Traumatic brain and spinal injuries in a pedestrian struck by an electric scooter

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A 68-year-old woman presented to the emergency department after she was struck by an electric scooter (e-scooter) travelling at about 30 km/h while she was walking on a city sidewalk. She hit her head on the pavement and lost consciousness for 3 minutes. In the emergency department, she underwent trauma team assessment.[1] She was examined in the Aspen cervical collar in which she had been delivered by emergency services. She was amnestic to the event and had persistent headache, nausea and vomiting. Her vital signs were stable and she had a score of 13 (E3, V4, M6) on the Glasgow Coma Scale (GCS). The rest of the neurological examination was normal. We saw an 8 cm occipital scalp laceration, but no evidence of cerebrospinal fluid leak. Computed tomography (CT) showed trace subarachnoid hemorrhage (Figure 1), a nondisplaced occipital bone fracture (Figure 2) and a nondisplaced right posterior C2 arch fracture (Figure 3). A CT angiogram and venogram did not show any vascular injury or dural venous sinus involvement.

The patient had no indication for immediate surgical intervention, so we replaced the Aspen collar with a hard cervical spine (C-spine) collar, and monitored her with repeated GCS and pupillary assessments. A repeat CT scan of her head, taken 10 hours after the initial scan, showed no changes from the first scan, and magnetic resonance imaging (MRI) of her C-spine showed no ligamentous injuries. We discharged the patient 48 hours after admission. Repeat imaging of C-spine and physical examination 6 weeks later

Key points

- Use of electric scooters (e-scooters) has increased dramatically around the world.
- Motorized vehicles that travel in physical spaces intended for pedestrians pose a threat to pedestrian safety.
- Clinicians must have a high index of suspicion for potentially serious injuries in e-scooter collisions with pedestrians, given the substantial transfer of energy that can occur.
- Although e-scooters have beneficial features, policies and interventions to reduce the rate and burden of injuries associated with their use are required.

Figure 1: Axial computed tomography scan of the head of a 68-year-old woman who was struck by an electric scooter, showing trace traumatic subarachnoid hemorrhage along the lateral margins of the right temporal lobe (arrow A) and the left temporal lobe (arrow B).

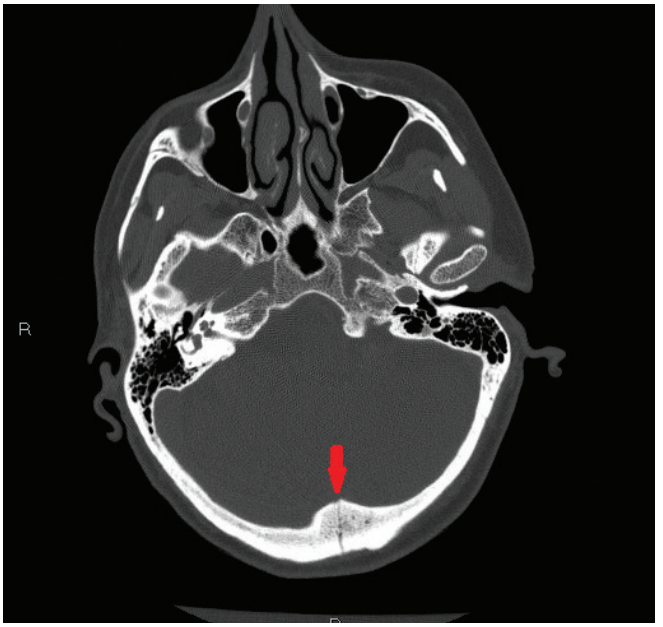

Figure 2: Bone window of an axial computed tomography scan of the head of a 68-year-old woman who was struck by an electric scooter, showing a nondisplaced occipital fracture, identified by the arrow.

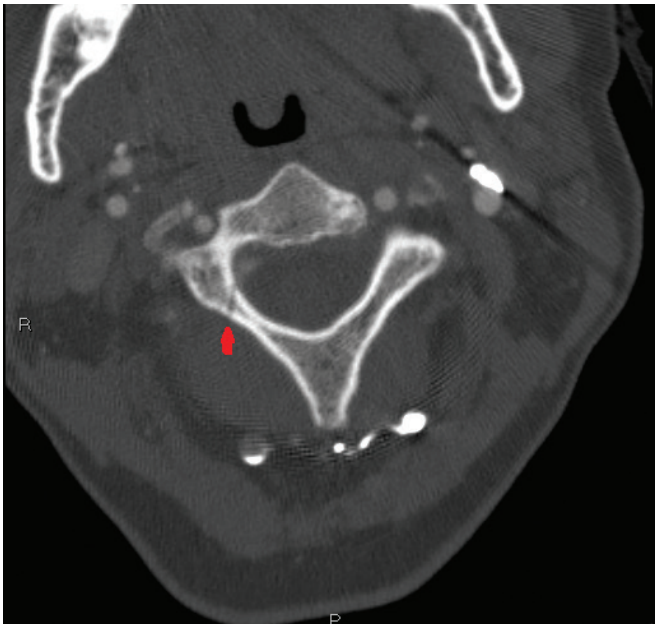

Figure 3: Axial computed tomography scan of the cervical spine of a 68-year-old woman who was struck by an electric scooter, showing a nondisplaced fracture of the right posterior C2 arch, identified by the arrow.

were unremarkable, so we removed her collar and referred her to physiotherapy to lessen pain and to increase range of motion. Four months after the admission, she was back to her baseline function and had no postconcussive symptoms.

Discussion

Current management of patients with traumatic subarachnoid hemorrhage includes admission to hospital for monitoring of neurologic status, with a repeat CT scan of the head 6–24 hours after the initial scan to evaluate for progression of any abnormalities. Neurosurgical consultation is suggested for patients with decreasing GCS score, unrelenting vomiting or new focal deficits.[2] However, recent evidence suggests that fewer than 10% of patients with mild traumatic brain injury and isolated traumatic subarachnoid hemorrhage have progression on repeat CT. Repeat CT of the head and a brief period of observation has been shown to facilitate early discharge from hospital without delayed adverse outcomes.[3] Given our patient's age, refractory headaches, persistent nausea and initial abnormal CT, with a fracture near the transverse venous sinus and torcula, we performed a CT venogram and angiogram to assess for blunt cerebrovascular injury. Given our patient's age and mechanism of injury, with a confirmed cervical fracture, we obtained a C-spine MRI to assess for epidural bleeding, ligamentous disruption, spinal cord edema and herniated discs. In our experience, the choice of imaging modality depends on a combination of clinical findings, mechanism of injury and site-dependent trauma protocols. In patients with a head injury associated with substantial energy transfer and subarachnoid hemorrhage or skull fracture, it is prudent to acquire both a CT angiogram and CT venogram to assess the integrity of arteries and dural venous sinuses. An MRI of the spine is useful for patients who have undergone a trauma or who have abnormal CT C-spine findings suspicious for ligamentous injury and neurologic deficits, and those who cannot reliably have their cervical spine cleared owing to distracting injuries or altered level of consciousness.

E-scooter use and related injuries

An e-scooter looks similar to a conventional 2-wheel scooter, but is powered by an electric battery, which enables riders to reach top speeds of about 48 km/h.[4] Depending on the jurisdiction, e-scooters may be ridden on roads, bicycle lanes or sidewalks. Their convenience of use, efficiency and affordability have led to striking increases in their use in the last 5 years.[5] Although e-scooters and similar devices, like electric bicycles (e-bikes), reduce the number of trips and, consequently, the risks associated with automobile use, their rising popularity has led to a rapid increase in injuries related to their use.[6] In the United States, the number of visits to emergency departments associated with e-scooter use was estimated to increase from 4881 in 2014 to 29 628 in 2019.[6] A scoping review on e-scooter–related injuries found that riders most often injured their head and extremities.[7] More than 90% of riders were injured without involving other road users, commonly from falls, collisions with objects, speeding and adverse road conditions.[7] Nonriders were most often injured by being struck by an e-scooter (59.1%) or by tripping over a parked e-scooter (29.5%).[7] Most patients (86%) had relatively minor injuries that did not require hospital admission.[7]

In Calgary, a shared e-bike and e-scooter pilot program from October 2018 to October 2020 recorded 1.9 million trips and more than 200 000 users.[8] During the pilot period, about 1300 emergency department visits related to e-scooters were identified, and 1 in every 1400 e-scooter trips led to an emergency department visit.[8] A retrospective study of medical records of 75 patients seen in the emergency department after this pilot program showed that 71 injuries occurred in riders and 4 occurred in nonriders like pedestrians and cyclists.[8] Risks associated with these injuries included riders losing control, removing a hand or foot from the scooter while riding and encountering environmental hazards such as potholes, gravel and curbs.[8]

Reports of intracranial hemorrhages as a result of e-scooter injuries are relatively uncommon, but concerning. A retrospective case series from 2 facial trauma centres in Paris, France, between 2017 and 2019 included 125 patients with e-scooter–associated head and neck trauma.[9] The oldest patient was a 95-year-old pedestrian struck by an e-scooter. The study identified 2 patients with intracranial hemorrhage, 1 with subdural hematoma and 1 with a subarachnoid hemorrhage.[9] Trivedi and colleagues[5] reported 249 patients with injuries associated with e-scooter use who were seen at 2 urban emergency departments during a 1-year study period. About a tenth (10.8%) of patients were younger than 18 years. Twenty-one patients (8.4%) were nonriders, and just over half of nonrider injuries were from being hit by the e-scooter.[5] Notably, 40.2% of the reported injuries were to the head and none of the riders with intracranial hemorrhage had documentation of helmet use while riding.[5]

Another study on injured e-scooter riders showed that 8% sustained skull fractures or intracranial hemorrhages.[10] A

multi-institutional case series showed that intracranial hemorrhages and facial fractures accounted for 18% and 26%, respectively, of e-scooter injuries among riders.[11] Use of protective equipment (e.g., helmets) was low or not reported.[4,10]

The need for practical policy and approaches

Despite a local municipal policy prohibiting the use of e-scooters on sidewalks, our patient sustained serious injuries from a collision with an e-scooter. Similar invasions of pedestrian spaces have been reported elsewhere and have caused injuries to both riders and pedestrians, suggesting that stronger enforcement of traffic regulations that limit speeds and sidewalk use is needed.[5] Safety issues identified in Calgary and elsewhere have resulted in policy changes, such as adding visible identification on shared e-scooters for easy reporting of inappropriate behaviour and directly fining e-scooter companies for improperly parked e-scooters.[8]

Providing protected physical environments for vehicles like e-scooters and e-bikes should be similarly beneficial as physically separating cyclists from motorized vehicles.[12] A case-crossover study in Toronto and Vancouver found that cycle tracks had the lowest risk of cycling injury among 14 studied route infrastructures.[12] Cycle tracks include paved cycling paths with a physical barrier (e.g., curbs or bollards) from major streets.[12] This specially built environment significantly reduced the injury risk of cyclists to about one-ninth of those riding in major streets with parked cars and without bike lanes.[12] Creating such infrastructure requires substantial input from stakeholders, and requires a review and rethinking of existing built environments and infrastructure. Other novel infrastructure possibilities include refurnishing underused sidewalks for electric vehicles.

Mandatory helmet use for e-scooter riders is another possible strategy for injury prevention, given the effectiveness of helmet use for cyclists.[13] Compared with unhelmeted bicyclists, helmeted cyclists show significantly reduced rates of scalp lacerations, scalp hematomas, skull fractures, subdural hematomas and any serious traumatic brain injury, classified as those with a Head Abbreviated Injury Score of 3 or greater.[13] New health-related policies, like those related to seat belt and helmet usage, require educational and marketing messaging to optimize effectiveness.[9]

Measures that reduce the overall use of cars with safe alternatives such as e-scooters can improve community well-being and safety, and have beneficial effects on air quality and overall health, but effective policies to mitigate injuries are needed.

References

1. *Advanced Trauma Life Support (ATLS): student course manual*. 10th ed. Chicago: American College of Surgeons; 2018.
2. Van Ornam J, Pruitt P, Borczuk P. Is repeat head CT necessary in patients with mild traumatic intracranial hemorrhage. *Am J Emerg Med* 2019;37:1694-8.
3. Kreitzer N, Lyons MS, Hart K, et al. Repeat neuroimaging of mild traumatic brain-injured patients with acute traumatic intracranial hemorrhage: clinical outcomes and radiographic features. *Acad Emerg Med* 2014;21:1083-91.
4. Schlaff CD, Sack KD, Elliott RJ, et al. Early experience with electric scooter injuries requiring neurosurgical evaluation in District of Columbia: a case series. *World Neurosurg* 2019;132:202-7.
5. Trivedi TK, Liu C, Antonio ALM, et al. Injuries associated with standing electric scooter use. *JAMA Netw Open* 2019;2:e187381.
6. Farley KX, Aizpuru M, Wilson JM, et al. Estimated incidence of electric scooter injuries in the US from 2014 to 2019. *JAMA Netw Open* 2020;3:e2014500.
7. Toofany M, Mohsenian S, Shum LK, et al. Injury patterns and circumstances associated with electric scooter collisions: a scoping review. *Inj Prev* 2021;27:490-9.
8. Sedor A, Oriold J. Shared e-bike and e-scooter final pilot report. Calgary: University of Calgary; 2020. Available: https://www.calgary.ca/content/dam/www/transportation/tp/documents/cycling/cycling-strategy/shared-e-Bike-and-eScooter-final-pilot-report.pdf (accessed 2022 Apr. 6).
9. Hennocq Q, Schouman T, Khonsari RH, et al. Evaluation of electric scooter head and neck injuries in Paris, 2017–2019. *JAMA Netw Open* 2020;3:e2026698.
10. Badeau A, Carman C, Newman M, et al. Emergency department visits for electric scooter-related injuries after introduction of an urban rental program. *Am J Emerg Med* 2019;37:1531-3.
11. Kobayashi LM, Williams E, Brown CV, et al. The e-merging e-pidemic of e-scooters. *Trauma Surg Acute Care Open* 2019;4:e000337.
12. Teschke K, Harris MA, Reynolds CCO, et al. Route infrastructure and the risk of injuries to bicyclists: a case-crossover study. *Am J Public Health* 2012;102:2336-43.
13. Sethi M, Heidenberg J, Wall SP, et al. Bicycle helmets are highly protective against traumatic brain injury within a dense urban setting. *Injury* 2015;46:2483-90.

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