Individuals who remain seated in wheelchairs while travelling in vehicles are “45 times more likely to be injured in a crash than the typical passenger”\(^1\) (p. 2). The “typical” passenger in a vehicle transfers into the vehicle manufacturer’s seat, which is secured to the vehicle, and uses the occupant restraint system; that is, the seat belt system that also is secured to the vehicle. Individuals who must remain seated in wheelchairs while travelling in vehicles also are at risk of injury in “non-collision events”, such as sudden braking or sharp turning, resulting in the wheelchair tipping, securement failure, or the occupant falling out of the wheelchair\(^1\) (p. 4). Many individuals who must remain seated in the wheelchair during transit do not have postural control or the ability to stabilize themselves or their wheelchairs during these non-collision events, which can result in serious injuries.

The position paper on Wheelchairs Used as Seats in Motor Vehicles by the Rehabilitation Engineering & Assistive Technology Society of North America (RESNA) states that the “ideal” safety practice is for individuals who use wheelchairs to “transfer into a manufacturer-installed vehicle seat and use the vehicle’s crash-tested occupant restraint system”\(^1\) (p.5). This is not always possible; for example, if a person is unable to safely transfer into a vehicle seat or requires the postural support provided by the wheelchair seating system.

**Wheelchairs Used as Seats in Motor Vehicles (WC19)**

If a person must remain seated in a wheelchair while travelling in a vehicle, it is important that the wheelchair meets certain standards. “WC19 is a voluntary industry standard for designing, testing and labeling a wheelchair that is ready to be used as a seat in a motor vehicle. A WC19 wheelchair has:

- Four permanently attached and labeled securement points that can withstand the forces of a 30 mph, 20 g impact.
- Specific securement point geometry that will accept a securement strap end fitting hook.
- A clear path of travel that allows proper placement of vehicle mounted occupant safety belts next to the skeletal parts of the body,
- Anchor points for an optional wheelchair anchored pelvic safety belt, that is designed to withstand a 30 mph, 20 g impact, that has a standard interface on it that allows it to connect to a vehicle-anchored shoulder belt.\(^2\)

Each bullet point is explained in more detail below.

**Permanently Attached Securement Points**

The four securement points on a wheelchair are the brackets installed on the wheelchair – two at the front of the wheelchair and two at the rear of the wheelchair – to which securement straps can be attached. The required label that indicates that the wheelchair securement points conform to the WC19 standards is a hook symbol. If the metal rings do not have the hook logo, it means that the wheelchair has not been crash tested successfully for occupant safety.\(^3\)

The forces that the securements points must withstand – 30 miles per hour (or 48 kilometres per hour), 20 g impact – refer to the testing standards. Thirty miles per hour is the same standard that is used for testing passenger vehicles and child safety seats.\(^4\) When testing wheelchairs for WC19 compliance, the wheelchair is secured to a sled on a test track and an appropriately-sized crash test dummy is secured to the wheelchair. A frontal impact sled test is used in which there is a 30 mile per hour change in speed, simulating a frontal crash. A sudden change of speed of 30 miles per hour represents the 95th percentile of crash severity of frontal crashes of cars, minivans and SUVs.\(^4\) Therefore, most crashes in the “real world” will be less severe than the testing conditions.
**Securement Point Geometry**

The geometry of the securement point must allow for one-handed attachment of the hook of a tiedown strap when a driver or caregiver reaches for the securement points from one side of the wheelchair. This means that the securement brackets are easily identifiable and easily accessible. In addition, when tiedown straps are applied to the securement points on the wheelchair and to the typical anchor points on the floor of the vehicle, the position of the straps should not be close to any sharp edges that could damage the strap material in the event of a crash.

**Clear Path for Placement of Vehicle Mounted Occupant Safety Belts**

A WC19 compliant wheelchair may be used with a wheelchair tiedown and occupant-restraint system (WTORS) in a vehicle. A WC19 compliant wheelchair allows for the easy passage of the shoulder belt, from the mounting in the vehicle and connecting to the pelvic belt near the hip of the wheelchair seated individual, without getting in the way. The shoulder belt needs to be snug and positioned over the middle of the clavicle and across the sternum, and then connect to the pelvic belt near the hip. Wheelchair manufacturers are required to disclose the rating that each wheelchair model is assigned after undergoing independent testing with respect to accommodating the proper use and positioning of a vehicle anchored belt-restraint. The ratings are poor, acceptable, good or excellent.

**Anchor Points for a Pelvic Safety Belt**

A pelvic safety belt is different than a positioning belt that is used for postural support in seating. Unless they have been labeled as having been crash tested, postural supports, such as positioning belts and chest harnesses, do not provide for restraint for an occupant seated in a wheelchair in a vehicle. In contrast, a safety belt is “a length of energy-absorbing webbing material used in occupant restraint systems.” That is, a pelvic safety belt is specifically designed, tested, and labelled for crashworthiness. A WC19 compliant wheelchair has anchor points that allow for the installation of a pelvic safety belt that meets the testing standards.

It should be noted that WC19 is a voluntary standard, which means that it has not been mandated by federal or provincial legislation. Many wheelchair manufacturers have their products tested in order to be WC19 compliant, however, not all wheelchairs have been tested or meet these standards. If a person will be using a wheelchair as a seat in a motor vehicle, or may in the future need to remain seated in a wheelchair during transit, it is important to consider the safety of the wheelchair at the time of prescription. If a product is prescribed that is not crashworthy, the rationale for its prescription “should be clearly documented to avoid possible confusion for parents and transporters over who made the final decision and why, if the lack of transit technology should result in injury” (p. 9).

**Wheelchair Tiedowns and Occupant Restraint Systems (WTORS)**

The wheelchair tiedown part of WTORS refers to securing the wheelchair to the floor of the motor vehicle, while the occupant restraint system refers to providing restraint to the person in the wheelchair. Both are required to enhance safety when seated in a wheelchair while travelling in a motor vehicle.

Wheelchair tie-downs typically refer to a four-point strap tiedown system. A four-point strap tiedown system is “a method for securing a wheelchair where four straps are attached to the wheelchair at four separate securement points and attached to the vehicle at four separate anchor points.” A four-point strap tiedown system is most commonly used on public transit, paratransit and school buses as it can adapt to a range of wheelchair sizes and models.

When attaching the tiedown straps to the securement points on the front of the wheelchair, the straps should be angled slightly outward, such that the attachment points on the floor are wider than the width of the wheelchair to add lateral stability. The position of the front tiedowns is important to enhance lateral stability to minimize the risk of tipping during a sudden driving maneuver. The front tiedowns should attach to the floor at an angle between 40 and 60 degrees (relative to horizontal).
The tiedowns that attach to the securement points on the rear of the wheelchair should be attached "straight back to the floor." These tiedowns should attach to the floor at an angle of 30 to 45 degrees (relative to horizontal). It is noteworthy that the rear tiedowns usually take twice the amount of force compared to the front tiedowns and therefore their correct placement is important.

Wheelchair tiedowns also may refer to docking systems, which are commercially available mechanical systems that secure particular wheelchairs to particular vehicles. A docking tiedown, therefore, is "a method for securing wheelchairs where portions of the wheelchair frame, or add-on components fastened to the wheelchair frame, engage with a securement device anchored to the vehicle." This would be most commonly used in a privately-owned vehicle for a specific wheelchair. This replaces the need for using a four strap tiedown system and can promote independence with securing one’s wheelchair to one’s vehicle.

Whether a strap tiedown system or a docking system is used, an occupant restraint system is necessary in either case. An occupant restraint is "a system or device designed to restrain a motor vehicle occupant in a crash by keeping the occupant in the vehicle seat and minimizing contact with the vehicle interior, other occupants, or objects outside the vehicle." An occupant restraint system is a three-point lap and shoulder belt system that has been crash-tested. A pelvic safety belt has been specifically designed and tested for crash-worthiness and is used in conjunction with a shoulder belt anchored to the vehicle to provide restraint to the hips and torso in the event of a crash. "The shoulder belt needs to be snug and positioned over the middle of the clavicle and across the sternum, and then connect to the pelvic belt near the hips" (p. 11). The pelvic belt must fit low on the hips to minimize risk of injury in the event of a crash.

Just as a wheelchair must meet certain standards to be deemed WC19 compliant, so too must tiedown and occupant restraint products. The standards for tiedown and occupant restraint products require that:

- "pelvic and shoulder restraints be used in the tests and recommend use of both belts during transport, especially in vehicles that have occupant restraint belts normally installed,
- a dynamic 30 mph (48kph) frontal-impact test be used to confirm the performance of the WTORS,
- the end fittings on tiedown straps meet a specific design so that the end fitting will readily latch to the mating receptacle on the transport-compliant wheelchair,
- the product be permanently labeled as to the test passed, instruction and warnings be provided for both installers and users."

In addition, an effective WTORS “must provide for the release of the wheelchair and occupant in under 60 seconds by a single attendant.”

Wheelchair Seating Systems for Use in Motor Vehicles (WC20)

WC19 is the voluntary standard related to wheelchairs used as seats in motor vehicles. It is recognized that one manufacturer’s seating system, however, may be affixed to another manufacturer’s mobility base. Thus, when looking at safety for individuals who must remain seated in their wheelchairs, it became apparent that there should be separate testing to evaluate the design and performance of wheelchair seating systems separate from specific wheelchair frames. WC20 is the voluntary standard for wheelchair seating systems used in motor vehicles. Wheelchair seating includes seats and back support with attachment hardware.

In order to test the crashworthiness of seating and attachment hardware, a surrogate wheelchair base is used. The surrogate wheelchair base, which can withstand repeated 48 kph/20 g crash tests, is able to accommodate various sizes and types of commercial seating. In order to test the seating, the seating is attached to the surrogate wheelchair base with its attachment hardware and the wheelchair base is secured to a frontal impact sled with 4-point tiedowns. An anthropomorphic test device, or “crash test dummy”, is secured with a 3-point occupant restraint system. The testing is completed to ensure that the crash test dummy remains in a seated posture at the completion of the test and does not “submarine” under the pelvic safety belt. In addition, the attachment hardware must remain
attached to the seating system and to the wheelchair and no part of the seating system weighing greater than 100 g should break loose. If a piece broke loose while in a collision, it could become a projectile and injure others in the vehicle.

It is intended that WC20-compliant seating is installed on a WC19-compliant wheelchair base. The base must then be secured to a vehicle with an approved Wheelchair Tiedown and Occupant Restraint System (WTORS). “The combination of these devices is indicated to obtain the best possible performance when in a transit condition.”

References:


**Speaker Bios:**

**Sheilagh Sherman** is the Clinical Educator for Sunrise Medical Canada. Since graduating as an occupational therapist from McMaster University in 1994, she has worked in a variety of settings, including in-patient neurological rehabilitation, complex continuing care, and community rehabilitation. Since joining Sunrise Medical in 2010, Sheilagh has led numerous seminars, workshops and in-services on seating and mobility in Canada.

**Toni-Marie Taylor** is an occupational therapist in the Windsor area. Toni graduated from the University of Western Ontario and began her career as an OT in 1994. Since this time, she has worked in the hospital, clinic and community settings. As an ADP authorizer since 1999, Toni has extensive experience with wheelchair prescription. In 2000, Toni became Windsor’s only Certified Driver Rehabilitation Specialist. And in 2013, Toni joined the team at Sunrise Medical where she currently works as an account manager in South Western Ontario.