistic regression analysis. In-hospital mortality of male vs. female adjusted odds ratio was 1.04 with 95% confidence interval [CI] of 0.82 to 1.32 (Table 13).

The temporal trends in the annual rate of vascular injury-related in-hospital mortality in Ontario for the study period for both sexes are shown in figure 12.

4.4.4 Age

The rate of vascular injury-related in-hospital mortality in Ontario for fiscal years 1991-2010 for each age group is noted in table 12. Vascular injury-related in-hospital mortality was highest among seniors (65 years and above).

Multivariable logistic regression analysis shows significant association of in-hospital mortality and seniors (65 & over) compared to other age groups (adjusted odds ratio, 4.34; 95% confidence interval [CI], 2.25 to 8.38) (Table 13). The rate of in-hospital mortality among seniors having experienced vascular injuries was the highest over the study period with average rate of 0.14, whereas the lowest rate was among children (ages 0-14) with average rate of 0.02.

The temporal trends in the annual rate of vascular injury-related in-hospital mortality in Ontario for the study period for each age group are illustrated in figure13.
4.4.5 Economic Status

The rate of vascular injury-related in-hospital mortality in Ontario for fiscal years 1991-2010 for patients of low and high economic status was similar for both economic status groups (Table 12). The adjusted odds ratio did not demonstrate a significant difference. Low vs. high economic status adjusted odds ratio was 0.96 with 95% confidence interval [CI] of 0.78 to 1.19 (Table 13). The rate of in-hospital mortality between groups was an average rate of 0.052 for patients with vascular injuries in the low economic status group and 0.057 among those in the high economic status group.

The temporal trends in the annual rate of vascular injury-related in-hospital mortality in Ontario for the study period for low and high economic status groups are shown in figure 14.

4.4.6 Geographical Variation

The rate of vascular injury-related in-hospital mortality in Ontario for fiscal years 1991-2010 in both rural and urban areas is shown in Table 12. Vascular injury-related in-hospital mortality was slightly higher among residents of rural areas. Still, the urban vs. rural residency status adjusted odds ratio was 1.07 with 95% confidence interval [CI] of 0.82 to 1.4 (Table 13).

The rates of vascular injury-related in-hospital mortality were relatively similar in both regions with an average of 0.06 among rural patients and 0.05 among urban patients with vascular injury.
The temporal trends in the annual rate of vascular injury-related in-hospital mortality in Ontario for the study period according to geographical sitting are illustrated in figure 15.

4.4.7 Body Regions

The rate of vascular injury-related in-hospital mortality in Ontario for fiscal years 1991-2010 according to the anatomical body region is noted in table 12. Abdominal and thoracic vascular injuries were associated with the highest in-hospital mortality rate, 18.6% (n=191) and 18.2% (n=135) respectively. According to the multivariable logistic regression analysis as well, thoracic and abdominal vascular injuries was associated with a higher rate of in-hospital mortality (adjusted odds ratio, 2.24; 95% confidence interval [CI], 1.56 to 3.2 and adjusted odds ratio, 2.45; 95% confidence interval [CI], 1.75 to 3.42 respectively) (Table 13). The temporal trends in the annual rate of vascular injury-related in-hospital mortality in Ontario for the study period for each affected anatomical body region are shown in figure 16.

4.5 Temporal Variation

Quarterly-based temporal trends in the rate of overall vascular injury-related hospital admissions in Ontario for fiscal years 1991-2010 are illustrated in figure 17. Temporal variations with annual peaks of vascular injuries occurring in the summer months were observed (end of the first and beginning of the second quarter; FK: p<0.01, BKS: p<0.01).
Spectral analysis\textsuperscript{79} was used here to detect statistically significant seasonality of hospital admissions related to vascular injury over the study period. Spectral analysis detects seasonal or temporal variation and periodicity in time series, by plotting the periodogram or spectral density of the series against the period or frequency.

### 4.6 Geographical Distributions

Figure 18 shows the geographical distribution of vascular injury-related hospital admissions for fiscal years 2007-2010 over different areas of Ontario based on data from the Local Health Integration Networks (LHIN).

Descriptive statistics were used here to assess the variation in vascular injury admission rate distributions geographically between April 1, 2007 and March 31, 2010 based on information from the Local Health Integration Networks (LHIN).
Table 4: Characteristics of vascular injury-related hospital admissions in Ontario, for fiscal years 1991 to 2010.

<table>
<thead>
<tr>
<th></th>
<th>Neck</th>
<th>Thorax</th>
<th>Abdomen</th>
<th>Upper extremity</th>
<th>Lower extremity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injuries (%)</td>
<td>826 (10)</td>
<td>741 (9)</td>
<td>1025 (12.4)</td>
<td>4287 (52)</td>
<td>1373 (16.6)</td>
<td>8252</td>
</tr>
<tr>
<td>Adult 25 - 64 (%)</td>
<td>484 (59)</td>
<td>427 (58)</td>
<td>587 (57)</td>
<td>2654 (62)</td>
<td>736 (54)</td>
<td>4888 (59)</td>
</tr>
<tr>
<td>Sex, male (%)</td>
<td>600 (72.6)</td>
<td>577 (77.9)</td>
<td>734 (71.6)</td>
<td>3548 (82.8)</td>
<td>1047 (76.2)</td>
<td>6506 (78.8)</td>
</tr>
<tr>
<td>Transport (%)*</td>
<td>218 (26.4)</td>
<td>403 (54.4)</td>
<td>464 (45.3)</td>
<td>249 (5.8)</td>
<td>485 (35.3)</td>
<td>1819 (22)</td>
</tr>
<tr>
<td>Economic status, high (%)</td>
<td>421 (51)</td>
<td>384 (52)</td>
<td>502 (49)</td>
<td>2170 (50.6)</td>
<td>743 (54)</td>
<td>4220 (51)</td>
</tr>
<tr>
<td>Urban setting (%)</td>
<td>671 (81.2)</td>
<td>576 (77.7)</td>
<td>847 (82.6)</td>
<td>3609 (84)</td>
<td>1094 (79.6)</td>
<td>6797 (82.3)</td>
</tr>
</tbody>
</table>

* Numbers here represent the percentage of transport injuries from all vascular injuries for each group (body region).
Table 5: Positive predictive value of (PPV) of vascular injury codes by CIHI coding compared to review and analysis of patients’ charts.

<table>
<thead>
<tr>
<th>Section</th>
<th>PPV&lt;sup&gt;a&lt;/sup&gt; (%)</th>
<th>95% CI&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>95</td>
<td>92.3 – 96.8</td>
</tr>
<tr>
<td>Neck</td>
<td>97.4</td>
<td>91 – 99.3</td>
</tr>
<tr>
<td>Thorax</td>
<td>90.8</td>
<td>82.2 – 95.5</td>
</tr>
<tr>
<td>Abdomen</td>
<td>96</td>
<td>88.9 – 98.6</td>
</tr>
<tr>
<td>Upper extremity</td>
<td>97.3</td>
<td>90.8 – 99.3</td>
</tr>
<tr>
<td>Lower extremity</td>
<td>93.4</td>
<td>85.5 – 97.2</td>
</tr>
</tbody>
</table>

<sup>a</sup>Positive predictive value, <sup>b</sup>95% confidence interval calculated according to centre for Evidence-based Medicine Toronto, Stat Calculator<sup>80</sup>
### Table 6: Sensitivity of vascular injury coding among the individual code groups.

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Neck</td>
<td>98.7</td>
</tr>
<tr>
<td>Thorax</td>
<td>94.5</td>
</tr>
<tr>
<td>Abdomen</td>
<td>90</td>
</tr>
<tr>
<td>Upper extremity</td>
<td>97.3</td>
</tr>
<tr>
<td>Lower extremity</td>
<td>95.9</td>
</tr>
</tbody>
</table>

<sup>a</sup> 95% confidence interval calculated according to centre for Evidence-based Medicine Toronto, Stat Calculator<sup>80</sup>
Table 7: Distribution of vascular injury-related hospital admissions by site and mechanism in Ontario for fiscal years 1991-2010.

<table>
<thead>
<tr>
<th></th>
<th>Transport</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>% (n)</td>
<td>Number</td>
</tr>
<tr>
<td>Neck</td>
<td>12% (218)</td>
<td>9.5% (608)</td>
<td>10% (826)</td>
</tr>
<tr>
<td>Thorax</td>
<td>22% (403)</td>
<td>5.2% (338)</td>
<td>9% (741)</td>
</tr>
<tr>
<td>Abdomen</td>
<td>25.5% (464)</td>
<td>8.7% (561)</td>
<td>12% (1025)</td>
</tr>
<tr>
<td>Upper limb</td>
<td>13.8% (249)</td>
<td>62.8% (4038)</td>
<td>52% (4287)</td>
</tr>
<tr>
<td>Lower limb</td>
<td>26.7% (485)</td>
<td>13.8% (888)</td>
<td>17% (1373)</td>
</tr>
<tr>
<td>Total</td>
<td>22% (1819)</td>
<td>78% (6433)</td>
<td>8252</td>
</tr>
</tbody>
</table>

- The denominators in table 7 reflect total numbers of transport and non-transport events, respectively.
Table 8: Analysis of vascular injury events by gender and site of injury.

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neck % (n)</td>
<td>9% (600)</td>
<td>13% (226)</td>
<td>10% (826)</td>
</tr>
<tr>
<td>Thorax % (n)</td>
<td>9% (577)</td>
<td>9% (164)</td>
<td>9% (741)</td>
</tr>
<tr>
<td>Abdomen % (n)</td>
<td>11% (734)</td>
<td>17% (291)</td>
<td>12% (1025)</td>
</tr>
<tr>
<td>Upper limb % (n)</td>
<td>55% (3548)</td>
<td>42% (739)</td>
<td>52% (4287)</td>
</tr>
<tr>
<td>Lower limb % (n)</td>
<td>16% (1047)</td>
<td>19% (326)</td>
<td>17% (1373)</td>
</tr>
<tr>
<td>Total % (n)</td>
<td>79% (6506)</td>
<td>21% (1746)</td>
<td>8252</td>
</tr>
</tbody>
</table>

- The denominators in table 8 reflect total numbers of events in males and females, respectively.
Table 9: Analysis of vascular injury events by age and site of injury.

<table>
<thead>
<tr>
<th>Location</th>
<th>Children 0 – 14 y</th>
<th>Youth 15 – 24 y</th>
<th>Adult 25 – 64 y</th>
<th>Seniors 65 y &amp; over</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neck % (n)</strong></td>
<td>13% (64)</td>
<td>9.5% (193)</td>
<td>10% (491)</td>
<td>10% (87)</td>
<td>10% (826)</td>
</tr>
<tr>
<td><strong>Thorax % (n)</strong></td>
<td>3.4% (17)</td>
<td>9.3% (188)</td>
<td>8.7% (427)</td>
<td>13% (109)</td>
<td>9% (741)</td>
</tr>
<tr>
<td><strong>Abdomen % (n)</strong></td>
<td>7.5% (37)</td>
<td>12.8% (258)</td>
<td>12% (587)</td>
<td>17% (143)</td>
<td>12% (1025)</td>
</tr>
<tr>
<td><strong>Upper limb % (n)</strong></td>
<td>58.7% (289)</td>
<td>52.2% (1054)</td>
<td>54.3% (2654)</td>
<td>34% (290)</td>
<td>52% (4287)</td>
</tr>
<tr>
<td><strong>Lower limb % (n)</strong></td>
<td>17.4% (86)</td>
<td>16.2% (327)</td>
<td>15% (736)</td>
<td>26% (224)</td>
<td>17% (1373)</td>
</tr>
<tr>
<td><strong>Total % (n)</strong></td>
<td>6% (493)</td>
<td>24.5% (2018)</td>
<td>59.2% (4888)</td>
<td>10.3% (853)</td>
<td>8252</td>
</tr>
</tbody>
</table>
Table 10: Analysis of vascular injury events by economic status and site of injury.

<table>
<thead>
<tr>
<th></th>
<th>LES</th>
<th>HES</th>
<th>Missing</th>
<th>Total Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck % (n)</td>
<td>10% (385)</td>
<td>10% (421)</td>
<td>20</td>
<td>10% (826)</td>
</tr>
<tr>
<td>Thorax % (n)</td>
<td>9% (349)</td>
<td>9% (384)</td>
<td>8</td>
<td>9% (741)</td>
</tr>
<tr>
<td>Abdomen % (n)</td>
<td>13% (516)</td>
<td>12% (502)</td>
<td>7</td>
<td>12% (1025)</td>
</tr>
<tr>
<td>Upper limb % (n)</td>
<td>52% (2075)</td>
<td>51% (2170)</td>
<td>42</td>
<td>52% (4287)</td>
</tr>
<tr>
<td>Lower limb % (n)</td>
<td>16% (619)</td>
<td>18% (743)</td>
<td>11</td>
<td>17% (1373)</td>
</tr>
<tr>
<td>Total % (n)</td>
<td>48% (3944)</td>
<td>51% (4220)</td>
<td>1% (88)</td>
<td>8252</td>
</tr>
</tbody>
</table>

- The denominators in table 10 reflect total numbers of LES and HES events, respectively.
Table 11: Analysis of vascular injury events by geographic location and site of injury.

<table>
<thead>
<tr>
<th></th>
<th>Rural</th>
<th>Urban</th>
<th>Missing</th>
<th>Total Number</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neck % (n)</strong></td>
<td>10.6% (152)</td>
<td>10% (671)</td>
<td>3</td>
<td>10% (826)</td>
</tr>
<tr>
<td><strong>Thorax % (n)</strong></td>
<td>11.4% (164)</td>
<td>9% (576)</td>
<td>1</td>
<td>9% (741)</td>
</tr>
<tr>
<td><strong>Abdomen % (n)</strong></td>
<td>12% (176)</td>
<td>12% (847)</td>
<td>2</td>
<td>12% (1025)</td>
</tr>
<tr>
<td><strong>Upper limb % (n)</strong></td>
<td>47% (669)</td>
<td>53% (3609)</td>
<td>9</td>
<td>52% (4287)</td>
</tr>
<tr>
<td><strong>Lower limb % (n)</strong></td>
<td>19% (274)</td>
<td>16% (1094)</td>
<td>5</td>
<td>17% (1373)</td>
</tr>
<tr>
<td><strong>Total % (n)</strong></td>
<td>17.4% (1435)</td>
<td>82.4% (6797)</td>
<td>0.2% (20)</td>
<td>8252</td>
</tr>
</tbody>
</table>

- The denominators in table 11 reflect total numbers of rural and urban events, respectively.
Table 12: Analysis of in-hospital mortality related to vascular injury in Ontario for fiscal years 1991-2010, numbers and percentage.

<table>
<thead>
<tr>
<th>Number of Deaths</th>
<th>Death % of Injury Type (group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>451</td>
</tr>
<tr>
<td>Mechanism</td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td>255</td>
</tr>
<tr>
<td>Others</td>
<td>196</td>
</tr>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>Children (0 – 14)</td>
<td>11</td>
</tr>
<tr>
<td>Youth (15 – 24)</td>
<td>87</td>
</tr>
<tr>
<td>Adult (25 – 64)</td>
<td>234</td>
</tr>
<tr>
<td>Seniors (65 &amp; over)</td>
<td>119</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>320</td>
</tr>
<tr>
<td>Female</td>
<td>131</td>
</tr>
<tr>
<td>Economic status</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>204</td>
</tr>
<tr>
<td>High</td>
<td>243</td>
</tr>
<tr>
<td>Body region</td>
<td></td>
</tr>
<tr>
<td>Neck</td>
<td>57</td>
</tr>
<tr>
<td>Thorax</td>
<td>135</td>
</tr>
<tr>
<td>Abdomen</td>
<td>191</td>
</tr>
<tr>
<td>Upper limb</td>
<td>25</td>
</tr>
<tr>
<td>Lower limb</td>
<td>43</td>
</tr>
<tr>
<td>Location of residence</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>359</td>
</tr>
<tr>
<td>Rural</td>
<td>90</td>
</tr>
</tbody>
</table>

- The denominators in table 12 reflect the number of relevant vascular injury events for each group.
Table 13: Multivariable logistic regression analysis of vascular injury-related in-hospital mortality.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odd ratio (OR)</th>
<th>95% Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanism of injury</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>1.00 (reference)</td>
<td>N/A</td>
</tr>
<tr>
<td>Transport</td>
<td>2.21</td>
<td>1.76</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1.00 (reference)</td>
<td>N/A</td>
</tr>
<tr>
<td>Male</td>
<td>1.04</td>
<td>0.82</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child (0 – 14)</td>
<td>1.00 (reference)</td>
<td>N/A</td>
</tr>
<tr>
<td>Youth (15 – 24)</td>
<td>1.34</td>
<td>0.69</td>
</tr>
<tr>
<td>Adult (25 – 64)</td>
<td>1.55</td>
<td>0.82</td>
</tr>
<tr>
<td>Seniors (65 &amp; over)</td>
<td>4.34</td>
<td>2.25</td>
</tr>
<tr>
<td>Economic Status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>1.00 (reference)</td>
<td>N/A</td>
</tr>
<tr>
<td>Low</td>
<td>0.96</td>
<td>0.78</td>
</tr>
<tr>
<td>Geographical residency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>1.00 (reference)</td>
<td>N/A</td>
</tr>
<tr>
<td>Urban</td>
<td>1.07</td>
<td>0.82</td>
</tr>
<tr>
<td>Anatomical site of injury</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neck</td>
<td>1.00 (reference)</td>
<td>N/A</td>
</tr>
<tr>
<td>Thoracic</td>
<td>2.24</td>
<td>1.56</td>
</tr>
<tr>
<td>Abdomen</td>
<td>2.45</td>
<td>1.75</td>
</tr>
<tr>
<td>Upper limbs</td>
<td>0.1</td>
<td>0.06</td>
</tr>
<tr>
<td>Lower limbs</td>
<td>0.36</td>
<td>0.24</td>
</tr>
</tbody>
</table>
Figure 1: Flow chart to identify eligible records for analysis from the Canadian Institute for Health Information for hospital admission related to vascular injury in Ontario, from April 1, 1991 to March 31, 2010.
Total of 380 records selected from both centers

190 records from St. Michael’s Hospital

189 charts reviewed
174 charts matched same codes
15 charts matched other vascular injury codes

One chart missing

190 records from Sunnybrook Health Sciences Centre

All of the 190 charts reviewed

186 charts matched same codes
3 charts matched other vascular injury codes
One chart did not have any vascular injury

Figure 2: Record selection and chart review flow chart (validity study).
Figure 3: Annual rate of all vascular injury-related hospital admissions in Ontario for fiscal years 1991-2010.

Overall vascular injury event rate shows slight but statistically significant decline over the study period (p<0.01).
Figure 4: Annual event rate of vascular injury-related hospital admissions in Ontario classified by mechanism of injury for fiscal years 1991-2010.

The trend was stable over the study period (p=1.00) for transport and declined slightly after 2003 for other injuries (p<0.01).
Figure 5: Annual event rate of vascular injury-related hospital admission in Ontario for fiscal years 1991-2010, gender analysis.

Statistically significant decreases found in overall trends during the study period for both male (p<0.01) and female populations (p=<0.01).
Figure 6: Annual event rate of vascular injury-related hospital admissions in Ontario for fiscal years 1991-2010, age analysis.

Trends decreased significantly over time for children (p=0.04), youth (p=0.03), and adults (p<0.01) but not seniors (p=0.82).
Figure 7: Annual event rate of vascular injury-related hospital admissions in Ontario for fiscal years 1991-2010, economic status analysis. Trends declined slightly over the study period for both high economic status (p<0.01) and low economic status (p<0.01).
Figure 8: Annual event rate of vascular injury-related hospital admissions in Ontario for fiscal years 1991-2010, geographical variation analysis.

Trend declined among the urban population (p<0.01) but did not show such a decline among rural population (p=0.62).
Figure 9: Annual event rate of vascular injury-related hospital admissions in Ontario for fiscal years 1991-2010, anatomical site of injury analysis.

Trend declined slightly over time for the neck (p=0.03), thorax (p=0.03), upper limb (p=0.02), and lower limb (p<0.01) injuries but not for abdominal injuries (p=0.67).
Figure 10: Annual rate of overall vascular injury-related in-hospital mortality in Ontario for fiscal years 1991-2010.

The rate of overall vascular injury-related in-hospital mortality revealed a trend of decreasing rates over time (p=0.08).
Figure 11: Annual rate of vascular injury-related in-hospital mortality classified by mechanism of injury in Ontario for fiscal years 1991-2010.

Vascular injury-related in-hospital mortality was approximately fourfold higher among transport associated or blunt vascular injuries.
Figure 12: Annual rate of vascular injury-related in-hospital mortality in Ontario for fiscal years 1991-2010, gender analysis.

Women had a slightly higher (but not statistically significant) rate of in-hospital vascular injury-related mortality for fiscal years 1991-2010.
Figure 13: Annual rate of vascular injury-related in-hospital mortality in Ontario for fiscal years 1991-2010, age analysis.

The rate of in-hospital mortality among seniors with vascular injury was the highest over the study period.
Figure 14: Annual rate of vascular injury-related in-hospital mortality in Ontario for fiscal years 1991-2010, economic status analysis.

The rate of vascular injury-related in-hospital mortality in Ontario for fiscal years 1991-2010 was similar for both economic status groups.
Figure 15: Annual rate of vascular injury-related in-hospital mortality in Ontario for fiscal years 1991-2010, geographical variation analysis.

The rates of vascular injury-related in-hospital mortality were relatively similar in both regions.
Figure 16: Annual rate of vascular injury-related in-hospital mortality in Ontario for fiscal years 1991-2010, anatomical site of injury analysis.

Abdominal and thoracic vascular injuries were associated with the highest in-hospital mortality rate.
Figure 17: Temporal variation in the event rate of overall vascular injury-related hospital admissions per quarter in Ontario for fiscal years 1991-2010. Variations with annual peaks of vascular injuries occurring in the summer months were observed here.
Figure 18: Distribution of hospital admissions related to vascular injury for fiscal years 2007-2010 over Ontario areas based on information from the Local Health Integration Networks (LHIN).
CHAPTER 5

DISCUSSION

The objectives of this chapter are to discuss:

1. The results of the analysis of hospital admissions related to vascular injury.
2. The results of the analysis of in-hospital mortality related to vascular injury.
3. The temporal variation in the rate of hospital admissions related to vascular injury.
4. The study limitations.
5. The public health and clinical implications of this study.
6. Future directions for further studies.

This population-based study is the first known comprehensive analysis evaluating vascular injuries in Ontario. Two key points should be kept in mind. First, this is an epidemiological public health-oriented study and thus provides a global image of vascular injuries and less clinical detail. The few available studies on civilian vascular injuries are clinically oriented and describe single-centre experiences\textsuperscript{12, 31, 36, 44, 45, 47, 81, 82} which may yield unsatisfactory comparisons. Second, most published studies about vascular injuries have dealt with military situations, whereas this study examined civilian vascular injuries, hence the results differ considerably.
5.1 Vascular Injury-related Hospital Admission Rate

In the last few decades, the incidence of civilian injury due to motor vehicles has increased in most countries\(^9\) whereas no changes, and even a mild decline have been observed in Canada and the United States.\(^6,83\) According to WHO, current trauma global trends suggest that by 2030 road traffic deaths will become the fifth leading cause of death unless urgent action is taken.\(^111\) Single center statistics worldwide\(^12,34,36,44,47\) provide some data, however information regarding national trends or incidence of all vascular injuries is not readily available. Given the significant data indicate increasing trends of all types of injury worldwide\(^13,111\) and harmful data indicate increasing vascular injury specifically in some countries\(^31-34\) as well as lacking of epidemiological data of vascular injury in Canada, we hypnotized that vascular injuries are increasing in Ontario as well.

In this study, the average rate of vascular injury-related admissions was 3.5 per 100,000, and the trend showed a slight but statistically significant decline between 1999 and 2010. This decline seems to follow the mild decline in the number of motor vehicle collisions in Canada\(^6\), and the injury-related hospitalization rate among some age groups in the United States.\(^83\)

The improvement of health care in Canada during the last 20 years in terms of transportation of injured patients to and between hospitals, triaging patients in the emergency department as well as the ability of treating some injuries at the emergency room without hospitalization could explain the slight decline in vascular injury-related hospitalization rates\(^112,113\).
Transport-associated injuries represented only 22% of all vascular injuries in Ontario examined during the study period. As motor vehicle collisions were considered the greatest cause of vascular injuries among civilians in most countries, this result was surprising and indicated that the majority of vascular injury is secondary to other mechanisms such as falls, traumatic accidents, and iatrogenic injury. The percentage of such civilian non-transport vascular injuries in Ontario was high compared to Europe, Australia and other developing countries, but not higher than that reported for the United States and Latin America.

Regarding the mechanism of injury in general (i.e. not specifically vascular injury) in Canada, sports are the leading overall cause of injury among youth whereas riding in a car and fighting are the main causes of injuries requiring significant medical treatment among youth across grade 6 to 10. Further, work-related injuries increase as young people enter the workforce. Such data might explain our finding that indicate most vascular injuries in Ontario do not involve transportation.

In contrast to non-transport (other) vascular trauma trends, the trends of transport vascular trauma remained stable over the study period despite the rate of motor vehicle accidents, which decreased in Canada over this period.

Vascular injuries were disproportionately higher among males, who accounted for 79% of the injuries reported, an average incidence rate of 5.6 per 100,000 males. This finding may be explained by a higher degree of involvement in motor vehicle driving, work injuries, or criminal violence as compared with females. The gender variation in this study followed most of the trauma and vascular injury gender variation discussed in previous studies.
Although 59% of vascular injury-related admissions were found to occur in adults 25-64 years of age, (with an average rate of 3.8 per 100,000 adult population), the highest rate of vascular injury-related admission was among youth aged 15 to 24 years (average rate of 6.6 per 100,000 youth). Despite a lack of data for the vascular injury rate among youth, between 1986 and 2003\textsuperscript{86}, injury hospitalizations for Canadian adolescents aged 15 to 19 year old accounted for an average of 31.0% and 9.3% of all hospitalizations in males and females, respectively. In the United States there were no statistical differences in the injury rates between adolescents and adults.\textsuperscript{83} In addition, teenage male drivers represent those at greatest risk for motor vehicle accidents\textsuperscript{87}.

Geographic location of residence and socioeconomic status also influence injury rates. Lower economic status individuals have higher rates of injuries, from motor vehicles or other eitologies.\textsuperscript{8, 10, 88-90} In this study, the average vascular injury-related hospital admission rate among persons with lower economic status was 4.2 per 100,000 compared to 3.1 per 100,000 in those with higher economic status. These results corroborate the higher injury rate among low-income populations in the literature\textsuperscript{8, 10, 88-90}. Trends were observed with vascular injury-related hospital admissions by geographical setting. The average rate of vascular injury-related hospital admission was 4.6 per 100,000 of rural population compared to 3.4 per 100,000 people of urban population. These data are in accordance with those reported by other studies that showed higher rate of injuries in rural areas, regardless of the statistical significance of the differences noted.\textsuperscript{6, 12, 91-95} Furthermore, the overall trends in the rate of vascular injury-related hospital admissions in rural regions did
not show a statistically significant decline when compared to the urban regions. The fact that there was no decline observed in the rural regions is interesting and could be due to many different factors, which would warrant further in-depth investigation. The location of vascular injuries differs significantly between military and civilian series. In military studies, extremities represent the most common site of vascular injury, mainly occurring in the lower limbs. Among the civilian population, variability in the anatomical site of vascular injury has been documented in several studies. Extremity vascular injuries were twice as common as thoracic and abdominal vascular injuries in the United States and Latin America, with either equal distribution between upper and lower limbs, or a slightly greater number of upper limb vascular injuries. In Australia, vascular injuries are occurring almost equally between thorax, abdomen and the extremities. In our study found more than two-thirds of vascular injury-related hospital admissions in Ontario were related to extremity vascular injuries with a disproportionate number of upper limb vascular injuries (52%). With non-transport (other) injuries, it was common to find upper limb vascular injuries representing the majority (62.8%), followed by lower limbs (13.8%). Abdominal and thoracic vascular injuries were found to be greater with transport injuries, 25.5% and 22%, respectively. This finding may also be explained by the nature and force necessary to injure the great vessels of the abdomen and thorax, which occurs mainly through blunt mechanisms like motor vehicle collisions. On the other hand, the overall rate of vascular injury-related hospital admissions in Ontario declined slightly over the study period for all anatomical body regions except for abdominal vascular injuries. This may be
explained by the finding that the transport vascular trauma-related hospital admission rate was stable without any significant decline over the study period and most of the abdominal vascular injuries occurred secondary to transport associated mechanisms.

5.2 Vascular Injury-related in-hospital Mortality

Overall, vascular injury-related in-hospital mortality only occurred in 5.5% of all documented vascular injury-related hospital admissions during the study period and there was a decreasing trend in this mortality over the second half of the study period. The average mortality rate of total vascular injuries is relatively low compared to that reported in other studies in the United States (13%)\(^1\)\(^2\),\(^1\)\(^3\)\(^1\)\(^2\) and Australia (19%).\(^3\)\(^1\)

Relative stability of vascular injury-related in hospital mortality trends throughout the study period supports our explanation above regarding the trend of hospitalization pointing that vascular injury-related hospitalization declined probably secondary to the decreasing of unnecessary hospitalization but not the hospitalization of severe injuries, which might remain the same.

Mortality was higher with transport-associated vascular injuries (OR, 2.21; 95% C.I, 95% confidence interval [CI], 1.76 to 2.76) than other injuries. This finding reflects a more substantial traumatic injury that is mainly blunt in mechanism as well as greater numbers of other associated injuries. Abdominal and thoracic vascular injuries had the highest incidence in mortality, with rates of 18.6% and 18.2%, respectively, and ORs of 2.24 (95% CI, 1.56 to 3.2) and 2.45 (95% CI, 1.75 to 3.42), respectively.

Among all vascular injury-related hospital admissions, the upper limb was the most
common site of injury, however it was the least life-threatening as it accounted for only 0.5% of all mortalities. These findings seem logical 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 as well as longer periods of intensive care.

Although the rate of vascular injury-related hospital admission was lower among females, with an average of 1.5 per 100,000 females compared to 5.6 per 100,000 males, the crude in-hospital mortality rate was surprisingly higher among females, with a mortality rate of 7.5% in females compared with 5% in males. However, this difference was not found to be statistically significant. Previous studies show either no difference or a slight tendency of higher mortality among males secondary to all kinds of injury$^9, 96, 97$ with no evidence of special mortality affinity among vascular injured female patients$^{12, 31, 81, 82}$. Our findings can be explained to some extent by the slightly higher percentage of total abdominal and lower limb vascular injuries, which are associated with a higher mortality among females, compared to males.

For all kinds of injury, the elderly population represent a smaller proportion of injuries compared to young people$^{9, 83, 98}$. However, mortality is always higher among the elderly, more than any other age group and increases with each decade of age.$^1, 70, 83, 99$ Increases in the risk of death among the elderly are mainly explained by high risk of complications and associated co-morbidities. Vascular injury-related in-hospital mortality was two-fold higher among seniors 65 years and older compared to other adults and youth. The average mortality rate was 14% for seniors with vascular injuries and they have a significantly higher rate of mortality than the other age
groups (adjusted OR, 4.34, 95% CI, 2.25 to 8.38). Additionally, abdominal, thoracic and lower limb vascular injuries were relatively higher among seniors with low rates of upper limb vascular injuries compared to other age groups. Thus, seniors have higher vascular injury-related mortality secondary to both age and site of injury.

Despite international and local statistics, and studies indicating a higher rate of injury and injury mortality among people living in low-income areas or among lower economic status populations, our findings show relatively little distinction in vascular injury-related in-hospital mortality for high and low income statuses, with a mortality rate of 5% among lower income individuals, and 5.7% among those with higher incomes. This could be due to the universal health care coverage provided to everyone in Ontario vs. different types of coverage provided in other countries.

Previous studies in various countries, including Canada, demonstrate statistically significant increases in mortality rates related to motor vehicle accidents occurring in rural areas. This variation is attributed to many factors such as greater propensity for high-risk behaviors like speeding, some environmental factors like exposure to agricultural machinery, and/or limited or delayed access to trauma care.

Vascular injury-related in-hospital mortality in Ontario was slightly higher (6.3%) among the residents of rural regions, compared with an average 5.3% mortality rate among residents of urban areas, a difference which is not statistically significant (OR, 1.07; 95% CI, 0.82 to 1.4).
5.3 Temporal Variations

Seasonal variations in hospital admissions for injury have been noted, for example, as the variations in traffic injuries.\textsuperscript{104, 105} No standardization can be determined as some peaks occur during summer due to the increased numbers of pedestrians and cyclists, or during winter, secondary to the increased use of motor vehicles for transportation. Quarterly-based temporal trends in the rate of overall vascular injury-related hospital admissions in Ontario during this study period showed temporal variation with regular patterns, with peaks of vascular injuries during the summer months (June, July, and August). An increase in travel and transportation, an increase in the number of pedestrians and cyclists, and the involvement of children and youth in more activities, including illegal driving during the summer holidays, could explain these summer peaks. Furthermore, climate may play a considerable factor. In Canada, the winter is cold, and many people in this season participate in activities that take place indoors, therefore it is plausible that in the summer we would observe an increase in the number of vascular injuries from outdoor activities. This variation due to climate might explain the difference in the temporal variations from other countries.

The highest rate of vascular injury-related hospital admissions in Ontario, with respect to geography (according to the Local Health Integration Networks (LHIN)) were found to occur in North Simcoe Muskoka and Hamilton Niagara Haldimand Brant, followed by areas like North Eastern Ontario, South Western Ontario and Waterloo-Wellington. The reasons for the geographic differences in vascular injury rates cannot be determined by from these databases.
5.4 Limitations

This observational study has several strengths, which include: 1) a population-based study covering the full range of the vascular injury-related admissions in Ontario over the past two decades (1991 to 2010); 2) the Ontario healthcare databases used in this study are not affected by the significant selection bias characteristics of the Medicare and Medicaid databases\textsuperscript{106, 107} since Canadian access to care is universal and has not changed over the time period of this study\textsuperscript{108}; 3) the confidentiality of patients is preserved, and 4) The implementation of ICD-10 coding only began in 2002 in Canada. Therefore, the new CIHI diagnostic codes (ICD-10) have been validated by using samples from the two main trauma centers in Ontario, which receive both local cases and those transported in from the regional area for specialized care.

This study also has several important limitations to note.

The first limitation is related to the accuracy of the databases used. Although the percentage of matched CIHI records with patient charts for vascular trauma codes in the validity study (the PPV and sensitivity) is high and impressive, the validation was performed only in two main hospitals (which are trauma centers) in Toronto, and thus this may not be representative of the whole province. On the other hand, the two hospitals where the validation study performed may be more familiar with such type of coding since they are trauma centers. Use of non-trauma hospitals may have resulted in lower levels of accuracy; as such centers may not be as familiar with vascular injury-related codes. As such, our findings may reflect an underestimation of vascular injury rates in Ontario.
Using the term ‘vascular injury’ without differentiation between arterial and venous injuries may be considered a limitation. The major vascular injury codes according to the anatomical site of injury were used in this study without using the sub-codes. As it is a population-based study covering the entire province of Ontario and the first study analyzing vascular injury in Ontario, we chose to determine the annual rate of hospital admission secondary to vascular injuries and the in-hospital mortality, and analyze them according to study objectives for vascular injuries in general, thus both arterial and venous injuries are included without classification. In the validation study as well, the accuracy was assessed for the five main vascular injury codes according to the anatomical part of the body but not for sub-codes differentiating between arterial and venous injury.

Differentiating the mechanism of injury was a major issue in this study. In the coding system utilized in the database, there are no specific codes for blunt or penetrating injuries for example. Transport-associated vascular trauma is commonly classified in the literature as a blunt injury. In our study, we classify injuries into transport associated and other that includes falls, traumatic accident, iatrogenic or any other injuries. Using such classification may represent a limitation of the study. Given the circumstances, choosing this analysis and classification was the best possible solution. In addition, determining which vascular injuries were associated with transportation permitted us to identify the role that transportation had in injury. It also allowed us to understand the extent to which transportation contributed to the etiology of injuries in general, and to vascular injuries specifically.
Another limitation relates to the geographical setting, or analysis of vascular injury-related hospital admissions stratified by urban and rural areas. Geographical variation of vascular injury-related hospital admissions and in-hospital mortalities were analyzed based on the location of the principal residence of the individual, as registered in the database. The geographic site where the injury occurred was not available in the database. However, the postal codes from the Registered Persons Database (i.e. the contact files) were used as a proxy to differentiate between urban and rural geographical locations of injury.

Finally, duration of hospitalization was not analyzed in our study. This information may have been helpful in understanding how hospital practices have been changing over time with respect to inpatient management.

5.5 Public Health and Clinical Implications

The findings of this thesis work has several public health and clinical implications with respect to advancing the understanding of the epidemiology of vascular injury in Ontario, quantifying the extent of hospital admissions for vascular injury and its temporal trends and variations, geographic variation in trauma admissions, and drivers of vascular injury admissions such as motor vehicle accidents over the past two decades. Firstly, vascular injury-related hospitalization rates show a slight but statistically significant decline over the study period, reassuring public health and policy planners that a crisis of vascular injury admissions is not expected in the near future.
Second, vascular injury was more common in young adult males, with vascular injury-related admission rates being highest among youth between the ages of 15 and 24 years. This raises questions regarding causes of these events and the possible role of preventative public health interventions. Furthermore, examination of the temporal variation revealed that vascular injuries occurred more during summer months (June, July, and August). This observation may indicate that this young age group may potentially participate in risk-taking behavior when schools and universities are on summer holiday. Public prevention programs or educational campaigns targeted to youth, as well as parental education, may help to alleviate some of these injuries, especially if undertaken toward the end of the typical academic year. Alternatively, greater vigilance may be needed during summer months.

Third, vascular injury-related hospital admission rates were higher in rural areas and did not show a statistically significant decline over time relative to the incidence of admissions of residents of urban areas. Special prevention programs targeting people living in rural areas may be recommended. Encouraging safe driving behaviors and making greater efforts in taking precautions with agricultural machinery may help to decrease these rates in the rural areas.

Fourth, transport-associated vascular injuries accounted for only 22% of all vascular injury-related hospital admissions. The surprising finding that the majority of vascular injuries (78%) were not caused by transportation accidents indicates that other causes are likely. Industrial, agricultural, or home injuries may be the source of these vascular injuries, as well as criminal violence. This would assist in public health intervention planning to enable more targeted efforts in reducing vascular injuries.
Traditionally, public health campaigns have focused on messages related to safe driving and transportation. While these areas are still important targets for public health messaging, our findings suggest that broader messaging may be relevant. Given the unexpected nature of these findings, further studies are required to determine the actual causes of the other types of vascular injury.

Fifth, the total in-hospital mortality rate in this study was 5.5%, which is considerably lower than expected. These findings also have implications for public health planners as the long-term disability associated with vascular injuries, although this could not be directly measured in our research, may be more common than expected and result in significant long-term disability with considerable economic implications.

Sixth, vascular injury-related in-hospital mortality was higher with abdominal and thoracic vascular transport associated injuries relative to other types of vascular injury, and among seniors 65 years and over relative to the younger population. From a clinical standpoint, improving the degree of attention to transportation or traffic injuries and speeding up transfers of these types of injuries, as well as attending to injuries of the major (trunk) vessels as early as possible may help reduce both morbidity and mortality. Additionally, the rates of hospital admissions for vascular injuries in seniors do not appear to be declining, as opposed to the rates for all other age groups. Moreover, the mortality rate is highest among seniors, indicating that improvements in the multifaceted care environment are necessary for the elderly. This information may be insightful to public health planners as it identifies a core group of the population for whom greater efforts may be warranted.
5.6 Future and Further Studies

The findings of this study provide a fundamental overview of vascular injury in Ontario, and serve as a basis for further studies and analyses at the province level and nationally. First, cross-provincial and cross-national comparisons of our findings would provide greater insight into the generalizability of our research and the comparability of our findings.

Second, ongoing evaluation by repeating a similarly designed study in Ontario over the next decade will provide further information on the consistency of the observed trends. Third, more focused analyses examining a range of clinical outcomes such as peripheral arterial injuries and amputations, elderly vascular injuries and death, etc, will provide more insight into the clinical implications of vascular injury. Fourth, extending the analysis of trends and clinical outcomes to inform a burden-of-illness study with a health economics and policy evaluation would be particularly valuable to policy planners.

Fifth, while we found the coding of vascular injury-related hospital diagnosis to be reasonably good, a more detailed study using vascular injury diagnosis sub-codes, and analyzing vascular injuries according to each artery and vein specifically will assist in providing a wider and more advanced image of vascular injuries in Ontario. Analyzing vascular injuries specifically according to vessel type (artery or vein) and functional role (major or minor) will have a more clinically relevant impact. Direct causes and mechanisms of injury were determined in this study with some limitations due to lack of understanding/available data. In fact, finding a suitable
methodology to determine the exact mechanism of vascular injuries such as iatrogenic vascular injuries will feed these data with more significant details and would improve the impact of the research, i.e. injury prevention. As such, a methodological paper on assessing coding validity would be extremely helpful and the findings of such a validation exercise would provide considerable insights into planning of future research studies in this area.

Sixth, a more detailed evaluation of the management approaches used for vascular injury patients would be extremely beneficial in understanding the clinical, economic, and social impacts of different management approaches. The variation in approaches across regions and time that have been observed in our current work could be explored further. For example, comparing the utilization and outcomes of surgical interventional procedures such as open and/or endovascular repair taking into account the relevant indications, limitations, and short and long term consequences would provide extremely important information to help shape clinical practice and health policy.

Seventh, further analysis on vascular injury-related death as 30-days mortality, 6-month mortality and/or one-year mortality could provide important findings that reflect the severity of the vascular injury.

Further, analysis of the type of specialty services caring for these kinds of patients (paramedical care, emergency medicine, intensive care, surgery, etc) would further our understanding of how patients are currently being managed and patterns of care that result in optimal patient outcomes. Our current research has largely been epidemiological in nature and such studies would need to consider study designs that
are more patient-focused such as cohort studies and path analysis. Additionally, prospective studies, both quantitative and qualitative, to better understand patients, healthcare professionals, and system factors that contribute to health services patterns and clinical outcomes would be extremely valuable.

5.7 Conclusions

The overall trend in the annual rate of vascular injury-related hospital admissions in Ontario shows a slight but statistically significant decline occurring over the last 19 years. The highest vascular injury event rate was observed among young males, aged 15 to 24 years, and for those living in rural areas with low income, suggesting supplementary public health education prior to the end of the school year may have a positive impact. Non-transport associated (other) vascular injuries were disproportionately greater than transport associated injuries which indicates the possibility of injury resulting from causes other than transport. Although the vascular injury-related in-hospital mortality rate was only 5.5%, an important clinically oriented observation was found in that mortality was strongly associated with the senior age group (above 65) and transport associated abdominal and thoracic vascular trauma. Finally, the vascular event rate was found to be higher during the summer months of June, July and August, and in rural locations. These findings provide a broad picture of vascular related injuries and have important public health implications for injury prevention strategies.
Reference List


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http://ktclearinghouse.ca/cebm/ 2011


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(112) CIHI. Health Care in Canada: 2012 A Focus on Wait Times 2012.

(113) Sampalis JS. Canadian Major Trauma Cohort Research Program. canadian health services research foundation. March 2006.
Appendix 1: Ethical approval from St. Michael’s hospital.

11 August 2010

Dr Muhammad Mamdani
Applied Health Research Centre
St Michael’s Hospital

Dear Dr Mamdani

Re: REB 10-235C: Validity of vascular trauma codes at SMH trauma centre

REB APPROVAL:

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<tr>
<th>Original Approval Date</th>
<th>August 11, 2010</th>
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<td>Annual/Interval Review Date</td>
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Thank you for your application submitted on 29 July 2010. The above noted study has been reviewed through an expedited/delegated process (not by Full Board review). The views of the SMH REB have been documented and resolved.

The REB approves the study as it is found to comply with relevant research ethics guidelines, as well as the Ontario Personal Health Information Protection Act (PHIPA), 2004. The REB hereby issues approval for the above named study for a period of 12 months from the date of this letter. Continuation beyond that date will require further review of REB approval. In addition, the following documents have been reviewed and are hereby approved.

During the course of this investigation, any significant deviations from the approved protocol and/or unanticipated developments or significant adverse events should immediately be brought to the attention of the REB.

Please note that if a Clinical Trial Agreement is required, it must be submitted to the Office of Research Administration for review and approval. Any additional institutional approvals must be coordinated through the Office of Research Administration prior to initiation of this research. All drug dispensing must be coordinated through the Research Pharmacy at 416-864-5413.

The SMH REB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans, the Ontario Personal Health Information Protection Act, 2004, and ICH Good Clinical Practice Consolidated Guideline E6, Health Canada Part C Division 5 of the Food and Drug Regulations, Part 4 of the Natural Health Product Regulations, and the Medical Devices regulations. Furthermore, all investigational drug trials at SMH are conducted by Qualified Investigators (as defined in the latter document).

With best wishes,

Sharon Freitag
Director, Research Ethics Office

Dr. Brenda McDowell
Vice Chair, Research Ethics Board

Dr. Muhammad Mamdani (REB # 10-235)
Appendix 2: Ethical approval from Sunnybrook Health Science Centre.

To: Dr. Andrew Dueck  
Cardiac & Vascular Surgery  
Room H1 85

From: Dr. Philip Hébert

Date: December 13, 2010

Subject: Validity of Vascular Trauma Codes at Sunnybrook Health Sciences Trauma Centre

Project Identification Number: 359-2010  
Approval Date: December 13, 2010  
Expiry Date: December 13, 2011

The Research Ethics Board of Sunnybrook Health Sciences Centre has conducted a Delegated Board review of the research protocol referenced above and approved the involvement of human subjects on the above captioned date. The quorum for approval did not involve any member associated with this project.

The approval of this study includes the following documents:
- Protocol Version 1 dated July 29, 2010
- Case Report Form Version 2 dated December 10, 2010

☑ A formal Informed Consent Form (ICF) is not included in the approved documentation for this study as it is considered not required by the Sunnybrook REB; consent requirements, if applicable, have been otherwise dealt with.

All correspondence with the REB must include the assigned Project Identification Number. The REB requires immediate notification of all internal serious adverse events and significant deviations. Study continuation beyond one year requires submission of a renewal form prior to the expiry date or a study completion report must be received to close the file with the REB.

All REB approved studies may be subject to review by the Sunnybrook Quality Assurance and Education Program and, as Principal Investigator, you are responsible for the ethical conduct of this study. Approval by the Sunnybrook REB entails compliance with current legislation outlined in the Ontario Personal Health Information Protection Act (PHIPA) and all policies and guidelines established by Sunnybrook. All applicable contracts and agreements must be submitted to Sunnybrook Research Administration before this research may be initiated.

Philip C. Hébert, MD PhD FCPC  
Chair, Research Ethics Board
OR  
Miriam Shuchman, MD  
Vice-Chair, Research Ethics Board

The Research Ethics Board of Sunnybrook Health Sciences Centre operates in compliance with the Tri-Council Policy Statement, ICH GCP Guidelines, Part C Division 5 of the Food and Drug Regulations, Part 4 of the Natural Health Products Regulations, and Part 5 of the Medical Devices Regulations. All Health Canada regulated trials at Sunnybrook are conducted by a Qualified Investigator.

Fully affiliated with the University of Toronto