The Canadian Journal of Neurological Sciences (2024), 1–7
doi:10.1017/cjn.2024.48

Canadian Journal of Neurological Sciences
Journal Canadien des Sciences Neurologiques

Original Article

Health Care Encounters Prior to Hospitalization for Cerebral Venous Thrombosis Patients

Zeina Waheed[1], Thalia S. Field[2] and Lily W. Zhou[2]

[1]School of Public Health, University of British Columbia, Vancouver, BC, Canada and [2]Division of Neurology and Vancouver Stroke Program, University of British Columbia, Vancouver, BC, Canada

ABSTRACT: ***Background:*** Unlike other causes of stroke, symptoms in cerebral venous thrombosis (CVT) can be nonspecific at onset with gradual worsening over time. To explore potential opportunities for earlier diagnosis, we analyzed healthcare interactions in the week prior to hospitalization for patients admitted with incident CVT in British Columbia (BC). ***Methods:*** We constructed a population-based cohort (2000–2017) using linked patient-level administrative data to identify patients aged ≥18 diagnosed with CVT in BC. We used descriptive analysis to describe the frequency and types of healthcare encounters within the 7 and 3 days prior to hospitalization. Multivariable logistic regression modeling was performed to examine risk factors associated with prior encounters. ***Results:*** The cohort included 554 patients (mean age 50.9 years, 55.4% female). Within the 7 days prior to CVT hospitalization, 57.9% of patients had ≥1 outpatient encounter and 5.6% had ≥1 inpatient encounter. In the 3 days prior to hospitalization, 46.8% of patients had ≥1 outpatient encounter and 2.0% had ≥1 inpatient encounter. Women more frequently had outpatient interactions within 7 days (64.8% women vs. 35.2% men, $p < 0.001$) and 3 days (51.8% vs. 48.2%, $p = 0.01$) before admission. Common provider specialties for outpatient encounters were general practice (58.0%), emergency (8.3%) and neurology (5.7%). Females had higher odds (OR = 1.79) of having ≥1 outpatient encounter after adjusting for confounding. ***Conclusions:*** Within our Canadian cohort, over half of patients had a healthcare encounter within 7 days before their hospitalization with incident CVT. Women more commonly had an outpatient encounter preceding hospital admission.

RÉSUMÉ : Rencontres de patients atteints de thrombose veineuse cérébrale avec des professionnels de la santé avant leur hospitalisation. ***Contexte :*** Contrairement à d'autres causes d'AVC, les symptômes de la thrombose veineuse cérébrale (TVC) peuvent être non spécifiques au début et s'aggraver progressivement au fil du temps. Afin d'explorer les possibilités d'établir un diagnostic plus précoce, nous avons analysé les interactions avec des professionnels de la santé au cours de la semaine précédant l'hospitalisation de patients de Colombie-Britannique atteints d'une TVC. ***Méthodes :*** Pour les années 2000 à 2017, nous avons ainsi élaboré une cohorte basée sur la population en utilisant des données administratives liées aux patients pour identifier ceux âgés de ≥18 ans chez qui on avait diagnostiqué une TVC. Nous avons aussi utilisé une analyse descriptive pour décrire la fréquence et les types de rencontres avec des professionnels de la santé dans les 7 et 3 jours précédant l'hospitalisation. On a par ailleurs recouru à un modèle de régression logistique multivariable pour examiner les facteurs de risque associés aux rencontres antérieures. ***Résultats :*** Notre cohorte comprenait 554 patients (âge moyen : 50,9 ans ; 55,4 % de femmes). Dans les 7 jours précédant une hospitalisation en raison d'une TVC, 57,9 % des patients avaient eu ≥1 consultation externe et 5,6 % d'entre eux avaient eu ≥1 consultation interne. Dans les 3 jours précédant une hospitalisation, 46,8 % des patients avaient eu ≥1 consultation externe et 2,0 % d'entre eux avaient eu ≥1 consultation interne. Notons que ce sont les femmes qui ont le plus souvent bénéficié de consultations externes dans les 7 jours (64,8 % des femmes contre 35,2 % des hommes, $p < 0$,001) et dans les 3 jours (51,8 % contre 48,2 %, $p = 0{,}01$) précédant une hospitalisation. Les spécialités les plus courantes lors de consultations externes étaient la médecine générale (58 %), les urgences (8,3 %) et la neurologie (5,7 %). Enfin, les femmes ont donné à voir une probabilité plus élevée (RC = 1,79) d'avoir ≥1 consultation externe après ajustement sur les facteurs de confusion. ***Conclusions :*** Dans notre cohorte canadienne, plus de la moitié des patients ont obtenu une consultation médicale dans les 7 jours précédant leur hospitalisation pour une TVC. À noter que ce sont les femmes qui ont le plus souvent obtenu une consultation externe avant leur admission à l'hôpital.

Keywords: Cerebral venous thrombosis; clinical epidemiology; stroke

(Received 10 October 2023; final revisions submitted 19 March 2024; date of acceptance 21 March 2024)

Introduction

Cerebral venous thrombosis (CVT) refers to thrombosis of the intracranial venous sinuses, deep cerebral veins, or cortical veins. CVT diagnosis can often be delayed with previous studies reporting an average time to diagnosis of 4–9 days from symptom onset.[1–3] There are multiple reasons that contribute to diagnostic delays. First,

Corresponding author: Lily W. Zhou; Email: Lily.Zhou@vch.ca

Cite this article: Waheed Z, Field TS, and Zhou LW. Health Care Encounters Prior to Hospitalization for Cerebral Venous Thrombosis Patients. *The Canadian Journal of Neurological Sciences*, https://doi.org/10.1017/cjn.2024.48

CVT is a rare condition, with an incidence of 10–20 per million[4] and thus may not be front-of-mind on a differential diagnosis. Second, presentations of CVT may be different from other stroke types, sometimes presenting with isolated increased intracranial pressure symptoms (headache, visual changes, nausea and vomiting) or seizures without additional sudden-onset focal features.[2,5] Finally, CVT most commonly affects younger women, and both women and young adults most commonly face delays in diagnosis of stroke.[6,7]

A US study from 2005 to 2013 showed that 3.6% of patients with CVT were first assessed for headache or seizure within the emergency department prior to a subsequent visit where CVT was diagnosed. Those patients with a delay in diagnosis of CVT had a longer length of stay in hospital.[1] However, within the Canadian context, the specific issue of missed opportunities for earlier diagnosis has not been well documented. Examining Canadian data may clarify the potential scope of the issue to be addressed and can be the first step in developing educational strategies and clinical pathways to improve the timeliness of CVT diagnosis. We used administrative health-care data from British Columbia (BC) to create a population-based inclusive cohort of adult CVT patients. We then examined encounters with physicians in the 3 and 7 days prior to hospital admission for those with a new diagnosis of CVT between 2000 and 2017.

Methods

Study design, setting and data sources

We conducted a population-based study using linked patient-level administrative and registry data for adults ≥18 years hospitalized with CVT in British Columbia (BC) between 2000 and 2017. Data linkages and secure data storage were conducted by Population Data BC, a multi-university, data and education resource that helps facilitate population health research by providing timely access to de-identified patient-level data in BC.[8] Access to data provided by the Data Stewards is subject to approval but can be requested for research projects through the Data Stewards or their designated service providers. The following data sets were used in this study: hospital separations Discharge Abstract Database, Medical Services Plan (MSP), MSP Consolidation File, BC Cancer Registry, and BC Perinatal Data Registry. You can find further information regarding these data sets by visiting the PopData project webpage at: https://my.popdata.bc.ca/project_listings/19-118/collection_approval_dates. All inferences, opinions, and conclusions drawn in this publication are those of the authors, and do not reflect the opinions or policies of the Data Stewards. The study was approved by the Clinical Research Ethics Board at the University of British Columbia (H18-03598).

Study population and analytic dataset/variables

The study cohort was created by Population Data BC by scanning the Discharge Abstract Database[9] for hospital admissions that contained an ICD-9 (325.0, 437.6, 671.5) or ICD-10-CA (G08, I63.6, I67.6, O22.5, O87.3) diagnosis code for CVT which has previously been validated for BC-based data.[10] Inpatient admissions contiguous in time to this initial CVT admission (i.e., on the same day or the day before or after) were concatenated to capture the individual's entire index admission (e.g., including patients admitted to one hospital but transferred to another). The date of CVT diagnosis was defined as the admission date for the first hospital admission. Demographic information (age, sex) was collected from the MSP Consolidation File.[11] Detailed methodology for developing the cohort, alongside description of baseline characteristics, have been published previously.[4]

Cohort members' cancer status was determined using data from the BC cancer registry dataset. Cancer-related CVTs were defined as a CVT diagnosis within 12 months of registration into the registry (squamous and basal cell skin carcinomas were excluded).[12] Peripartum status was determined using registration within the BC perinatal data registry, which contains data from an estimated 99% of all live births and stillbirths at ≥20 weeks or with a birthweight of ≥500 g. Peripartum CVT was defined as a CVT diagnosis within 3 months of delivery.[13] Peripartum, trauma and cancer status were supplemented from manual review of the first five ICD diagnosis codes from the patient's index CVT admission.

Pre-hospitalization health care utilization

Using the MSP physician billing dataset,[14] we examined the number of each individual's unique encounters with a health care provider within the 3 and 7 days prior to index hospital admission for CVT. We selected this timeframe because of previous publications on delays to diagnosis.[1–3] Unique encounters were identified by removing multiple billed services provided on the same date from physicians with the same specialty code. Diagnostic service entries such as radiology, pathology, medical microbiology and nuclear medicine services were excluded. Services provided on the day of CVT hospitalization were excluded as these were assumed to be related to the index admission. A sensitivity analysis was conducted by further removing services from the day prior to admission to remove encounters that may have directly resulted in the index admission (i.e., assessment by a physician and referral for admission within a single encounter occurring over two calendar days due to wait times past midnight). MSP billings were then divided into inpatient and outpatient encounters. Inpatient encounters were visits on a date where a patient was admitted at any hospital then discharged without a diagnosis of CVT. If a patient was not admitted to hospital on the date of the encounter, the encounters were classified as outpatient encounters.

Statistical analysis

Associations between patient factors (age, sex, and CVT risk factors such as peripartum status, use of estrogen, malignancy status, traumatic cause of CVT) and pre-CVT health care utilization were examined first through bivariate analysis through Chi-squared and t-tests where appropriate, and then through multivariable logistic regression modeling while controlling for covariates (age, sex, time epoch of admission, and CVT risk factors). Age was binned into categories for multivariable analysis due to evidence of non-linearity. Using encounter frequency, we also summarized the most common physician specialties involved in outpatient and inpatient encounters within 7 days of admission.

Data in small subgroups (i.e., non-zero low numbers with $n < 5$) were suppressed to avoid the identification of specific patients in compliance with the data use agreement with Population Data BC. All statistical analyses were performed using RStudio version 4.0.5.

https://doi.org/10.1017/cjn.2024.48 Published online by Cambridge University Press

Table 1. Cohort characteristics ($n = 554$)

Variable	Overall $n = 554$	Outpatient encounter(s) within 7 days prior to CVT diagnosis			Outpatient encounter(s) within 3 days prior to CVT diagnosis		
		No $n = 233$	Yes $n = 321$	*p*-value	No $n = 295$	Yes $n = 259$	*p*-value
Sex (%)				**<0.001**			**0.010**
Female	307	108 (35.2)	199 (64.8)		148 (48.2)	159 (51.8)	
Male	247	125 (50.6)	122 (49.4)		147 (59.5)	100 (40.5)	
Age, mean (SD)	50.9	52.2 (17.7)	50.0 (20.5)	0.187	52.8 (18.1)	48.7 (20.5)	**0.012**
Age category (%)				**0.024**			**0.013**
18–34	129	41 (31.8)	88 (68.2)		53 (41.1)	76 (58.9)	
35–49	146	67 (45.9)	79 (54.1)		82 (56.2)	64 (43.8)	
50–64	123	61 (49.6)	62 (50.4)		74 (60.2)	49 (39.8)	
65+	156	64 (41.0)	92 (59.0)		86 (55.1)	70 (44.9)	
Peripartum (%)				0.111			0.143
Yes	33	9 (27.3)	24 (72.7)		13 (39.4)	20 (60.6)	
No	521	224 (43.0)	297 (57.0)		282 (54.1)	239 (45.9)	
Cancer (%)				0.472			0.157
Yes	89	41 (46.1)	48 (53.9)		54 (60.7)	35 (39.3)	
No	465	192 (41.3)	273 (58.7)		241 (51.8)	224 (48.2)	
Traumatic CVT (%)				**0.003**			**0.001**
Yes	51	32 (62.7)	19 (37.3)		39 (76.5)	12 (23.5)	
No	503	201 (40.0)	302 (60.0)		256 (50.9)	257 (49.1)	
Epoch (%)				0.425			0.223
2000–05	102	42 (41.2)	60 (58.8)		60 (58.8)	42 (41.2)	
2006–11	150	57 (38.0)	93 (62.0)		72 (48.0)	78 (52.0)	
2012–17	302	134 (44.4)	168 (55.6)		163 (54.0)	139 (46.0)	
CVT hospitalization length of stay in days, median (IQR)	11.0 (5.0, 25.75)	11.0 (5.0, 30.0)	11 (6.0, 20.0)	0.745	11.0 (5.0, 33.0)	11.0 (5.0, 19.0)	0.188
Any non-traumatic intracranial bleed during CVT hospital stay (%)*				0.575			0.396
Yes	73	28 (38.4)	45 (61.6)		35 (47.9)	38 (52.1)	
No	481	205 (42.6)	276 (57.4)		260 (54.1)	221 (45.9)	
Seizure during CVT hospital stay (%)				0.558			0.396
Yes	88	40 (45.5)	48 (54.5)		51 (58.0)	37 (42.0)	
No	466	193 (41.4)	273 (58.6)		244 (52.4)	222 (47.6)	
Death during Index hospitalization (%)				0.962			0.122
Yes	46	20 (43.5)	26 (56.5)		30 (65.2)	16 (34.8)	
No	508	213 (41.9)	295 (58.1)		265 (52.2)	243 (47.8)	

*Including all non-traumatic intracerebral hemorrhagic (I60-I62).
CVT = cerebral venous thrombosis; IQR = interquartile range; SD = standard deviation.
Overall and stratified by presence of at least one outpatient encounter within the 7 or 3 days prior to their CVT diagnosis. Values in parentheses represent row percentages.

Results

Study cohort

A total of 554 individuals were diagnosed with CVT between 2000 and 2017 (mean age 50.9 years, SD 19.4; 55.4% female). Baseline characteristics of this cohort have been described previously,[4] and are presented in Table 1 for reference.

With respect to outpatient encounters (Figure 1, Panel A), 57.9% had ≥1 encounter within 7 days prior to CVT admission (median = 1 day, IQR = 2) and 46.8% had ≥1 outpatient encounter within 3 days prior to CVT admission (median = 0 days, IQR = 1). The timeframe for these encounters is shown in Figure 1, Panels C and D. Encounters from the day prior to CVT admission only accounted for 32.1% of all outpatient encounters within 7 days.

Within the 7 days prior to hospital admission with incident CVT, 31/554 (5.6%) of this cohort had ≥1 inpatient health care encounter during a previous hospitalization without receiving a diagnosis of CVT. Within 3 days of admission with incident

https://doi.org/10.1017/cjn.2024.48 Published online by Cambridge University Press

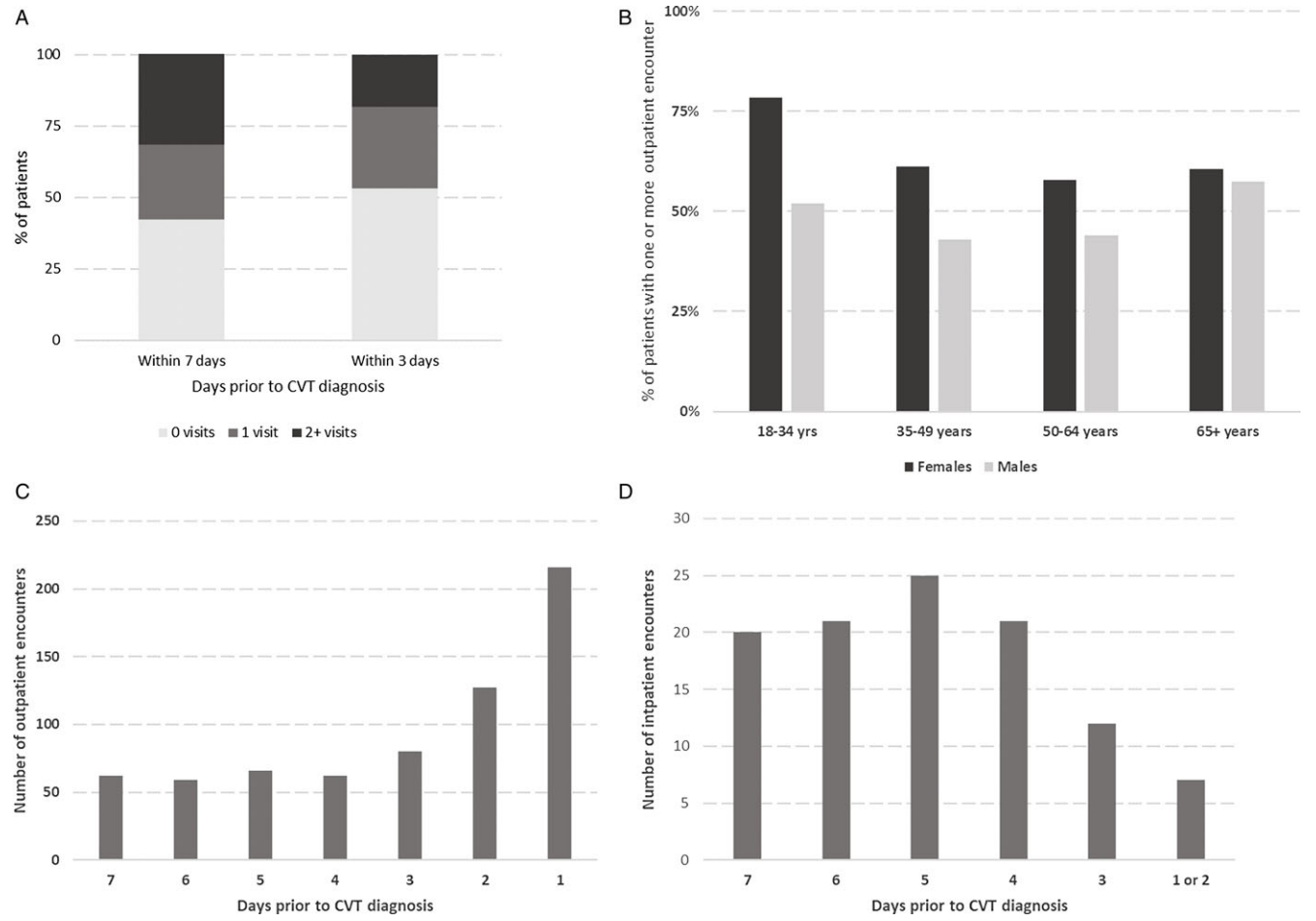

Figure 1. Frequency and timing of healthcare encounters prior to cerebral venous thrombosis (CVT) admission. Legend: Panel (A) Percentage of patients with or without outpatient encounters within the 7 and 3 days prior to their CVT diagnosis. Panel (B) Prevalence of ≥1 outpatient visit in the 7 days prior to hospitalization stratified by age and sex. Panel (C) Total number of outpatient encounters for study cohort within the 7 days leading up to CVT admission. Panel (D) Number of inpatient encounters for study cohort within the 7 days leading up to CVT admission. *Note:* Encounters within 1 or 2 days prior to CVT admission in Panel (D) are combined due to privacy requirements for small values.

CVT, 11/554 (2.0%) had an inpatient health care encounter. The three most common categories for hospitalization were related to pregnancy, infectious causes (both systemic and intra-cranial infections) followed by non-infectious central nervous system causes.

Factors associated with presence of outpatient encounters

Frequency of outpatient healthcare encounters by age and sex is shown in Figure 1, Panel B. Compared to males, females more frequently had ≥1 outpatient encounter in both the 7 and 3 days leading up to their CVT diagnosis (7 days: 64.8% vs. 49.4%, $p < 0.001$; 3 days: 51.8% vs. 40.5%, $p = 0.01$). This difference remained significant after removal of peripartum and traumatic CVTs ($n = 83$). Mean age was lower in individuals with ≥1 prior outpatient encounter 7 days prior to CVT admission compared to those who did not. However, this difference was not statistically significant (Table 1). Patients with traumatic CVTs were less likely to have a pre-admission healthcare interaction either at 7 or 3 days (7 days: 37.3% vs 60.0 % $p = 0.003$; 3 days: 23.5% vs. 49.1%, $p = 0.001$). There were no significant differences in frequency of outpatient encounters by cancer or peripartum status (Table 1).

Multivariable logistic regression modelling showed that females had higher odds of having ≥1 outpatient health encounter within the 7 and 3 days prior to admission compared to men (OR = 1.79; 95% CI: 1.25, 2.57) after adjusting for age, time epoch of admission, peripartum status, traumatic mechanism for CVT and recent cancer diagnosis (Table 2). After controlling for sex, time epoch of admission, peripartum status and CVT risk factors, all older age groups had lower odds of having a previous outpatient encounter compared to patients under age 35 (Table 2). This was significant for all age groups for encounters within 3 days and significant for outpatient encounters within 7 days except patients aged≥65. There were no significant interactions between age and sex. After controlling for age, sex and study epoch within the multi-variable regression, patients with traumatic CVTs were much less likely to have a pre-admission healthcare interaction both at 7 or 3 days. The direction of effect seen for age and sex was not altered by removing encounters in the day prior to admission but some categories were no longer significant due to smaller numbers (Table 3).

Physician specialty for encounters in the 7 days prior to CVT admission

Most outpatient encounters in the 7 days prior to CVT diagnosis were with general practice (58.0% of encounters). The next most common specialties for outpatient encounters within 7 days prior to CVT admission were emergency medicine (8.3%), neurology (5.7%), internal medicine (4.6%), and ophthalmology (3.3%) (Table 4). There

https://doi.org/10.1017/cjn.2024.48 Published online by Cambridge University Press

Table 2. Multivariate logistic regression for associations with odds of having an outpatient healthcare encounter within the 7 and 3 days prior to cerebral venous thrombosis (CVT) diagnosis

	Prior outpatient visits within 7 days prior to CVT diagnosis		Prior outpatient visits within 3 days prior to CVT diagnosis	
	Odds ratio	95% CI	Odds ratio	95% CI
Age <35	ref	–	ref	–
Age 35–49 years	**0.50**	**(0.30, 0.83)**	**0.48**	**(0.29, 0.79)**
Age 50–64 years	**0.49**	**(0.29, 0.85)**	**0.45**	**(0.26, 0.77)**
Age 65+ years	0.73	(0.43, 1.22)	**0.60**	**(0.36, 0.99)**
Female sex	**1.79**	**(1.25, 2.57)**	**1.49**	**(1.04, 2.14)**
Peripartum status	1.16	(0.51, 2.81)	1.10	(0.50, 2.45)
Cancer	0.71	(0.44, 1.15)	**0.61**	**(0.37, 0.98)**
CVT associated with trauma	**0.38**	**(0.20, 0.70)**	**0.28**	**(0.13, 0.54)**
Epoch 2000–2005	ref	–	ref	–
Epoch 2006–2011	1.33	(0.78, 2.28)	**1.81**	**(1.07, 3.08)**
Epoch 2012–2017	1.02	(0.64, 1.64)	1.46	(0.91, 2.36)

Table 3. Sensitivity analysis with exclusion of encounters one day prior to cerebral venous thrombosis (CVT) diagnosis

	Prior outpatient visits within 7 days prior to CVT diagnosis		Prior outpatient visits within 3 days prior to CVT diagnosis	
	Odds ratio	95% CI	Odds ratio	95% CI
Age <35	ref	–	**ref**	–
Age 35–49 years	0.66	(0.40, 1.08)	0.66	(0.39, 1.11)
Age 50–64 years	**0.54**	**(0.32, 0.91)**	**0.43**	**(0.23, 0.77)**
Age 65+ years	0.79	(0.48, 1.29)	0.61	(0.35, 1.04)
Female sex	**1.63**	**(1.14, 2.34)**	1.49	(1.00, 2.24)
Peripartum status	1.53	(0.70, 3.50)	**1.30**	**(0.60, 2.80)**
Cancer	1.09	(0.67, 1.75)	0.97	(0.57, 1.63)
CVT associated with trauma	**0.40**	**(0.20, 0.78)**	**0.33**	**(0.12, 0.76)**
Epoch 2000–2005	ref	–	ref	–
Epoch 2006–2011	1.07	(0.63, 1.80)	1.08	(0.62, 1.90)
Epoch 2012–2017	0.78	(0.49, 1.25)	0.82	(0.50, 1.36)

were no sex differences in presentation to emergency medicine vs. general practice. The most common provider specialties remained unchanged after encounters from the day prior to CVT admission were removed (numbers provided in brackets in Table 4).

For inpatient encounters in the 7 days prior to CVT diagnosis, the most common associated specialty was also general practice (34.9%), internal medicine (16.0%), and obstetrics and gynecology (11.3%) (Table 4).

Associations with CVT complications, mortality and length of stay

There were no differences in the deaths during index hospitalization for those with vs. without encounters within 7 days nor for those with vs. without encounters within 3 days. Inpatient length of stay also did not differ between the groups for encounters within 7 days and for 3 days), nor did the presence of intracranial hemorrhage or seizures (Table 1).

Discussion

In this population-based study of patients hospitalized with incident CVT in BC, Canada, there was a high proportion (57.9%) of individuals who had ≥1 outpatient physician encounter within the 7 days prior to their CVT hospitalization. We found females and younger patients had a higher odds of having an outpatient physician encounter in the 7 days prior to their CVT admission after adjustment for common CVT mechanisms (peripartum status, recent cancer diagnosis, head trauma), and time period of hospitalization. These findings suggest that a proportion of those admitted to hospital with CVT, particularly women and younger adults, likely did not receive a correct diagnosis for CVT-related symptoms that prompted prior presentations to medical attention in the days before. A comparatively small proportion (5.3% at 7 days, 2.0% at 3 days prior to CVT hospitalization) had an inpatient encounter with subsequent discharge prior to readmission with CVT. It is possible that some of these encounters were in part related to medical conditions that may have led to a subsequent CVT (i.e., head or neck infection, birth); others may potentially represent admissions for symptoms related to a CVT (e.g., seizure, headache, nausea or vomiting) that was not diagnosed until a subsequent admission.

Studying pre-hospitalization care patterns may allow for future opportunities for the earlier diagnosis of diseases that worsen in severity over days to weeks. We found that most individuals had at least one outpatient physician encounter within the 7 days prior to their CVT hospitalization. By comparison, a recent systematic review showed that 10.3% to 52.9% of patients admitted to hospital with sepsis had outpatient healthcare encounters prior to hospitalization.[15] A previous study of emergency room visits using administrative data from New York, California, and Florida from 2005-2013 showed that 3.6% of patients with CVT had an emergency room visit in the 14 days before admission[1] for headache or seizure but did not comment on the overall burden of emergency room visits. Within our study, 8.3% of prior outpatient encounters were seen by an emergency medicine physician within 7 days prior to CVT admission. In the emergency department setting, women with stroke are more often misdiagnosed compared to men.[6,17] Gender differences in health services utilization between men and women in Canada have previously been described and show that women have higher healthcare utilization but are only half as likely to use the emergency room compared to men.[16] Although healthcare utilization prior to CVT was higher in women in our study, we did not find a difference between men and women with regards to visits with general practitioners vs. emergency physicians. However, it is possible that some general practitioner visits actually represent presentations to the emergency room with a GP-emergency provider, as most emergency rooms in BC employ a proportion of GPs with additional emergency medicine training. Although it is highly likely that a proportion of GP encounters (the most common specialty for pre-hospitalization encounters) in fact represent emergency room assessments, it is a limitation of our study that we

https://doi.org/10.1017/cjn.2024.48 Published online by Cambridge University Press

Table 4. Physician specialties for healthcare encounters in the 7 days prior to cerebral venous thrombosis (CVT) diagnosis for the study cohort

Outpatient encounters within the 7 days prior to CVT diagnosis				Inpatient encounters within the 7 days prior to CVT diagnosis			
Rank	Specialty	Number of encounters	%	Rank	Specialty	*N*	%
1st	General Practice	390 (275)	58.0 (60.3)	1st	General Practice	37 (37)	34.9 (35.6)
2nd	Emergency Medicine	56 (20)	8.3 (4.4)	2nd	Internal Medicine	17 (17)	16.0 (16.3)
3rd	Neurology	38 (18)	5.7 (3.9)	3rd	Obstetrics & Gynaecology	12 (12)	11.3 (11.5)
4th	Internal Medicine	31 (20)	4.6 (4.4)	4th	Neurology	7 (6)	6.6 (5.8)
5th	Ophthalmology	22 (16)	3.3 (3.5)	5th	Anaesthesia	6 (6)	5.7 (5.8)
	Other	135 (107)	20.1 (23.5)		Other	27 (26)	25.5 (25.0)

Values in brackets represent results from the sensitivity analysis (i.e., following removal of services provided on the day prior to CVT admission).

are unable to confirm this by distinguishing which general practice encounters were in a community-based clinic as compared to the emergency room.

Our findings differ from a sub study of the International Study on Cerebral Vein and Dural Sinus Thrombosis (ISCVT), a large prospective cohort of patients with CVT, in which delays to diagnosis were more common in men.[18] However, the nature of this study's cohort is different, given that participants in ISCVT were consecutively recruited from academic hospitals with a primary diagnosis of symptomatic CVT and 74.5% of participants in that cohort were female whereas our study used an unselected population-based cohort where 55.4% are female. The female-to-male ratio among CVT patients in more recent population-based cohorts[19–21] has been lower than what has been previously reported from prospective registries, suggesting differences in patient populations captured resulting from different approaches to ascertainment.

A limitation of the study is that our cohort did not include linkages to outpatient diagnostic codes nor diagnoses from emergency room visits through the National Ambulatory Care Reporting System which prevented us from being able to distinguish encounters that were most likely related to the CVT vs. those for clearly unrelated symptoms. Unlike a previous US study,[1] we did not find a difference in length of stay (or any other outcome measure) in CVT patients with and without pre-hospitalization healthcare encounters. However, being limited to administrative data, detailed information regarding markers of disease severity, such as depressed level of consciousness on admission, radiological features or longer-term functional outcomes such as modified Rankin Scale scores and patient-centered outcomes common after CVT including such as headache or cognitive changes[23,24] are not available. Related to this, using administrative data, we are unable to comment on the exact delay from symptom onset to eventual CVT diagnosis.

Another limitation of our study is the lack of data on referrals and imaging generated from outpatient visits. Future work examining referrals for specialty assessment and imaging would allow for quantification for effects of interventions that reduce waits in emergent access to specialists and outpatient imaging. In conditions such as symptomatic carotid stenosis, previous Canadian research has demonstrated that the location of initial health care contact (ambulatory clinic vs. emergency room) was a significant factor in reducing time to imaging and subsequent treatment.[22] Finally, CVT cases were identified using ICD-9 and 10 codes which although previously validated, still show lower sensitivity than other methods such as radiology reports or EMR free-text searches.[10]

Unlike other causes of stroke, symptoms in CVT can be non-focal and with an insidious symptom onset. Within our Canadian population-based CVT cohort across almost 2 decades, over half of patients had a healthcare encounter within 7 days of their hospital admission with incident CVT, mostly with general practitioners. Outpatient encounters were more common in women compared to men and in younger patients. From our study, it is uncertain if this is due to differences in health-seeking behavior, intrinsic differences in CVT symptoms or differences in how symptoms in younger people and women are interpreted by physicians. It is likely that a proportion of these encounters may represent a missed opportunity for a more timely diagnosis. Further education about CVT, its presenting symptoms, and at-risk populations should be provided to front-line practitioners assessing patients with undifferentiated symptoms to redirect them for urgent imaging. Public education campaigns bringing awareness to biases faced by women and young adults with stroke, which have been put forth by the Heart and Stroke Foundation of Canada and other organizations, should continue to include CVT survivor stories to encourage self-advocacy from patients.

Acknowledgements. This project is supported by a project grant from the Canadian Institutes of Health Research (RN 387091 - 420683).

Author contributions. ZW organized and analyzed the data and prepared the first draft of the manuscript. TSF was involved in the conception of the project and participated in editing and revising the manuscript. LWZ was also involved in the conception of the project, provided oversight of the data analysis, participated in the preparation of the first draft of the manuscript, and provided edits and revisions to the manuscript.

Funding statement. ZW: Financial support from CIHR Project Grant (RN 387091 - 420683). TSF: Support from CIHR Project Grant (RN 387091 - 420683) and Sauder Family/Heart & Stroke Professorship of Stroke Research; Consulting fees from Bayer Canada, AstraZeneca, Roche Canada; Honoraria from HLS Therapeutics; Payment for expert witness testimony; Board Member of DESTINE Canada. LWZ: Fellowship salary support from CIHR Project Grant (RN 387091 - 420683) and salary support from Vancouver Coastal Health Research Institute.

Competing interests. The authors report no disclosures relevant to the manuscript.

References

1. Liberman AL, Gialdini G, Bakradze E, Chatterjee A, Kamel H, Merkler AE. Misdiagnosis of cerebral vein thrombosis in the emergency department. *Stroke*. 2018;49:1504–6.

2. Ferro JM, Lopes MG, Rosas MJ, Fontes J. Delay in hospital admission of patients with cerebral vein and dural sinus thrombosis. *Cerebrovasc Dis*. 2005;19:152–6.
3. Timoteo A, Inacio N, Machado S, Pinto AA, Parreira E. Headache as the sole presentation of cerebral venous thrombosis: a prospective study. *J Headache Pain*. 2012;13:487–90.
4. Zhou LW, Yu AYX, Ngo L, Hill MD, Field TS. Incidence of cerebral venous thrombosis: a population-based study, systematic review, and meta-analysis. *Stroke*. 2023;54:169–77.
5. Ferro JM, Canhão P, Stam J, Bousser MG, Barinagarrementeria F. Prognosis of cerebral vein and dural sinus thrombosis: results of the International Study on Cerebral Vein and Dural Sinus Thrombosis (ISCVT). *Stroke*. 2004;35:664–70.
6. Newman-Toker DE, Moy E, Valente E, Coffey R, Hines AL. Missed diagnosis of stroke in the emergency department: a cross-sectional analysis of a large population-based sample. *Diagnosis (Berlin, Ger.)*. 2014;1:155–66.
7. Eddelien HS, Butt JH, Christensen T, Danielsen AK, Kruuse C. Sex and age differences in patient-reported acute stroke symptoms. *Front Neurol*. 2022;13:846690.
8. Population Data BC [Internet]. [cited 2021 Feb 23]. Available from: https://www.popdata.bc.ca/about.
9. Canadian Institute for Health Information [Creator]. Discharge Abstract Database (Hospital Separations). V2. Population Data BC [publisher]. Data Extract. MOH (2020), 2019.
10. Zhou LW, Yu AYX, Hall W, Hill MD, Field TS. Validity of ICD-10 codes for cerebral venous thrombosis depends on clinical context. *Can J Neurol Sci/Le J Can des Sci Neurol*. 2022;49:813–6.
11. British Columbia Ministry of Health [creator]. Consolidation File (MSP Registration & Premium Billing). V2. Population Data BC [publisher]. Data Extract. MOH (2020), 2020. http://www.popdata.bc.ca/data
12. BC Cancer. BC Cancer Registry Data. V2. Population Data BC. Data Extract. BC Cancer (2020), 2020.
13. Perinatal Services BC. British Columbia Perinatal Data Registry. V2. Population Data BC. Data Extract. PSBC (2020), 2020. http://www.perinatalservicesbc.ca/health-professionals/data-surveillance/perinatal-data-registry
14. British Columbia Ministry of Health [creator]. Medical Services Plan (MSP) Payment Information File. V2. Population Data BC [publisher]. Data Extract. MOH (2020), 2019. http://www.popdata.bc.ca/data
15. Flannery AH, Venn CM, Gusovsky A, et al. Frequency and types of healthcare encounters in the week preceding a sepsis hospitalization: a systematic review. *Crit Care Explor*. 2022;4:e0635.
16. Kazanjian A, Morettin D, Cho R. Health care utilization by Canadian women. *BMC Womens Health*. 2004;4 Suppl 1:S33.
17. Tarnutzer AA, Lee S-H, Robinson KA, Wang Z, Edlow JA, Newman-Toker DE. ED misdiagnosis of cerebrovascular events in the era of modern neuroimaging: a meta-analysis. *Neurology*. 2017;88:1468–77.
18. Ferro JM, Canhão P, Stam J, et al. Delay in the diagnosis of cerebral vein and dural sinus thrombosis: influence on outcome. *Stroke*. 2009;40:3133–8.
19. Nasreen S, Calzavara AJ, Sundaram ME, et al. Background incidence rates of hospitalisations and emergency department visits for thromboembolic and coagulation disorders in Ontario, Canada for COVID-19 vaccine safety assessment: a population-based retrospective observational study. *BMJ Open*. 2021;11:e052019.
20. Otite FO, Patel S, Sharma R, et al. Trends in incidence and epidemiologic characteristics of cerebral venous thrombosis in the United States. *Neurology*. 2020;95:e2200–13.
21. Ruuskanen JO, Kytö V, Posti JP, Rautava P, Sipilä JOT. Cerebral venous thrombosis: Finnish nationwide trends. *Stroke*. 2021;52:335–8.
22. Charbonneau P, Bonaventure PL, Drudi LM, Beaudoin N, Blair J-F, Elkouri S. An institutional study of time delays for symptomatic carotid endarterectomy. *J Vasc Surg*. 2016;64:1726–33.
23. Preter M, Tzourio C, Ameri A, Bousser MG. Long-term prognosis in cerebral venous thrombosis. Follow-up of 77 patients. *Stroke*. 1996;27:243–6.
24. Ji K, Zhou C, Wu L, et al. Risk factors for severe residual headache in cerebral venous thrombosis. *Stroke*. 2021;52:531–6.

https://doi.org/10.1017/cjn.2024.48 Published online by Cambridge University Press