Cervical Spine Injuries among Submersion Victims

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Background: Submersion victims are frequently considered at high risk for cervical spine (C-spine) injury regardless of whether they sustain a traumatic injury. We hypothesized that C-spine injury is unlikely in submersion victims who do not sustain high-impact injuries.

Methods: The study was a cohort study of all people who submerged between January 1974 and July 1996 and received medical care or were seen by the medical examiner in King, Pierce, and Snohomish counties in Washington State.

Results: Eleven (0.5%) of 2,244 submersion victims had C-spine injuries. All 11 had submerged in open bodies of water; had clinical signs of serious injury; and had a history of diving, motorized vehicle crash, or fall from height. No C-spine injuries occurred in 880 low-impact submersions.

Conclusion: Submersion victims are at risk for C-spine injury only if they have also sustained a traumatic injury. Routine C-spine immobilization does not appear to be warranted solely on the basis of a history of submersion.

Key Words: Spinal fractures, Spinal injuries, Cervical vertebrae, Cohort studies, Drowning, Near drowning, Immersion, Diving, Risk factors, Epidemiology.

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Cervical spine (C-spine) injuries are found in 1% to 4% of patients treated at trauma centers in the United States and are generally associated with high-impact injuries.[1–6] Because water sports and diving have been reported to be associated with C-spine injuries[7] and because the consequences of missing a C-spine injury can be devastating, some authors and practitioners recommend that all submersion victims receive C-spine immobilization.[8–10] These recommendations may be overly cautious, particularly for very young submersion victims. One fifth of infant and toddler submersions are bathtub related,[11] and this age group seems unlikely to be engaged in water sports associated with high-impact injuries.

Although C-spine immobilization is an important element in the management of patients truly at increased risk for C-spine injury, effective C-spine immobilization is difficult[12–14] and can have adverse effects. C-spine immobilization can make resuscitation more difficult because it interferes with airway management,[15,16] limits the ability of providers to effectively dry the patient, and hinders physical examination. Improperly fitted cervical collars (C-collars) can lead to upper airway obstruction in obtunded patients.[17] C-collars can also significantly increase intracranial pressure, which may be harmful to patients at risk for cerebral edema after submersion-related hypoxia.[18–20]

If groups of patients who are not at increased risk for C-spine injury can be identified, it may be possible to decrease both the morbidity and the cost of caring for submersion victims. We hypothesized that C-spine injury would be unlikely after low-impact submersions: those related to swimming, bathing, wading, fishing, and scuba diving.

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MATERIALS AND METHODS

After obtaining institutional review board approval, we sought data regarding submersion victims who were submerged in and/or received medical care in, King, Pierce, and Snohomish counties in Washington State between January 1, 1974, and August 31, 1996. These counties contain the cities of Seattle and Tacoma and had 2,559,136 residents in 1990.[21] A data collection form was used to abstract information from the records of all 32 acute care hospitals in King, Pierce, and Snohomish counties, from the medical examiner offices, and from the emergency medical services agencies of the three counties. Case finding was supplemented by using the computerized files of Washington State death certificates for the years 1975 through 1996 and computerized files of state civilian hospital discharges from 1987 through 1996. Submersion victims were identified from the computerized records of discharges using the *International Classification of Diseases, 9th Revision, Clinical Modification* submersion diagnosis code 994.1.[22]

C-spine injuries in submersion victims who received medical care were identified from a combination of hospital records and computerized files of hospital discharges. The following *International Classification of Diseases, 9th Revision, Clinical Modification* diagnosis codes were used to identify the presence of C-spine injury in submersion victims:

805.0 to 805.19, 806 to 806.19, 839 to 839.50, 847, 905.1, 905.6 to 905.89, 907.2, 952 to 953, and 959.0.[22] These diagnosis codes include fractures and dislocations, cervical spinal cord injury (with or without evidence of vertebral injury), as well as the diagnosis of neck strain. All patients who died and whose bodies were found had autopsies performed by forensic pathologists. In all autopsied patients, the neck was routinely examined. In victims who died before receiving medical care, C-spine injuries were identified from medical examiner autopsy reports.

We excluded from analysis 90 victims who had incomplete records. These victims were identified as submersion victims from computerized death certificate files. The death certificate files on these victims contained only the diagnosis of submersion, without any secondary diagnoses. All of these victims died before receiving hospital care. We were able to match 32 of these death certificate files to medical examiner reports, and none of these victims had a C-spine injury.

Collected information included the victim's age, gender, submersion details (site of submersion, activity before submersion injury), associated injuries, and whether the victim survived. For those submersion victims who received medical care, information regarding physical signs at different levels of medical care (emergency medical services, emergency department, hospital admission), laboratory values, and therapy were recorded.

Specific locations of submersion were further categorized as open water (large bodies of water such as rivers, lakes, streams, and ocean) and nonopen water (man-made, smaller bodies of water such as pools, bathtubs, hot tubs, buckets, and toilets). Specific presubmersion activities were assigned to one of three categories, on the basis of our hypotheses that C-spine injury would be more likely in high-impact submersions and that submersions that generally do not involve a large transfer of energy to the victim would not be associated with C-spine injury. Submersions related to diving, water skiing, surfing, assault, and motorized vehicles (boats, personal watercraft [Jet Skis], automobiles, planes) were categorized as "high risk." Submersions related to swimming, bathing, wading, fishing, soaking in a hot tub, and scuba diving were categorized as "low risk." A third category of activity was "not in water, NOS" (not otherwise specified). These victims were not in the water before submersion, but specific details about their activity that would have permitted more specific classification (as high or low risk) were not available.

Data were missing for some variables. For the submersion victims receiving medical care, the largest proportions of missing data were for the variables related to Glasgow Coma Scale (GCS) score (23% missing) and mental status (20% missing) obtained by emergency medical services at the site of submersion. The proportion of missing data for other variables was never greater than 11%.

Means of continuous variables were compared using *t* tests, and proportions were compared using Fisher's exact test. We also computed relative risks with 95% confidence limits. All *p* values are two-tailed. We used Stata statistical software (Stata Corp., College Station, TX) for the analyses.[23]

RESULTS

A total of 2,244 submersion victims were identified. Thirty-four percent of the victims survived until discharge from medical care; 66% died. Seventy-four percent of all victims were male. The mean age was 25 years (median, 21 years). Nearly 35% of the victims were younger than 13 years, 21% were 13 to 24 years old, and 45% were older than 24 years. The most common sites of submersion were lakes or ponds (31%) and swimming pools (18%). Nearly two thirds (65%) of the victims were submerged in open bodies of water. The most common presubmersion activities were swimming (19%), boating (13%), and bathing (12%). A total of 43% of victims were engaged in low-risk activities before submersion; 21% were engaged in high-risk activities. Seven patients were released to home after being seen by emergency medical services, and 117 were discharged home from the emergency department. None of these patients was readmitted for serious injury. Forty-two percent of the victims died before receiving any medical care. Hospitalization occurred in 37% of the victims.

The prevalence of C-spine injury among submersion victims was 0.49% (11 of 2,244) among all victims, 0.38% (5 of 1,304) among victims who received some type of medical care, and 0.64% (6 of 940) among victims who died without receiving medical care. No C-spine injuries occurred in 880 low-impact submersions (95% confidence interval [CI], 0-0.4%). All C-spine injuries were fractures of the cervical spine (Table 1). Four out of the five victims with C-spine injury who received medical care were injured while diving, and one was a passenger in a private plane that crashed into the water. These five victims all had evidence of serious injury. One died at the scene, one died in the emergency department, and the remaining three who survived to emergency department discharge were all endotracheally intubated. Only one of the victims with C-spine injury survived to hospital discharge.

All six victims with C-spine injury who died before receiving medical care had multiple blunt traumatic injuries. Three (50%) with C-spine injury were ruled suicides after having jumped from a high bridge. Two (33%) with C-spine injury fell over waterfalls, and one (17%) was in a motor vehicle crash.

To identify risk factors for C-spine injury that would be relevant to medical personnel, we focused the rest of our analysis on the 1,304 submersion victims who received medical care (Table 2). All five submersion events involving victims with C-spine injury were witnessed by friends or bystanders. The mean age of those with C-spine injury was 25 years (range, 15–42 years). None of the submersion victims with a C-spine injury was younger than 13 years old,

Table 1 Characteristics of Submersion Victims with C-Spine Injury Who Were Submerged in or Received Medical Care in King, Pierce, or Snohomish County, Washington

Victim Number	Age (y)	Sex	Fracture Level(s)	Activity	Body of Water	Population Density	Mental Status EMS	Level of Care	Outcome
1	15	M	C5	Diving	Pond	Rural	Lethargic	Hospitalized	Alive
2	22	M	C6	Diving	Lake	Rural	Comatose	EMS	Dead
3	23	M	C1,2,6,7	Diving	Lake	Rural	Comatose	ED	Dead
4	24	M	C3–5	Diving	River	Rural	Comatose	Hospitalized	Dead
5	42	F	C5,6	Plane crash	Ocean	Rural	Comatose	Hospitalized	Dead
6	15	M	C7	Fall	Waterfall	Rural	NA	None	Dead
7	23	M	C7	Fall	Waterfall	Rural	NA	None	Dead
8	25	M	C1,2	Jump from high bridge	Lake	Urban	NA	None	Dead
9	28	M	C7	Jump from high bridge	Lake	Urban	NA	None	Dead
10	30	M	C4,5	Jump from high bridge	Puget Sound	Urban	NA	None	Dead
11	40	M	C2,5	Driver of car	Puget Sound	Urban	NA	None	Dead

EMS, emergency medical services; ED, emergency department; NA, not applicable.

Table 2 Comparison of Submersion Victims with C-Spine Injury (n = 5) and without C-Spine Injury (n = 1,299) Who Received Medical Care and Were Submerged in, or Received Medical Care in, King, Pierce, or Snohomish County, Washington

Characteristic	C-Spine Injury		No C-Spine Injury		*p* Value[a]
	No.	%	No.	%	
Age (y)					
≤12	0	0	716	55	
13–24	4	80	205	16	0.001
≥25	1	20	378	29	
Gender					
Male	4	80	914	70	1.0
Female	1	20	385	30	
Population density					
Rural	5	100	486	42	0.02
Urban	0	0	677	58	
Body of water					
Open water	5	100	632	50	0.06
Nonopen water	0	0	626	50	
Lake or pond	3	60	355	28	0.1
Swimming pool	0	0	387	31	0.3
Bathtub	0	0	153	12	1.0
Risk groups					
High risk	5	100	187	15	
Low risk	0	0	575	47	<0.001
Not in water, NOS	0	0	455	37	
Activity					
Diving	4	80	17	1	<0.001
Swimming	0	0	284	23	0.6
Bathing	0	0	141	12	1.0
Clinical characteristics					
Alert at scene	0	0	324	35	0.2
GCS score > 8 at scene	0	0	411	46	0.07
GCS score > 8 in ED	0	0	523	61	0.06
Discharged from ED without having been intubated	0	0	508	52	0.05

NOS, not otherwise specified; GCS, Glasgow Coma Scale; ED, emergency department.
[a] *p* value for a test that the proportions were the same between those with and those without C-spine injury.

whereas 716 (55%) patients without C-spine injury were younger than 13 ($p = 0.02$).

C-spine injury was significantly associated with presubmersion activity. The relative risk for C-spine injury in diving accidents was 229 compared with all other presubmersion activities (95% CI, 27-1,961). None of the 284 (95% CI, 0-1.3%) submersion victims who were swimming, or any of the 141 (95% CI, 0-2.6%) victims who were bathing, had a C-spine injury. The proportion of submersion victims with C-spine injury differed by activity group ($p < 0.001$); all five fractures occurred in those engaged in high-risk activities.

C-spine injury was also associated with location of submersion. All C-spine injured victims were submerged in rural bodies of water ($p = 0.017$), and all were in open bodies of water ($p = 0.06$). There were no C-spine injuries in the 387 (95% CI, 0-0.9%) swimming pool submersions, or in 153 (95% CI, 0-1.4%) bathtub submersions.

None of the victims with C-spine injury was alert at the scene, whereas 35% of the victims without C-spine injury were alert at the scene ($p = 0.17$). All of the C-spine injured victims had a GCS score ≤ 8 at the scene, compared with 54% of the victims without C-spine injury ($p = 0.07$). Of the four who survived resuscitation at the scene, three had a GCS recorded in the emergency department (the one who did not was pharmacologically paralyzed). The mean GCS score of these C-spine injured victims was 3.0, and the mean GCS score of the victims without C-spine injury was 10.3 ($p < 0.001$). None of the C-spine injured victims had a GCS score of 15 in an emergency department, whereas 55% of those without C-spine injury had a GCS score of 15 ($p = 0.09$).

Groups of patients at very low risk of C-spine injury could be identified on the basis of historical and clinical criteria. There were no C-spine injuries identified in 860 victims who were either engaged in a low-risk presubmersion activity or who were alert in the emergency department (Table 3). Furthermore, of 1,109 victims who were either alert in the emergency department or were not engaged in a high-risk presubmersion activity, none had a C-spine injury.

Table 3 **Subgroups of Submersion Victims Who Received Medical Care and in Whom No C-Spine Injuries Were Present**

Group without C-Spine Injury	No.	95% CI (%)
Either bathing activity or tub site of submersion	0/157	0–2.3
Either swimming activity or swimming pool site of submersion	0/521	0–0.7
Either low risk or alert at scene	0/763	0–0.5
Either low risk or GCS score > 8 at scene	0/806	0–0.5
Either low risk or alert in ED	0/860	0–0.4
Either low risk or GCS score > 8 in ED	0/873	0–0.4
Either low risk or not intubated (at scene or in ED)	0/866	0–0.4
Either not high risk or alert in ED	0/1109	0–0.3

CI, confidence interval; GCS, Glasgow Coma Scale; ED, emergency department; low risk, swimming, bathing, wading, fishing, soaking in a hot tub, or scuba diving; high risk, diving, water skiing, surfing, assault, or involving motorized vehicles (boats, Jet Skis, automobiles, planes).

DISCUSSION

The prevalence of C-spine injury in submersion victims was low (0.49%) in our study population. Characteristics of all C-spine injured victims included high-impact submersions, submersion in open bodies of water, and submersion resulting in severe injury (death at the scene or unresponsiveness on arrival in the emergency department). The C-spine injured victims who died before receiving medical care had higher impact mechanisms of injury and were more severely injured than victims who survived long enough to receive medical care.

Our data were not originally collected to study C-spine injuries, so it is possible that some cases of C-spine injury were missed. However, by using multiple sources of information for each submersion victim (hospital records, computerized files from the state of Washington, emergency medical services records, and medical examiner reports), we sought to minimize the chance that an identified major injury, such as C-spine injury, would not be captured in the data.

We do not have information regarding evaluation of the C-spine in the submersion victims. Patients who had a history of high-impact submersion probably received a different evaluation of the C-spine than patients who did not. This difference in evaluation may mean that there was a greater chance of missed injury in patients with a history that was not thought likely to cause C-spine injury; however, no patients were readmitted with a serious injury.

Our results are consistent with those of other authors who have reported that C-spine injury is usually related to a history of high-impact injuries.[1–7,24] In a series of 52 water-related C-spine injuries occurring over 8 years in Australia, all occurred during diving, water skiing, or surfing.[7] All of the C-spine injuries described by Williams and colleagues for which a history was available were related either to motor vehicle crashes, falls, diving, or horseback riding.[24] Over 80% of the 1,505 cervical spinal cord injuries reported from the Major Trauma Outcome Study were related to motor vehicle crashes, assaults, or falls.[2]

None of the five C-spine injured victims in this study who received medical care had a normal physical examination. Other authors have also found clinical examination to be useful in identifying the presence of C-spine injury. Hoffman and others recently reported that alert, nonintoxicated patients without other painful injuries who had no neurologic deficits and no midline cervical tenderness were extremely unlikely to have a clinically significant C-spine injury.[1] These results were consistent with prior studies.[25,26] All 59 pediatric patients with C-spine injury reported by Jaffe and others had either a history of head or neck trauma, a complaint of neck pain, an abnormal neck examination, or an abnormal neurologic examination.[27] In contrast, Jacobs and Schwartz evaluated 233 patients with head and neck trauma and concluded that 5 of 24 C-spine injuries would have been missed if clinical examination and mechanism of injury were used as criteria to exclude the possibility of C-spine injury.[28]

We found no C-spine injuries in submersion victims younger than 15 years. McGrory and others reported few spinal injuries in young patients.[29] Kewalramani and others reported no diving-related C-spine injuries in patients younger than 15 years old.[30] Although anatomic differences between adults and children have been used to explain the variation in C-spine injuries between adults and children,[6,31] the results of this study suggest that this absence of C-spine injury in victims younger than 15 years old in this study may be at least partially explained by a dearth of high-risk submersions in those young victims. Only 51 (7%) of those younger than 15 years were engaged in high-risk activities, whereas 383 (31%) of those age 15 years or older were engaged in high-risk activities during the study period ($p < 0.001$).

In our series of 2,244 submersion victims, C-spine injury occurred only in victims who sustained traumatic injury either before or during their submersion episode. Submersion victims without a history of high-impact submersion or without physical signs of severe injury (altered mental status, need for intubation before emergency department discharge, or death before emergency department discharge) did not have C-spine injuries. Like any other patient, a submersion victim is at risk for C-spine injury only if he or she has also sustained a traumatic injury. Routine C-spine immobilization does not appear to be warranted solely on the basis of a history of submersion.

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