C38 Water/Snow Slide Tubing Neck Injury Biomechanics: Catastrophic Cervical Injuries Produced By Low-Level Head Loading When Base of Neck Is Immobilized

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The goals of this presentation are that attendees will gain skill in accurately synthesizing injury mechanisms responsible for fracturedislocation of the cervical spine under conditions where (1) low-level head loading occurs with (2) the base of the neck immobilized.

A healthy, athletic 17-year-old female (height=5'3"; weight=117 lbs.) was sitting, buttocks-down, in a large tube, floating at a staging area of a water park, awaiting clearance to float down a chute. She and her tube were pushed into and down the chute when she was facing backwards, looking upstream. She was proceeding without difficulty, traveling backwards down the chute, when she and her tube floated into an adult male (height-5'4"; weight=135 lbs.) who was facing down the chute and walking down the chute to retrieve his tube. The girl and her tube impacted the rear aspect of the man's lower legs, knocking his legs out from under him, causing the man to fall backwards and land on top of the girl. This collision of the girl, sitting in her tube, and this adult male occurred at a place where the chute incline was relatively gentle, the water flow rate was of moderate speed, and the water was less than one foot deep. Lying on his back on top of the girl and her tube, with the girl facing down, the man and the girl then floated down together on her tube into the pool below.

Upon impact of the girl in her tube and the man, the girl could neither move nor feel her legs. In this accident, the girl suffered a C6-7 cervical spinal dislocation, with anterior flexion of C6 forward of C7, with her right C6-7 facet joint completely disrupted and her left C6-7 facet joint perched, and with subluxation offset of 50-75% of vertebral body depth. She suffered a complete spinal cord injury at the C6-7 level. She remained conscious, and no evidence was ever found that head, torso, or extremity injuries were sustained in this accident. The man suffered no injuries in this incident.

Experimentation was conducted with a surrogate seated, buttocksdown, in an exemplar water slide tube, with the surrogate's legs draped over the top of the tube and her hands gripping the right and left hand holds located on the top of the tube. The outside diameter of this tube was approximately 4', and the inside opening diameter was approximately 17-1/4". When the surrogate was seated/folded-up in a typical relaxed, comfortable configuration in the tube, the upper back and lower aspect of the surrogate's shoulders were leaning and braced against the tube. This typical rider configuration resulted in significant bracing of the tuber's base of the neck, relative to the tube. Low levels of downward, forward loading applied to the top-rear aspect of the authors' heads left little doubt that loading the head in this fashion could produce dislocation of the cervical spine.

Bauze and Ardran[1] conducted compressive loading studies on fourteen human cadaveric cervical spinal specimens that were intact extending from the basiocciput down to the second thoracic vertebra. The T1-2 base of the cervical spine was fixed to a lower plate, while the previously prepared flat surface of the basiocciput lay flush against the smooth, lubricated surface of an upper plate. When this cervical spinal specimen was subjected to compressive loading, quasi-statically, progressive "ducking" of the head, with the orientation of the head remaining essentially unchanged, caused bilateral dislocation of the facets without fracture. The maximal vertical load achieved was only 319 pounds force (lbf) and this coincided with rupture of the posterior ligament and capsule and stripping of the longitudinal ligament, prior to dislocation. These studies indicated the vulnerability of the cervical spine to head loading that induced ducking of the head when the base of the cervical spine remained relatively immobile.

This pioneering work of Bauze and Ardran identified the injury mechanism responsible for the catastrophic cervical injury sustained in the relatively low-speed impact of the girl, riding in a tube, in shallow water, and the walking man who was upended, falling backward onto the top-rear aspect of the girl's head. However, absent the significant neck base immobilization achieved riding/seated, buttocks-down, in a large water/snow slide tube, the level of contact loading sustained from a standing adult falling over rearward on top of a seated adult is typically insufficient to cause dislocation of the cervical spine.

[1] Bauze, R.J., Adran, G.M.; "Experimental production of forward dislocation in the human cervical spine." J. of Bone & Joint Surg. 60-B (2), May, 1978.

Dislocation of Cervical Spine, Locked Facets, Quadriplegia

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