Canadian Journal of Emergency Medicine (2025) 27:215–220
https://doi.org/10.1007/s43678-024-00853-7

BRIEF ORIGINAL RESEARCH

The value of MRI in transient ischemic attack/minor stroke following a negative CT for predicting subsequent stroke

Matthieu Robitaille[14] · Marcel Émond[5,6] · Mukul Sharma[3] · Ariane Mackey[5,14] · Pierre-Gilles Blanchard[5,6] · Marie-Joe Nemnom[2] · Marco L. A. Sivilotti[4] · Ian G. Stiell[1,2] · Grant Stotts[7] · Jacques Lee[8,9] · Andrew Worster[10] · Judy Morris[11] · Ka Wai Cheung[12] · Albert Y. Jin[13] · Demetrios J. Sahlas[3] · Heather E. Murray[4] · Steve Verreault[5,14] · Marie-Christine Camden[5,14] · Samuel Yip[15] · Philip Teal[15] · David J. Gladstone[16] · Mark I. Boulos[16] · Nicolas Chagnon[17] · Elizabeth Shouldice[18] · Clare Atzema[9] · Tarik Slaoui[11] · Jeanne Teitlebaum[11] · George A. Wells[2] · Jeffrey J. Perry[1,2]

Received: 11 July 2024 / Accepted: 23 December 2024 / Published online: 4 February 2025

Abstract

Background Diffusion weighted magnetic resonance imaging's (MRI) role in predicting subsequent strokes beyond the validated Canadian TIA Score in in transient ischemic attack (TIA)/minor stroke patients with normal CT scans is unknown. In this study, we assessed the incidence of acute cerebral infarction on MRI in these patients, overall and stratified by the Canadian TIA Score levels and then we assessed subsequent stroke rates at 7, 30 and 90 days based on the presence of acute infarct on MRI.

Methods This pre-planned substudy of the Canadian TIA risk score cohort was conducted across 13 Canadian emergency departments over an 11-year period. Eligible patients included adult TIA/minor stroke patients with negative CT scans who underwent MRI within 7 days.

Results Among 11,507 patients, 1048 with negative CT scans had early MRI, which revealed infarction in 330 (31.5%) patients. Acute infarction rates varied by Canadian TIA Score risk group: 130 (15.4%) in low-risk, 754 (30.4%) in medium-risk, and 162 (50.0%) in the high-risk group. At 90 days, the rates of stroke in patients with a positive MRI were 2 (10.0%), 168 (22.3%), and 40 (24.7%) in low-risk, medium-risk, and high-risk groups, respectively. In comparison, in patients with a negative MRI the rate was 1 (0.9%), 7 (1.3%), and 4 (4.9%).

Conclusions Combining the Canadian TIA Risk Score with follow-up MRI improves stroke risk assessment. MRI enhance the accuracy of diagnosis TIA, especially when CT is negative. The risk score helps prioritize MRI, benefiting medium-risk patients most, while high-risk patients need prompt management regardless of MRI results. Low-risk patients benefit from MRI for determining further investigations.

Keywords Diffusion magnetic resonance imaging · Ischemic attack · Stroke

Résumé

Contexte On ne connaît pas le rôle de l'imagerie par résonance magnétique (IRM) pondérée en diffusion dans la prédiction des accidents vasculaires cérébraux ultérieurs au-delà du score canadien validé du TIA chez les patients atteints d'un accident ischémique transitoire (AIT)/AVC mineur avec tomodensitométrie normale. Dans cette étude, nous avons évalué l'incidence de l'infarctus cérébral aigu parIRM chez ces patients, globalement et stratifiée selon les niveaux du score canadien de TIA, puis nous avons évalué les taux d'accidents vasculaires cérébraux subséquents à 7, 30 et 90 jours en fonction de la présence d'un infarctus aigu sur l'IRM.

Méthodes Cette sous-étude préplanifiée de la cohorte canadienne des cotes de risque du TIA a été menée auprès de 13 services d'urgence canadiens sur une période de 11 ans. Les patients admissibles comprenaient des patients adultes atteints d'AIT/AVC mineur avec des résultats négatifs à la tomodensitométrie qui ont subi une IRM dansun délai de sept jours.

Extended author information available on the last page of the article

Résultats Parmi 11507 patients, 1048 avec des résultats de tomodensitométrie négatifs ont subi une IRM précoce, ce qui a révélé un infarctus chez 330 patients (31,5 %). Les taux d'infarctus aigus variaient selon le groupe de risque du Canadian TIA Score: 130 (15,4 %) dans le groupe à faible risque, 754 (30,4 %) dans le groupe à risque moyen et 162 (50,0 %) dans le groupe à risque élevé. À 90 jours, les taux d'AVC chez les patients ayant une IRM positive étaient de 2 (10,0 %), 168 (22,3 %) et 40 (24,7 %) dans les groupes à faible risque, à risque moyen et à risque élevé, respectivement. En comparaison, chez les patients ayant une IRM négative, le taux était de 1 (0,9 %), 7 (1,3 %) et 4 (4,9 %).

Conclusions La combinaison du TIA Canadian Score avec l'IRM de suivi améliore l'évaluation des risques d'AVC. IRM améliore la précision du diagnostic de l'AIT, en particulier lorsque la tomodensitométrieest négatif. Le score de risque aide à prioriser l'IRM, ce qui profite surtout aux patients à risque moyen, tandis que les patients à risque élevé ont besoin d'une prise en charge rapide, indépendamment des résultats de l'IRM. Les patients à faible risque bénéficient de l'IRM pour déterminer d'autres investigations.

Mots-clés Imagerie par résonance magnétique de diffusion · Crise ischémique · Coup

Clinician's capsule

What is known about the topic?
In patients with TIA who have undergone CT imaging and risk-stratification with clinical prognostic scores, the additional benefit of MRI on stroke risk is unknown.

What did this study ask?
After risk-stratification using the Canadian TIA score, what is the additional benefit of rapid magnetic resonance imaging to determine the risk of a subsequent stroke within the following 90 days?

What did this study find?
After stratifying patients using the Canadian TIA score, 15% of the low-risk group, 30% of the medium-risk group, and 50% of the high-risk group had a positive MRI, with the presence of cerebral infarction on MRI indicating an elevated risk of subsequent events.

Why does this study matter to clinicians?
MRI can identify patients at higher risk for subsequent stroke within 90 days, which allows resources to be targeted towards patients most at risk in resource resource-limited health care systems.

Introduction

Patients with transient ischemic attack (TIA) or minor stroke face an 8–12% risk of subsequent stroke within 90 days [1]. Despite advances in TIA management to reduce the risk, TIA remains a medical emergency. US guidelines recommend brain MRI within 24 h of symptom onset to evaluate for acute ischemic infarct [2]. MRI identifies up to a 67% of cerebral infarctions in TIA patients, while CT, despite its role in excluding other conditions, is less sensitive to small acute infarctions [3]. While MRI is valuable for TIA assessment, it is unavailable in many hospitals and mandating immediate MRI could strain stroke centers and resources.

The Canadian TIA Score [4] stratifies patients as low (< 1%), medium (1–5%) and high (> 5%) 7-day subsequent stroke risk. It uses clinical information available at the initial ED visit (Appendix 1).

Our objectives were to assess: (1) the proportion of patients with acute cerebral infarction (MRI positive) in TIA/minor stroke patients with normal CT, stratified by Canadian TIA Score level; and (2) subsequent stroke rates at 7, 30 and 90 days based on the presence acute infarct on MRI.

Methods

Study design, population and setting

We performed a secondary analysis of multicenter cohort studies that derived and validated the Canadian TIA Score for assessing subsequent risk after TIA. Patients were enrolled at 13 Canadian centers from June 2006 to May 2017. Eligible patients were ≥ 18 years with an emergency department diagnosis of TIA or minor stroke. We excluded those with neurologic deficits > 24 h, decreased consciousness (Glasgow Coma Score < 15), alternative diagnoses, presentation > 7 days after symptom onset, or treatment with tissue plasminogen activator or embolectomy. The study was restricted to patients with CT scan (non-contrast or CT angiography) showing no ischemia who had MRI within 7 days of symptom onset. Patients with an acute infarct on initial CT scan were excluded.

Participant assessment

Assessments were done by emergency physicians, neurologists, or supervised residents. Data collection and eligibility

verification were handled by study personnel. MRI was performed using standard protocols and radiologists followed usual practices.

Outcomes

Our primary outcome was acute cerebral infarction on MRI within 7 days of symptom onset. Study personnel reviewed MRI reports for acute cerebral infarction. Secondarily, we assessed subsequent stroke defined as a new cerebral disturbance, lasting > 24-h, with no non-vascular cause. Blinded stroke experts adjudicated events based on subsequent visits/telephone follow responses, requiring agreement from two independent adjudicators.

Statistical analysis

Patient characteristics are shown as means with standard deviation (SD) for continuous variables and percentages for categorical ones. We compared groups based on MRI infarction using relative risk (RR) and 95% CI. Multivariable logistic regression, including prespecified covariates, determined associations with outcomes. Missing data were addressed with multiple imputations. Results were reported as odds ratios (OR) with 95% CI, and analyses used SAS 9.4. Sample size was based on the combined derivation and validation cohorts for the Canadian TIA Score. (Appendix 2, 3, 4).

Results

Out of 11,507 patients diagnosed with TIA/minor stroke in the ED, 1,048 with negative initial CT scans underwent MRI within 7 days. Of these patients, 330 (31.5%) had cerebral infarction on MRI. When stratified by the Canadian TIA risk score, 15.4% of low-risk patients, 30.4% of medium-risk patients, and 50.0% of high-risk patients had infarction on MRI (Table 1).

As their risk classification progressed from low to high risk, patients were more likely to have symptoms for longer, be older, have speech and motor findings (Table 1). Subsequent stroke at 90 days also increased from 2.3% in low risk, to 7.7% in medium risk and 14.8% in high-risk patients.

Patients with a positive MRI had higher subsequent stroke rates. At 90 days, stroke recurrence occurred in 2 (10.0%) patients in the low-risk group with MRI-detected infarction versus 1 (0.9%) without [RR = 11.0 (1.05–115.66)],; in 51 (22.3%) patients in the medium-risk group with infarction versus 7 (1.3%) without [RR = 16.70 (7.70–36.24)]; and in 20 (24.7%) patients in the high-risk group with infarction versus 4 (4.9%) without [RR = 5.00 (1.79–13.98)] (Table 1 and Appendix 2, 3, 4).

Discussion

Interpretation

Obtaining early MRI imaging improves stroke risk prediction beyond clinical risk-stratification with the Canadian TIA score. In the medium-risk Canadian TIA Score group, 30.4% showed ischemic lesions on MRI and 7.7% had stroke recurrence at 90 days. Very few patients with no cerebral infarction on MRI had a subsequent stroke risk yet one in four of the patients with an acute infarct had a subsequent stroke. Thus, clinicians can identify and re-triage these otherwise medium-risk patients as low-risk or very high-risk for subsequent stroke with an early MRI.

Among the 130 low-risk Canadian TIA Score group patients who did have an MRI, this test was helpful in confirming cerebral infarction in 20 patients (15.4%) and when this was diagnosed, 1 in 10 people (2 patients) had a subsequent stroke. The small number of patients in the low-risk cohort prevented us from performing a multivariate analysis, potentially identifying predictive factors for a positive MRI.

In the high-risk Canadian TIA Score group, MRI may not significantly change management, as patients with negative MRI still face a 4.9% risk of stroke recurrence at 90 days. This rate is similar to those who did not undergo MRI after a negative CT (Appendix 5). Hence, for high-risk Canadian TIA Score patients, negative neuroimaging does not re-triage patients and they still require prompt stroke prevention management.

Previous studies

Our low-risk group findings align with the DOUBT study, which reported a 13.4% MRI-positive rate among low-risk patients [5]. However, our study had a higher 90-day stroke recurrence rate among low-risk patients (2.3%) compared to DOUBT's 0.7% at 1 year. The small number of events (three) does not allow us to draw any definitive conclusions. In comparison, the Canadian TIA Score studies [4], with only 3% of patients undergoing MRI testing in the low-risk cohort, showed a lower 0.4% 90-day recurrence rate, which is lower than both our study and the DOUBT study.

Our study found a 1.7% 90-day stroke recurrence rate in TIA patients with negative MRI. This raises questions about whether TIA or minor strokes without MRI-confirmed infarctions should be classified as true vascular events, as the low recurrence rate suggests these might be stroke mimics and the absence of an underlying vascular mechanism. Two large prospective studies totaling 3,724 [6] and 4,574 [7] of TIA patients without cerebral infarction on MRI had similar early risk of subsequent events (1.5% and 0.4% respectively). This suggests further research is needed to determine if MRI

Table 1 Characteristics of CT negative patients who underwent MRI by Canadian TIA Score risk category ($N = 1,046$) values are numbers (percentages) unless stated otherwise

	Low[a] risk $n = 130$ (12.4)	Medium[a] risk $n = 754$ (72.0)	High[a] risk $n = 162$ (15.5)
Demographics			
Mean (SD) age, years	59.8 ± 14.9	66.5 ± 15.0	72.1 ± 10.2
Male, %	49.2	49.6	63.0
Past medical history			
Hypertension	54 (41.9)	419(55.6)	13(80.9)
Hyperlipidemia	34 (26.4)	256(34.0)	81(50.0)
Coronary artery disease	10 (7.8)	119(15.8)	63(38.9)
Diabetes	9 (7.0)	131(17.4)	51(31.5)
Known previous stroke	16 (12.4)	119(15.8)	24(14.8)
Active smoker	15 (11.6)	102(13.5)	23(14.2)
Atrial fibrillation or flutter	9 (7.0)	52 (6.9)	28(17.3)
Peripheral vascular disease	2 (1.6)	17 (2.3)	19(11.7)
Carotid stenosis	0 (0.0)	20 (2.7)	17(10.5)
Valvular heart disease	6 (4.7)	23 (3.1)	7 (4.3)
Clinical features history			
Symptoms duration			
< 10 min	47 (36.2)	59 (7.9)	3(1.9)
10–29 min	16 (12.3)	130 (17.3)	22(13.8)
30–59 min	13 (10.0)	102 (13.6)	18(11.3)
60 + min	54 (41.5)	460 (61.3)	117(73.1)
Unilateral weakness	50 (38.5)	375 (50.0)	118(72.8)
Altered sensation	76 (58.9)	358 (48.5)	75(46.6)
Language disturbance	44 (34.4)	361 (48.5)	102(63.0)
Gait disturbance	27 (20.9)	215 (29.1)	75(47.2)
Visual loss	20 (16.5)	76 (10.7)	13 (8.4)
Vertigo	50 (38.5)	52 (7.1)	4 (2.5)
Clinical features examination			
Mean (SD) systolic blood pressure, mmHg	149.7 ± 22.5	153.2 ± 25.2	159.7 ± 27.5
Mean (SD) diastolic blood pressure, mmHg	84.0 ± 11.0	82.7 ± 12.9	85.2 ± 17.0
Mean (SD) heart rate, bpm	80.2 ± 14.6	77.6 ± 15.5	77.5 ± 15.3
Any speech difficulty	7 (5.4)	141 (18.9)	51 (31.9)
Aphasia	5 (3.9)	39 (5.3)	13 (8.2)
Dysarthria	1 (0.8)	95 (12.9)	39(24.5)
Gait abnormality	10 (7.9)	92 (13.3)	27(19.1)
Pronator drift	10 (7.9)	84 (11.9)	31 (21.1)
Abnormal finger-nose test	7 (5.7)	50 (7.3)	21(14.5)
Atrial fibrillation or flutter on ED ECG	2 (1.6)	23 (3.3)	26(16.9)
MRI finding			
DWI positive	20 (15,4)	229 (30.4)	81 (50.0)
DWI negative	110 (84.6)	525 (69.6)	81 (50.0)
Subsequent strokes			
Subsequent stroke < 7 days	2 (1.5)	47 (6.2)	21 (13.0)
Subsequent stroke < 30 days	2 (1.5)	55 (7.3)	23 (14.2)
Subsequent stroke < 90 days	3 (2.3)	58 (7.7)	24(14.8)
Subsequent strokes (DWI positive)			
Subsequent stroke < 7 days	1/20 (5.0)	43/229 (18.8)	18/81 (22.2)
Subsequent stroke < 30 days	1/20 (5.0)	48/229 (21.0)	20/81 (24.7)
Subsequent stroke < 90 days	2/20 (10.0)	51/229 (22.3)	20/81 (24.7)
Other imaging			
CT angio (head or neck)	54/130 (41.5)	291/754 (38.6)	61/162 (37.7)

CT computed tomography, *MRI* magnetic resonance imaging, *TIA* transient ischemic attack, *SD* standard deviation, *ED* emergency department, *ECG* electrocardiogram, *DWI* diffusion weighted imaging (positive = acute infarction, negative = no acute infarction)

[a]Canadian TIA Score risk categories: low risk: score from −3 to 3; medium risk: 4 to 8; high risk: 9 +

should be the initial tool for assessing tissue infarction. Accurate diagnosis is crucial, as failure to correctly identify stroke is a missed opportunity for prevention, while incorrect diagnosis may lead to harmful treatments, unnecessary tests and increased health care costs.

As MRI diffusion-weighted hyperintensity diminishes after 10 days [8], timely MRI is crucial for detecting acute infarctions. For patients lacking access to specialized centers, an initial negative CT scan should not delay management. Our study shows that recurrent events often occur early and while MRI is not the only risk assessment tool, it is a strong predictor.

Strengths and limitations

This multicenter study shows the benefit of MRI in TIA/minor stroke patients with negative CT scans.

Selection bias may affect these findings, as patients who underwent MRI were likely perceived as high-risk, potentially leading to higher ischemic event rates in this group. This could explain the number of acute strokes detected on MRI in the low-risk category, which also had the highest percentage of CT angiography prescriptions, suggesting a clinical suspicion of ischemic events. (Table 1). By comparison, the 90-day event rate of 0.3% in low-risk patients who were not prescribed an MRI (Appendix 5) supports a selective approach, reserving MRI for cases with additional risk factors identified through clinical judgment. Due to the limited sample size, we could not conduct multivariate analyses to explore associations between vascular findings on CT angiography, TIA scores, and positive MRI results. Focusing on negative CT scans may favor detection of lacunar infarcts, which are often missed early on and mimic stroke recurrence [9].

Clinical implications

For medium-risk Canadian TIA Score patients, MRI refines risk stratification: the presence of infarction significantly increases the risk of stroke compared to the absence of infarction, thereby impacting management decisions. Given the low stroke rate (< 1%) in low-risk Canadian TIA Score patients [1], MRI should remain selective. If accessible, an MRI should be done within the first week of symptoms. For high-risk Canadian TIA Score patients, MRI is less useful in urgent settings, as they remain at high risk for a subsequent stroke even with a negative MRI.

Research implications

Further assessment will evaluate the impact and cost-effectiveness of using the Canadian TIA Score and selective MRI to optimize management in TIA/minor stroke patients.

Conclusion

Combining the Canadian TIA Risk Score with early MRI provides a nuanced approach to managing TIA and minor stroke patients. MRI is crucial for accurate diagnosis, particularly in patients with transient symptoms and negative CT scans. The Canadian TIA Score aids in prioritizing MRI in resource-limited settings: medium-risk patients should receive MRI urgently due to its significant impact on risk stratification, while low-risk patients benefit from MRI for determining further investigations, and high-risk patients require prompt management regardless of MRI results. This integrated approach enhances diagnostic accuracy and optimizes resource use.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s43678-024-00853-7.

Author contributions The author contributions were as follows: Jeffrey Perry and Marcel Emond conceived the idea and Matthieu Robitaille prepared the manuscript. Jeffrey Perry, Marcel Emond and Mukul Sharma contributed to the data curation, methodology and supervision. Jeffrey Perry and Matthieu Robitaille had direct access to the data and verified the data reported in the manuscript. All co-authors contributed to revising the manuscript.

Funding Canadian Institutes of Health Research (CIHR). The study funder had no role in the study design, data collection, analysis, or interpretation of the results. They had no role in the writing of the manuscript or in the decision to submit the article for publication. We confirm the independence of researchers from funders and that all authors, external and internal, had full access to all the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

Data availability Data will be made available to all interested researchers upon request. These requests will be reviewed by the Steering Committee and the data will be made available from the corresponding author upon reasonable request.

Declarations

Conflict of interest Jeffrey Perry and Clare Atzema are supported by a peer-reviewed Mid-Career Salary Support Award from the Heart and Stroke Foundation of Ontario. The authors affirm that the manuscript is an honest, accurate, and transparent account of the study being reported; no important aspects of the study have been omitted; and any discrepancies from the study as planned (and, if relevant, registered) have been explained.

References

1. Giles MF, Rothwell PM. Risk of stroke early after transient ischaemic attack: a systematic review and meta-analysis. Lancet Neurol. 2007;6(12):1063–72.
2. Amin HP, Madsen TE, Bravata DM, Wira CR, Johnston SC, Ashcraft S, et al. Diagnosis, workup, risk reduction of transient ischemic attack in the emergency department setting: a scientific statement from the American heart association. Stroke. 2023. https://doi.org/10.1161/STR.0000000000000418.
3. Förster A, Gass A, Kern R, Ay H, Chatzikonstantinou A, Hennerici MG, et al. Brain imaging in patients with transient ischemic attack: a comparison of computed tomography and magnetic resonance imaging. Eur Neurol. 2012;67(3):136–41.
4. Perry JJ, Sivilotti MLA, Émond M, Stiell IG, Stotts G, Lee J, et al. Prospective validation of Canadian TIA Score and comparison with ABCD2 and ABCD2i for subsequent stroke risk after transient ischaemic attack: multicentre prospective cohort study. BMJ. 2021;4: n49.
5. Coutts SB, Moreau F, Asdaghi N, Boulanger JM, Camden MC, Campbell BCV, et al. Rate and prognosis of brain ischemia in patients with lower-risk transient or persistent minor neurologic events. JAMA Neurol. 2019;76(12):1439.
6. Al-Khaled M, Eggers J. MRI findings and stroke risk in TIA patients with different symptom durations. Neurology. 2013;80(21):1920–6.
7. Giles MF, Albers GW, Amarenco P, Arsava EM, Asimos AW, Ay H, et al. Early stroke risk and ABCD2 score performance in tissue-vs time-defined TIA: a multicenter study. Neurology. 2011;77(13):1222–8.
8. Lansberg MG, Thijs VN, O'Brien MW, Ali JO, de Crespigny AJ, Tong DC, et al. Evolution of apparent diffusion coefficient, diffusion-weighted, and T2-weighted signal intensity of acute stroke. AJNR Am J Neuroradiol. 2001;22(4):637–44.
9. Vahidy FS, Hicks WJ, Acosta I, Hallevi H, Peng H, Pandurengan R, et al. Neurofluctuation in patients with subcortical ischemic stroke. Neurology. 2014;83(5):398–405.

Authors and Affiliations

Matthieu Robitaille[14] · Marcel Émond[5,6] · Mukul Sharma[3] · Ariane Mackey[5,14] · Pierre-Gilles Blanchard[5,6] · Marie-Joe Nemnom[2] · Marco L. A. Sivilotti[4] · Ian G. Stiell[1,2] · Grant Stotts[7] · Jacques Lee[8,9] · Andrew Worster[10] · Judy Morris[11] · Ka Wai Cheung[12] · Albert Y. Jin[13] · Demetrios J. Sahlas[3] · Heather E. Murray[4] · Steve Verreault[5,14] · Marie-Christine Camden[5,14] · Samuel Yip[15] · Philip Teal[15] · David J. Gladstone[16] · Mark I. Boulos[16] · Nicolas Chagnon[17] · Elizabeth Shouldice[18] · Clare Atzema[9] · Tarik Slaoui[11] · Jeanne Teitlebaum[11] · George A. Wells[2] · Jeffrey J. Perry[1,2]

✉ Jeffrey J. Perry
jperry@ohri.ca

1 Department of Emergency Medicine, University of Ottawa, Ottawa, ON, Canada

2 Ottawa Hospital Research Institute, Ottawa, ON, Canada

3 Division of Neurology, McMaster University, Hamilton, ON, Canada

4 Department of Emergency Medicine, Queen's University, Kingston, ON, Canada

5 CHU de Québec, Hôpital de l'Enfant-Jésus, Quebec City, Québec, Canada

6 Division of Emergency Medicine, Université Laval, Quebec City, Québec, Canada

7 Division of Neurology, Department of Medicine, University of Ottawa, Ottawa, ON, Canada

8 Schwartz\Reisman Emergency Medicine Institute, Mount Sinai Hospital, Toronto, ON, Canada

9 Department of Emergency Medicine, Sunnybrook Health Sciences Centre, Toronto, ON, Canada

10 Department of Medicine & Department of Health Research Methods, Evidence, and Impact (HEI), McMaster University, Hamilton, ON, Canada

11 Hôpital du Sacré-Cœur de Montréal, Université de Montréal, Montreal, Québec, Canada

12 University of British Columbia, Vancouver, BC, Canada

13 Division of Neurology, Queen's University, Kingston, ON, Canada

14 Division of Neurology, Laval University, Quebec City, QC, Canada

15 Division of Neurology, University of British Columbia, Vancouver, BC, Canada

16 Hurvitz Brain Sciences Research Program, Sunnybrook Health Sciences Centre & Division of Neurology, Department of Medicine, Sunnybrook Research Institute, University of Toronto, Toronto, ON, Canada

17 Department of Emergency Medicine, Montfort Hospital and University of Ottawa, Ottawa, ON, Canada

18 Queensway Carleton Hospital and University of Ottawa, Ottawa, ON, Canada