Halo-Vest Immobilization Increases Early Morbidity and Mortality in Elderly Odontoid Fractures

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Background: Odontoid fractures are the most common cervical spine fractures in elderly patients. Treatment options included operative fixation (OP) or nonoperative management with either a halo-vest (HV) or rigid cervical orthosis (CO). Our previous study suggested increased morbidity and mortality with the use of HV in the treatment of elderly patients with cervical spine fractures. We review a series of odontoid fractures in elderly patients and evaluate for predictors for in-hospital morbidity and mortality.

Methods: There were 78 patients >65 years of age who sustained a type II or III odontoid fracture from January 1997 to June 2004 identified from the Rhode Island Hospital Trauma registry. Demographic, mechanism, injury pattern, treatment, and outcome data were recorded. Patients were analyzed according to treatment method.

Results: The mean age was 80.7 ± 0.9 years. There were 50 type II, 17 type III, and 11 combined fractures. There were 38 (49%) patients treated with HV: 34 with halo alone, and 4 after OP; 40 (51%) patients were treated without HV: 27 with CO, and 13 with OP. There was no difference in injury severity or baseline medical condition between HV and non-HV patients. There were 24 (31%) patients who died during their hospital stay. Of the HV patients, 42% died compared with 20% in the non-HV group ($p = 0.03$). Major complications occurred in 66% of HV patients compared with 36% of non-HV patients ($p = 0.003$).

Conclusion: Odontoid fractures are associated with significant morbidity and mortality in elderly patients. Outcomes after treatment with HV appear inferior to those achieved with CO or OP.

J Trauma. 2006;60:199–203.

Odontoid fractures account for 10 to 15% of all cervical spine fractures.[1] Upper cervical spine injuries (C1 and C2) are extremely common in the elderly, accounting for greater than 50% of all cervical spine fractures in that population.[2–5] In patients over 70 years old, odontoid fractures are the most common cervical spine fracture.[4] The primary treatment options in these patients are halo-vest immobilization (HV), rigid cervical orthosis (CO), and internal fixation (OP).[6–8] The choice of treatment method is largely based upon the type of injury but is also influenced by medical co-morbidities, healing potential, and anticipated tolerance of a HV or surgical insult. Published series of odontoid fractures in elderly patients report early mortality rates as high as 25 to 40%.[5,6,9,10] It has been suggested that mortality rates are related to fracture management. Unfortunately, the small numbers of patients and wide variability of outcomes make it difficult to draw reliable conclusions regarding the optimal management strategy.

We recently reported our experience with cervical spine fractures in all patients, and compared outcomes in elderly (>65 years old) versus younger patients.[11] We found that elderly patients managed with HV had a 21% mortality rate. In this study, we hypothesized that a subgroup of elderly patients with odontoid fractures who are treated with HV would have worse outcomes than those treated with CO or OP. Further, we hoped to determine factors associated with in-hospital morbidity and mortality in this challenging patient group.

PATIENTS AND METHODS

The Rhode Island Hospital Trauma Registry (NTRACS) has been prospectively maintained since 1991, and contains comprehensive data on all trauma patients admitted to the hospital. We queried our trauma registry searching for patients older than 65 years of age suffering a type II or III odontoid fracture from January 1997 to June 2004. Patients presenting to the emergency department (ED) with a Glasgow Coma Score (GCS) of 3, as well as those that died within 48 hours of admission are excluded from the study.

Data extracted from the database on this group of patients included age, mechanism of injury, injury pattern, GCS on presentation, systolic blood pressure (SBP) on presentation, Injury Severity Score (ISS), disposition from the ED (intensive care unit, surgical floor, operating room), length of stay in the hospital, treatment modality of the odontoid fracture (HV, CO, OP, or some combination), medical comor-

Submitted for publication June 24, 2005.
Accepted for publication November 2, 2005.

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Presented at the 35th Annual Meeting of the Western Trauma Association, March 2005, Jackson Hole, Wyoming.
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DOI: 10.1097/01.ta.0000197426.72261.17

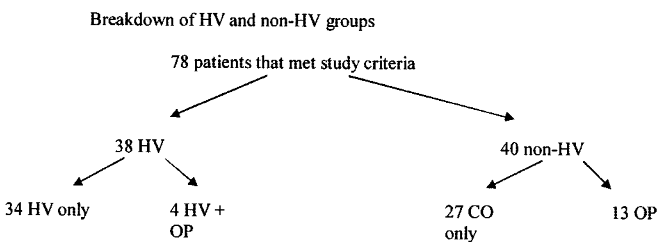

Fig. 1. *Breakdown of HV and non-HV groups.*

bidities, other injuries sustained at the time of odontoid fracture, complications, presence of paralysis, and hospital disposition. Individual patient charts and radiograph reports were reviewed to confirm correct diagnosis of specific fracture types.

Patients were divided into two groups: those treated with HV, and those not treated with HV. Patients who had surgery and then remained in a HV postoperatively were placed in the HV group. Those who were treated with surgery or a hard collar only were placed in the non-HV group.

Statistical analysis was performed on a personal computer utilizing Statistica version 5 (1997, Tulsa, OK) software. Data are presented as mean ± SEM. Unpaired Students' *t* test was used to compare continuous variables. Discrete variables were compared using the χ^2 test. A *p* value of less than 0.05 was considered significant

RESULTS

During the 90 month study period, there were 78 patients who met study criteria. The mean age was 80.7 ± 0.9 years. The mechanism of injury included 56 falls, 21 motor vehicle crashes, and 1 pedestrian struck. There were a total of 60 type II and 18 type III odontoid fractures. Nine of the type II fractures were combined with a C1 ring injury and one was combined with a C5 compression fracture. One type III fracture was combined with a C1 fracture.

The mean GCS and SBP upon presentation to the emergency room were 14.0 ± 0.3, 153 ± 3, respectively. The mean ISS was 13.7 ± 1.1. Disposition from the ED included 44 floor admissions, 32 intensive care unit admissions, and 2 patients who were taken directly to the operating room; 1 for a craniotomy and 1 for a laparotomy. The average length of stay in the hospital was 12 ± 19 days.

Overall, there were 38 (49%) patients in the HV group, and 40 (51%) patients in the non-HV group (Fig. 1). Of the non-HV group, 13 patients were treated with OP and 27 patients were treated with only a CO. Twenty-four of 78 patients died in the hospital resulting in an overall death rate of 31%. Of the patients who survived to discharge, 16 went home, 19 went to a skilled nursing facility, and 19 went to an acute-care rehabilitation unit.

The average number of major co-morbidities was 2.1 ± 0.9 per patient. There were 25 patients who suffered a total of 40 other injuries. The most common associated injuries included intracranial hemorrhages (9 patients), rib fractures (7 patients) facial fractures (5 patients), and femur fractures (4 patients).

Two patients (3%) had a neurologic injury resulting in tetraplegia. The first patient was a 68 year old male pedestrian struck by a motor vehicle who arrived in the ED with a GCS of 6 and was subsequently taken to the ICU. The patient had a type II odontoid fracture along with cord edema at the C5 level noted on MRI. The patient was successfully treated with HV and at discharge was sent to a rehabilitation center. The second patient was an 86 year old male who fell sustaining a type II odontoid fracture. The patient had no other injuries and was placed in HV for treatment but died of cardiac arrest before discharge from the hospital.

In comparing patients in the HV treatment group versus the non-HV treatment group, the non-HV group was slightly older (83 versus 79 years; $p = 0.02$). There was no difference between the groups with regard to ISS, GCS, SBP, number of comorbidities, or the presence of another injury (Table 1). Despite being younger and similarly injured, however, the mortality of the HV group was 42% (16 of 38 patients). This was significantly higher than in the non-HV group, where the mortality rate was 20% (8 of 40 patients) ($p = 0.03$).

Survivors are compared with nonsurvivors within the HV and non-HV groups in Tables 2 and 3, respectively. Among the HV patients, nonsurvivors were older, but otherwise shared similar injury severity and medical comorbidities with survivors (Table 2). In contrast, the non-HV patients who died were clearly more severely injured than the survivors, with significantly higher ISS and lower GCS (Table 3).

We next compared patients who were treated with either OP or CO only for survival with patients treated with HV

Table 1 Comparison of HV vs. non-HV Groups

	HV	Non-HV	*p* value (*significant)
Age (years)	78.8 ± 7.4	82.6 ± 1.0	0.02*
ISS	14.4 ± 10.3	13.1 ± 9.4	0.55
GCS	14.0 ± 2.2	13.9 ± 2.3	0.80
SBP	162 ± 24	157 ± 28	0.38
No. of comorbidities	2.1 ± 0.82	2.1 ± 0.95	0.73
Isolated injury	26 (68%)	29 (74%)	0.37
Deaths	16 (42%)	8 (20%)	0.03*

ISS, Injury severity score; GCS, Glasgow Coma Score; SBP, first systolic blood pressure on presentation.

Table 2 HV Survivors vs. Nonsurvivors

	Live (n = 22)	Die (n = 16)	*p* value (*significant)
Age (years)	76.1 ± 5.4	82.3 ± 8.0	0.007*
ISS	12.7 ± 8.0	16.8 ± 12.7	0.23
GCS	14.3 ± 2.0	13.7 ± 2.5	0.43
SBP	163 ± 21	161 ± 29	0.84
No. of comorbidities	2.0 ± 0.7	2.2 ± 0.9	0.47

ISS, Injury severity score; GCS, Glasgow Coma Score; SBP, first systolic blood pressure on presentation.

only. In the OP subgroup, the 4 patients who were treated with OP + HV were excluded from analysis. Of the 13 patients treated with OP, none died. This 0% mortality rate is significantly better than the HV group ($p = 0.03$). In the CO only group, 7 (26%) patients died. This is lower than in the HV group, although it did not reach statistical significance ($p = 0.11$).

Overall, there were 46 major complications reported in 40 patients (Table 4). The most frequent included pneumonia (16), cardiac arrest (12), urinary tract infections (6), and thromboembolic complications (3). When we looked at morbidity between the two groups, we found that 25 (66%) of the HV patients had at least one major complication compared with only 15 (36%) of non-HV patients ($p = 0.01$).

There were 16 patients who developed pneumonia. There were 13 (81%) in the HV group, significantly higher than the three in the non-HV group ($p = 0.003$). Of the 13 HV patients who contracted pneumonia, 10 died. There were 10 on the ventilator for at least 7 days, but only 3 underwent tracheostomy; 4 of the 13 pneumonias were thought to be secondary to aspiration. One was in a patient with a tracheostomy, while the other three were in patients off mechanical ventilation who were taking an oral diet. None of these patients had a formal swallowing evaluation before beginning a diet.

There were 12 patients who had a cardiac arrest, all of which eventually resulted in death. Of these, 10 were in HV patients, higher than in non-HV patients ($p = 0.01$); 6 of the HV patients who suffered cardiac arrest were on the surgical floor, and four of were in the ICU. Of note, three of the cardiac arrests occurred either during HV placement, or within 4 hours of placement, all in nonintubated patients on the surgical ward.

DISCUSSION

Cervical spine fractures have been shown to have a significant association with increased morbidity and mortality in patients older than 65 years of age.[12] HV treatment for upper cervical spine fracture is an alternative to operative stabilization. Choosing one method of treatment over another to manage these injuries may influence the rate of major complications and death. The decision to use operative versus nonoperative stabilization, however, varies considerably between spine surgeons, often within the same institution.

Several studies have reviewed mortality rates in elderly patients with odontoid fractures.[5,6,10,13–16] Hanigan et al.[6] reported on 19 patients older than 80 years old with odontoid fractures treated nonoperatively and found a mortality rate of 30% within the first 3 weeks postinjury but attributed this high rate to prolonged immobility, not the use of HV. Anders-

Table 3 Non-HV Survivors vs. Nonsurvivors

	Live (n = 32)	Die (n = 8)	*p* value (*significant)
Age (years)	82.3 ± 7.2	84 ± 8.6	0.56
ISS	10.4 ± 6.8	23.9 ± 10.8	<0.001*
GCS	14.5 ± 1.1	11.4 ± 4.0	0.002*
SBP	157 ± 27	154 ± 33	0.75
No. of comorbidities	2.1 ± 0.9	2.5 ± 1.1	0.29

ISS, Injury severity score; GCS, Glasgow Coma Score; SBP, first systolic blood pressure on presentation.

Table 4 Complication Rates for HV vs. Non-HV

	HV n = 38	Non-HV n = 40	*p* value
Pneumonia	13 (34%)	3 (8%)	0.003*
Cardiac arrest	10 (26%)	2 (5%)	0.01*
DVT/PE	2 (5%)	1 (3%)	0.48
UTI	3 (8%)	3 (8%)	0.63
Overall	25 (66%)	15 (38%)	0.01*

DVT, deep venous thrombosis; PE, pulmonary embolus; UTI, urinary tract infection.

son et al.[13] reported on 29 patients with odontoid fractures treated with anterior screw fixation (11), posterior fusion (7), hard collar (10), HV (1), and reported no deaths in the first 5 weeks postinjury. Muller et al.[10] evaluated 23 patients older than 70 years old with odontoid fractures treated with anterior screw fixation (5), hard collar (15), HV (3), and found a 40, 13, and 33% mortality rate in the immediate postinjury period for each group, respectively. Weller et al.[5] evaluated 10 patients older than 70 years old with odontoid fractures treated with HV and posterior fusion (2), HV alone (5), rigid collar (2), rigid collar and posterior fusion (1), and found a 40% early mortality rate (<5 weeks) in the HV alone group. Berlemann et al.[14] reported on 19 patients over 65 years old treated with anterior screw fixation for odontoid fractures and reported no deaths in the immediate postinjury time period. Campanelli et al.[16] reported on seven patients older than 63 years old with displaced type II odontoid fractures treated with posterior C1-C2 transarticular screws and found a 14% early mortality rate. Borm[15] et al. reported on 15 patients older than 70 years old with type II odontoid fractures treated with anterior screw fixation and reported 7% mortality in the immediate postinjury period. Most recently, Taitsman and Hecht[8] report a series of 75 patients treated nonoperatively over 10 years, and found an 11% mortality rate. This data has been presented at a national meeting, but the manuscript has yet to be published.

Obviously, early mortality is a significant risk in the elderly patient with an odontoid fracture. Unfortunately, because of the small patient numbers in each series and extremely variable results, it is difficult to make inferences regarding the effect of treatment (i.e. operative fixation versus HV versus hard collar) on early mortality in this patient population. Pepin et al. have suggested that "... the use of the halo vest in the elderly patient... requires extreme caution and demands close daily supervision," which corresponds with our experience.[3]

Previous authors have reported complication rates in over 50% of elderly patients with odontoid fractures.[10] This is certainly in keeping with our overall complication rate of 51%. The potential for major complications, either directly related to the method of fixation or systemic medical issues, is clearly significant, regardless of whether the fracture is stabilized with operative fixation (anterior or posterior surgery), rigid collar or HVI.

Complications relating directly to the HV itself are well documented and include pin site loosening, pin site infection, and pressure sores under the vest.[17] Also, HV usage has been demonstrated to significantly limit respiratory function (i.e. vital capacity).[18]

Cardiopulmonary complications, specifically pneumonia and cardiac arrest, are frequently cited complications and causes of death in this patient population independent of treatment method.[5,10,15] Our study clearly demonstrates that both are significantly increased when a patient is managed with HV. We found a 34% rate of pneumonia in patients in HV. This figure is similar to the previously reported 23% incidence of pneumonias in elderly (>65 years old) patients treated with HV for upper cervical spine fractures.[9] In this retrospective review, we found four documented cases of aspiration pneumonia, although we surmise that this number may be higher. Since performing this study, we have begun to routinely evaluate swallowing mechanisms in our elderly odontoid fracture patients before initiating an oral diet.

Most striking, perhaps, is the 26% incidence of cardiac arrest in our HV patients, versus 5% in the non-HV patients. No authors who have studied elderly patients with cervical spine fractures have commented specifically on this phenomenon.[3,5,6,13] As previously noted, however, all of these studies are much smaller than ours, with 10 to 19 total patients in each study. It is not completely clear why the rate of cardiac arrest was so high, and unfortunately, we do not have autopsy data to document exact causes of death. Previous reports have described retropharyngeal swelling leading to acute respiratory failure after posteriorly displaced odontoid fractures were reduced with cervical traction.[19-21] One should note that none of these studies look specifically at patients placed in HV. Our finding that the majority of the cardiac arrests happened on the general floor, as opposed to the ICU is worrisome. It has made us question whether all elderly patients in haloes should be placed in a more monitored setting, such as a stepdown unit or ICU.

Significant variability exists in the literature regarding early mortality rates in patients treated with and without HV immobilization. Reported mortality rates in elderly patients treated with odontoid fractures treated surgically and/or with HV immobilization range from 0 to 40%.[5,10,13] Ours is the only study to separate mortality rates of elderly patients treated in HV versus those who were not. Clearly there is a significantly higher risk of death among those treated in a HV in our patient population. We found this despite the fact that our HV and non-HV groups had similar ISS and GCS scores, as well as number of pre-existing co-morbidities. The one major difference between our groups was that the non-HV patients were about 4 years older than the HV patients. Despite having an average age of almost 83 years, however, the non-HV group still had less major complications and lower mortality than its HV counterparts.

When we evaluated the HV group, and compared those who lived to those who died, we again found little difference in injury severity, neurologic state at presentation, or number of medical co-morbidities. Thus, we infer that the presence of the HV itself had some part in contributing to death. In the non-HV group, the individuals who died had significantly higher ISS scores and lower GCS scores and were thus presumed to be more severely injured than those who lived. The reason for this may be that these severely injured patients were presumed to have a limited chance for survival. Thus, their odontoid fractures were likely placed in a rigid collar for some protection with the knowledge that any definitive treatment would be futile.

CONCLUSION

This study demonstrates that elderly patients with odontoid fractures who are treated with HV have higher rates of pneumonia, cardiac arrest, and death than those who are not treated in a HV. Given these increased risks, significant consideration must be made for alternative stabilization methods in this patient group. We recognize two major limitations of this study. First is its retrospective nature. Second is the small total number of subjects, which limits the power of the study. We acknowledge that we did not review post-treatment radiographs to document which treatment modalities provided better healing results, however, that was not the purpose of this study. Nevertheless, this is the largest known series of odontoid fractures in elderly patients in the literature. Further research is required through a prospective, randomized trial to evaluate the influence of HV immobilization on early morbidity and mortality in the elderly patient population.

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