Increased Large Vessel Occlusive Strokes After the Christchurch March 15, 2019, Terror Attack

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Sudden catastrophic events such as terror attacks have clear and immediate consequences for the people who are directly affected. However, less is known about the impact on the physical health of local community members (online supplemental available from Dryad doi.org/10.5061/dryad.bcc2fqz9t for further discussion). Acute psychological stress may cause a parallel physiologic response increasing risk of cardiovascular events.[1–3] On March 15, 2019, a gunman shot and killed 51 people praying at the Al Noor and Linwood mosques in Christchurch city, New Zealand. We observed an increase in ischemic stroke reperfusion treatments in the week starting Monday, March 18, 3 days after the terror attack. We hypothesized that this observation could have occurred because of either an effect of the attack on the total number of ischemic strokes and/or the severity of these strokes, or coincidence. We investigated these possibilities by analyzing the association between the terror attack and rate of stroke reperfusion treatment, proven intracranial large vessel occlusion (LVO), and total stroke admissions at Christchurch hospital and the national stroke data set.

Methods

Detailed methodology is available in the supplemental material. Briefly, we used a Bayesian Poisson model to estimate the effect of the terror attack on ischemic stroke admissions, occurrence of intracranial LVO and reperfusion therapy, in the week after the attack compared with weekly data from January 1, 2018, until April 21, 2019. These analyses were repeated for the rest of New Zealand excluding Christchurch data. The probability of the rate observed in the week after the terror attack being higher than the background rate was calculated for each measure, with a probability higher than 99.5% providing strong evidence of an effect.

To ensure any observed effects were not simply related to the default weekly grouping window (Monday to Sunday), we calculated daily left-aligned (i.e., events in the week after the index day, inclusive) rolling weekly totals for proven Christchurch LVOs across this same time period, analyzed using the same methods.

Results

In the week starting Monday after the terror attack, there was no evidence of a difference in the total ischemic stroke admissions at Christchurch hospital (figure A, p [probability higher than background rate] = 39%) or elsewhere in New Zealand (figure A, p = 80%). There was strong evidence of an increase in Christchurch reperfusion therapy (figure B, p = 99.9%) without strong evidence of an increase elsewhere in New Zealand (figure B, p = 96%). This effect was driven by an increase in intracranial LVOs at Christchurch Hospital (Supplemental figure available from Dryad doi.org/10.5061/dryad.bcc2fqz9t, p > 99.9%).

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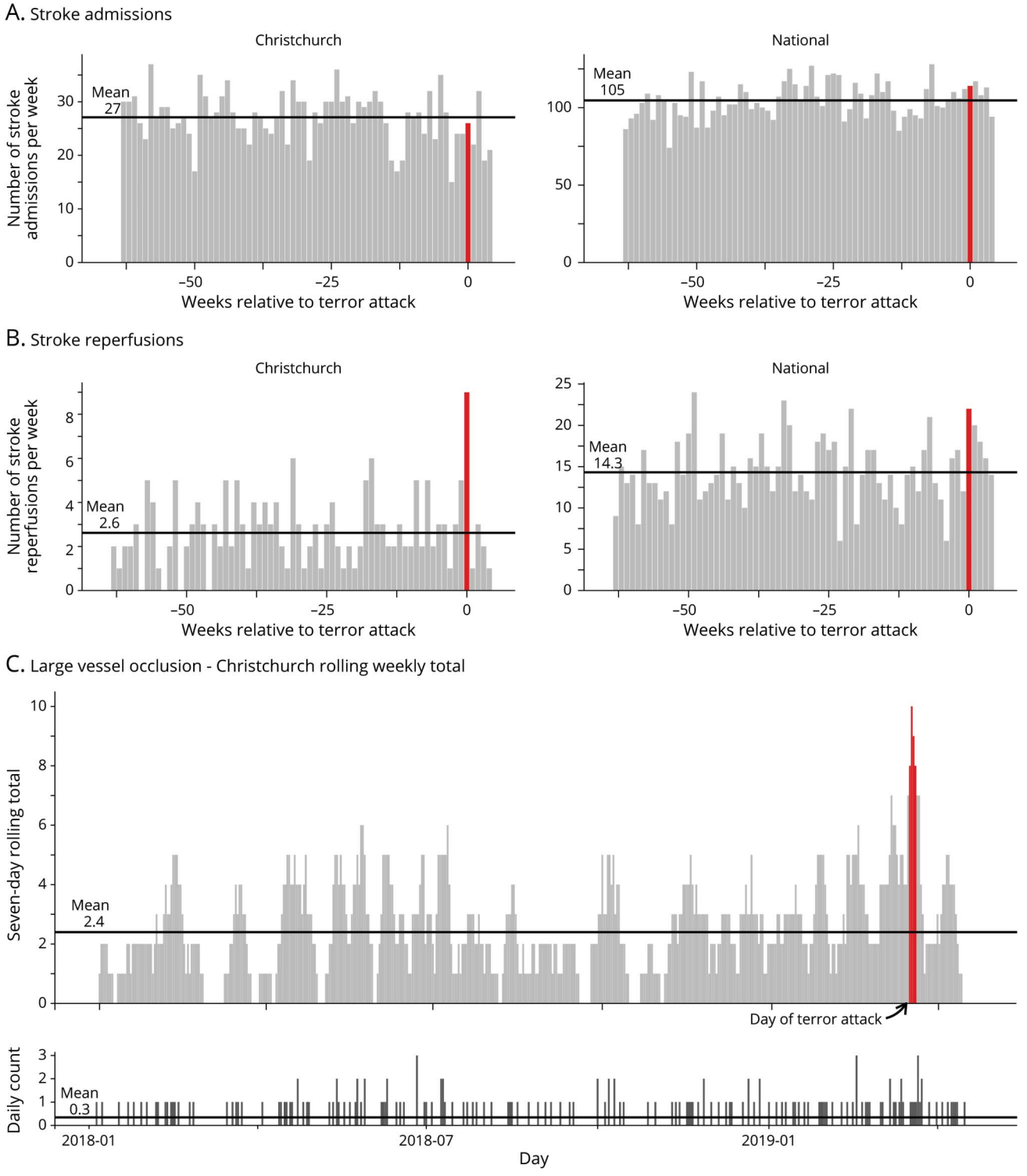
Figure Weekly Totals of Ischemic Strokes, Reperfusion Therapy, and Rolling Weekly Totals of Large Vessel Occlusion Leading to and After the Christchurch Terror Attack



(A) Number of ischemic strokes per week (Monday-Sunday) at Christchurch Hospital (left panel) and elsewhere in New Zealand (right panel) with the week after the terror attack highlighted at week 0. The average number of strokes per week is shown by the black horizontal line. There was no evidence for increase in total ischemic stroke admissions the week after terror attack in Christchurch Hospital (n = 26, mean rate = 27, $p = 39\%$) or elsewhere in New Zealand (n = 118, mean rate = 105, $p = 80\%$). (B) Total weekly (Monday-Sunday) number of stroke reperfusion treatments at Christchurch Hospital (left panel) and elsewhere in New Zealand (right panel) with the week after the terror attack highlighted at week 0. There was strong evidence for increase in reperfusion treatment in Christchurch (week after terror attack = 11, mean rate = 2.6, $p = 99.9\%$) without strong evidence for an increase elsewhere in New Zealand (week after = 22, mean rate = 14, $p = 96\%$). (C) Rolling left-aligned weekly total large vessel occlusions in Christchurch by day. Counts where there was strong evidence of an increase in the total LVOs were shaded red. Figure by Myall, Wu, and Le Heron (2020), distributed at DOI: 10.6084/m9.figshare.12965036 under an open CC-BY 4.0 license. LVO, large vessel occlusion.

There was also strong evidence ($p > 99.5\%$) of an increase in rolling weekly LVO totals (events in the week after the index day, inclusive) in Christchurch for 4 days after the terror attack (figure C). No other time periods reached this level of evidence for an increase. There was no difference in the age, sex, or rates of atrial fibrillation in ischemic stroke patients in the week after the terror attack (online appendix from Dryad doi.org/10.5061/dryad.bcc2fqz9t).

Discussion

The March 15 Christchurch terror attack was associated with a marked increase in the number of local stroke reperfusion treatments which is very unlikely to be due to chance. This increase was driven by a significantly higher rate of patients presenting with LVO compared with stable baseline data—an objective marker of significant acute ischemic stroke. This occurred despite no increase in the total number of ischemic strokes presenting to Christchurch hospital in the same period, suggesting the effect of the terror attack was specific to mechanisms underpinning severe stroke syndromes associated with LVO. Although there was no strong effect on national ischemic stroke admissions, there was a weak signal for increased national reperfusion treatments, suggesting that although the terror attack effect was mostly seen locally, a smaller more widespread impact remains possible.

What physiologic explanation could underpin the observed increase in LVO? Although LVO is more common with increasing age[4] and atrial fibrillation,[5] we did not observe a difference in these variables in the affected week compared with baseline. It is plausible that transient arrhythmias were undetected during hospitalization because extreme psychological stress could result in cardiac arrhythmias as observed in the aftermath of the September 11 attack on the World Trade Center.[6,7] Extreme psychological stress may promote thrombosis through sympathetic nervous system activation, hemoconcentration, platelet activation, and increased fibrin production.[1,2] Although unproven, it is plausible the combination of psychophysiologic factors and proarrhythmogenicity associated with acute stress triggered ischemic stroke due to LVO in patients admitted in the week after the terror attack. Such a mechanism may also account for the apparent lag, by a few days, in the increase in LVO presentations.

Study limitations include the absence of data for LVO rates outside of Christchurch Hospital and the absence of markers of physiologic or psychological stress, meaning we can only postulate regarding mediators of the observed LVO and terror attack association.

We demonstrate that sudden catastrophic events such as terror attacks may increase the numbers of patients developing intracranial LVO requiring stroke reperfusion therapies within the affected community.

Study Funding

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Disclosure

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Appendix Authors

Name	Location	Contribution
Teddy Wu, PhD	Christchurch Hospital, New Zealand	Designed the study, collected data, statistical analysis plan, wrote the first draft, and submitted the manuscript.
Daniel Myall, PhD	New Zealand Brain Research Institute	Designed the study, statistical analysis plan and performed statistical analyses, and wrote the first draft.
David Palmer, MBChB	Christchurch Hospital, New Zealand	Collected data and edited the manuscript for intellectual content.
James Beharry, MBChB	Christchurch Hospital, New Zealand	Collected data and edited the manuscript for intellectual content.
Jen Yuh Lim, MBChB	Christchurch Hospital, New Zealand	Collected data and edited the manuscript for intellectual content.
Deborah F. Mason, FRACP	Christchurch Hospital, New Zealand	Collected data and edited the manuscript for intellectual content.
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Mike A. Hurrell, FRANZCR	Christchurch Hospital, New Zealand	Collected data and edited the manuscript for intellectual content.

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Appendix *(continued)*

Name	Location	Contribution
P. Alan Barber, FRACP, PhD	Auckland City Hospital, New Zealand	Collected data and edited the manuscript for intellectual content.
Annemarei Ranta, FRACP, PhD	Wellington Hospital, New Zealand	Collected data and edited the manuscript for intellectual content.
John N. Fink, FRACP	Christchurch Hospital, New Zealand	Collected data and edited the manuscript for intellectual content.
Campbell Le Heron, FRACP, PhD	Christchurch Hospital, New Zealand	Designed the study, collected data and edited the manuscript for intellectual content.

References

1. Rozanski A, Blumenthal JA, Kaplan J. Impact of psychological factors on the pathogenesis of cardiovascular disease and implications for therapy. Circulation 1999;99:2192–2217.
2. Strike PC, Magid K, Whitehead DL, et al. Pathophysiological processes underlying emotional triggering of acute cardiac events. Proc Natl Acad Sci U S A 2006;103:4322–4327.
3. Aoki T, Fukumoto Y, Yasuda S, et al. The great east Japan earthquake disaster and cardiovascular diseases. Eur Heart J 2012;33:2796–2803.
4. Vanacker P, Heldner MR, Amiguet M, et al., Prediction of large vessel occlusions in acute stroke: national institute of health stroke scale is hard to beat. Crit Care Med, 2016. 44:e336–e343.
5. Inoue M, Noda R, Yamaguchi S, et al., Specific factors to predict large-vessel occlusion in acute stroke patients. J Stroke Cerebrovasc Dis, 2018. 27:886–891.
6. Feng J, Lenihan DJ, Johnson MM, Karri V, Reddy CV, Cardiac sequelae in Brooklyn after the September 11 terrorist attacks. Clin Cardiol, 2006. 29:13–17.
7. Steinberg JS, Arshad A, Kowalski M, et al., Increased incidence of life-threatening ventricular arrhythmias in implantable defibrillator patients after the World Trade Center attack. J Am Coll Cardiol, 2004;44:1261–1264.