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Original Article

Airway risk associated with patients in halo fixation

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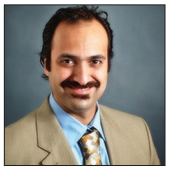

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ABSTRACT

Background: The halo fixation device introduces a significant obstacle for clinicians attempting to secure a definitive airway in trauma patients with cervical spine injuries. The authors sought to determine the airway-related mortality rate of adult trauma patients in halo fixation requiring endotracheal intubation.

Methods: This study was a retrospective chart review of patients identified between 2007 and 2012. Only adult trauma patients who were intubated while in halo fixation were included in the study.

Results: A total of 46 patients underwent 60 intubations while in halo. On five occasions, (8.3%) patients were unable to be intubated and required an emergent surgical airway. Two (4.4%) of the patients out of our study population died specifically due to airway complications. Elective intubations had a failure rate of 5.8% but had no related permanent morbidity or mortality. In contrast to that, 25% of non-elective intubations failed and resulted in the deaths of two patients. The association between mortality and non-elective intubations was statistically highly significant ($P = 0.0003$).

Conclusion: The failed intubation and airway-related mortality rates of patients in halo fixation were substantial in this study. This finding suggests that the halo device itself may present a major obstacle in airway management. Therefore, heightened vigilance is appropriate for intubations of patients in halo fixation.

Keywords: Halo Fixation, Airway Management, Tracheostomy, Loss of Airway Mortality, Cervical Injury, Trauma Intubation, Emergent Intubation

INTRODUCTION

The halo fixation device introduced by Nickel *et al.* in 1959 initially provided a novel approach to cervical spine stabilization in patients suffering from poliomyelitis, and shortly after that, it was also used to treat traumatic cervical spine injuries.[17,31,32,44] Today, orthosis is used primarily to immobilize unstable, traumatic cervical spine injuries.[8,10,18,23,35,39,43,49] Despite numerous modifications over time, the vest contains the same fundamental components as the original design, including a ring fixated to the skull and attached to immobile metal struts. While the rigidity of the structure is what provides critical support to the spine, it also introduces unique complications and obstacles in patient care.[13-15,21,33,48] One of the most daunting challenges faced by clinicians caring for these patients is airway management after halo fixation.[40]

Endotracheal intubation in patients with traumatic cervical spine injuries is particularly challenging due to simultaneous in-line stabilization, which prohibits the neck extension necessary to obtain an optimal tracheal view.[1,2,11,12,20,24,26,30,37,41,50,51] This physical restriction is one of the main contributing factors to the failure of trauma intubations.[22,29,34] Patients with halo fixation for these injuries introduce additional technical complexity due to the inflexible hardware positioned directly in the operator's field of view.[40] Furthermore, while emergent cricothyroidotomy and tracheostomy fail to obtain airway access in <1% of cases, this procedure also becomes more difficult, with multiple metal struts obstructing the surgical field. With these challenges inherent to all haloed patients, one would expect that the failed intubation and mortality rates associated with patients with halo fixation would be significantly greater than those of patients without haloes.[19] There are no studies that have explicitly compared the mortality of haloed patients requiring endotracheal intubation to those without halo fixation.

The purpose of this study was to determine the airway-related morbidity and mortality rate of adult trauma patients in halo fixation undergoing emergent and non-emergent endotracheal intubation.

MATERIALS AND METHODS

This study was a retrospective chart review at a single, urban, level 1 trauma center between 2007 and 2012. One hundred and thirty-six consecutive patients that required halo fixation provided by the senior author (IFE) were identified. All patients were placed in the same model of halo (Össur Americas, Foothill Ranch, CA; Hanger Orthotics, Tempe, AZ). Patients under the age of 18 years and those with atraumatic spinal pathology were excluded from the study. In addition, haloed patients who never required intubation while in halo were excluded from the study. Emergent intubation was deemed an unanticipated need for definitive airway control, while non-emergent intubations, such as intra-operative intubation, were planned. To specifically examine the mechanical challenges associated with intubating a haloed patient, only those who were intubated while in halo fixation were included in the study. Time to follow-up was defined as the number of days until removal of halo, death, or till lost to follow-up before halo removal. Failed intubation was defined as the immediate and unexpected need for a surgically established airway at the time of intubation and/or death or anoxic brain damage resulting from hypoxia immediately associated with complicated intubation. Failed intubation and overall mortality rates were calculated based on the final number of patients and number of intubations while in halo.

The Chi-square test for comparison of two proportions from independent samples was applied. $P = 0.05$ or less was considered statistically significant. $P < 0.001$ was considered statistically highly significant [Figure 1].

RESULTS

Based on our methods, the study population comprised 46 patients [Figure 1]. These adult trauma patients included in the analysis were comprised of o30 men (65%) and 16 women (35%) ranging from ages 20 to 79 years [Table 1]. The follow-up time was calculated as the number of days until the patient's halo was removed, the patient passed away or was lost to further follow-up while still in the halo, and the follow-up time ranged from 2 to 122 days (median of 90 days). Forty-six patients underwent a total of 60 intubations. Fifty-two of these intubations were conducted electively in the operating room (OR) by the anesthesia team. Advanced intubation techniques, including indirect vocal cord visualization, awake intubation, and laryngeal mask-assisted intubation, were routinely applied based on the preference of the individual managing the anesthesia team. Of these, three patients (5.8%) failed and required an immediate definitive surgical airway, which was established successfully without added morbidity or mortality.

In contrast, eight intubations had to be done urgently or emergently. These were done mainly in the intensive care

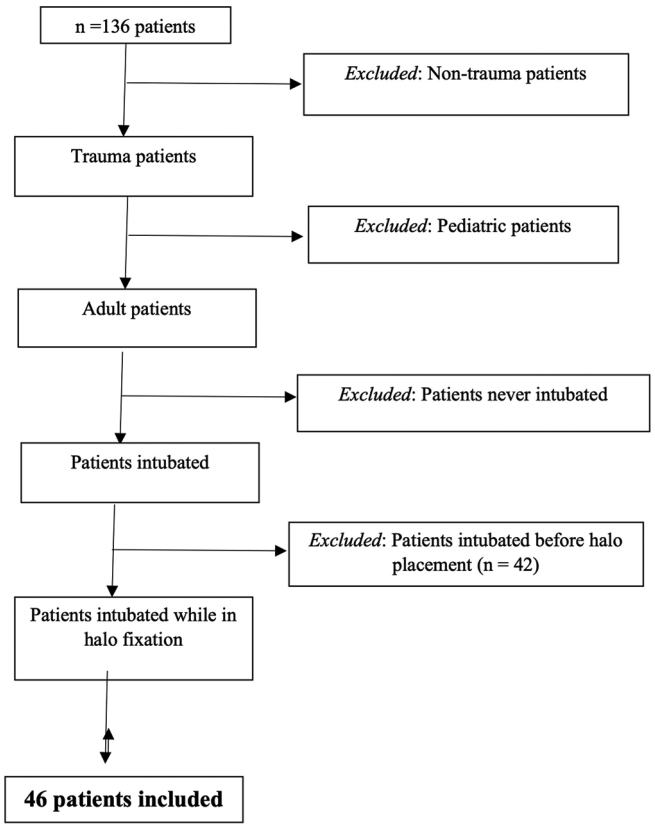

Figure 1: Patient selection criteria.

unit (ICU) in six instances. In one instance, non-elective intubation was done in the emergency department (ED) or OR. These intubations also applied the above mentioned techniques but on a non-elective basis. In these instances, personnel of the ED or ICU joined along with the anesthesia team to provide intubations. Under these circumstances, two intubations failed and required the placement of a definitive surgical airway. However, in both instances, the patient ultimately died secondary to hypoxia from the failure of timely establishment of functional airway and ventilation. Therefore, the mortality rate associated with non-elective intubations was 25%. Although there was a trend between airway failure and non-elective intubations, it did not reach statistical significance (P = 0.07). However, the mortality associated with failed non-elective intubation was statistically highly significant (P = 0.0003).

Calculated based on the number of intubations (n = 60), the airway failure rate was 8.3%, with an associated mortality rate of 3.3% [Table 2].

Analyzing based on the study population (n = 46), five patients (10.9%) required an emergent surgical airway, of which two (4.4%) died specifically due to the inability to establish an airway sufficiently [Table 3].

The presence of spinal cord injury (SCI) was noted in one patient out of five with failed intubations (20%) and in 6 patients (14.1%) out of 41 patients with successful intubations. Alternatively, 1 (14.3%) of seven patients with SCI suffered airway failure and death while being intubated in the halo. This contrasts with four patients (10.3%) out of 39 without SCI who suffered from airway failure while intubated in the halo. Of these, one patient (2.6%) died from this complication.

Table 1: Demographic information.

Category	*n* (%)
Sex	
Male	30 (65)
Female	16 (35)
Age in years	20–79, Median=39.5, mean 43
Time in days to follow up (halo removal)	2–122, Median=90, mean 83

Table 2: Airway-related outcome.

Outcome	Total intubations (n=60)	Percentage
Failed intubation	5/60	8.3
Deaths	2/60	3.3

DISCUSSION

Intubating trauma patients with potential cervical spine injuries is challenging, but obtaining a definitive airway in haloed patients is an even more formidable task. In a recent study by Lockey *et al.* involving more than 7000 trauma patients, investigators found that only 0.7% of intubations failed.[22] These intubations were overwhelmingly successful despite in-line stabilization being applied to each patient. Moreover, although these intubations failed, all subsequent surgical airways were successful, with no deaths due to the inability to establish an airway.[22] Moreover, in studies with additional complicating factors, such as resident-performed intubations or uniformly emergent settings, <1% of patients had airway-associated deaths.[36,37,41] In contrast, Sims and Berger reported an approximately 43% mortality associated with non-elective intubations in trauma patients with cervical injuries requiring halo fixation.[40] In this study, of 105 patients in a halo for cervical spine trauma, 14 patients required an emergent or semi-emergent intubation. Seven patients died, of which 6 (43%) died in association with non-elective intubation. The authors, however, retrospectively could not unequivocally attribute these deaths to airway failure itself since these deaths may have also been directly related to cardiovascular incidences.[40] Mortality and severe morbidity related to airway failure during intubation of patients in halo immobilization have not been a commonly reported complication in larger series of haloed patients, although rare reports of death related to airway failure during intubation of patients in halo fixation have been published.[7,9,19,28,46] In the present study, 10.9% of haloed patients had airway failure during intubation, with 4.4% of our study population dying specifically due to failure to obtain an airway properly.

Table 3: Demographics of haloed patients with failed intubation.

Case	Age (years)/sex	Injury level	Location	Emergent intubation	Surgical airway outcome	Airway-associated mortality/morbidity
1	59/M	C5-C7	ICU	Yes	Unsuccessful	Died
2	48/M	C5-C7	ED	Yes	Unsuccessful	Died
3	25/F	C6-C7	OR	No	Successful	Alive, intact
4	37/M	C5-C6	OR	No	Successful	Alive, intact
5	44/M	C6-C7	OR	No	Successful	Alive, intact

ICU: Intensive care unit, ED: Emergency department, OR: Operating room

A variety of factors may have contributed to the poor outcomes in these patients, though some may have been more influential than others. The haloes prohibited the extension of the patient's cervical spines, which notoriously made airway visualization more difficult.[4,24] Trauma patients, including those in the study by Lockey *et al.*, are manually held in this same fixed position with in-line stabilization during intubation. Both populations have limited cervical spine movement, yet there is a large difference between haloed and trauma patients, suggesting that position alone is not explanatory. Our findings further substantiate that 8.3% of intubation attempts in haloed patients failed, a number significantly higher than that reported by Lockey *et al.*[22]

Another contributing factor to airway complications in this population may be the presence of a concomitant SCI. Cervical SCI can paralyze a patient's diaphragm and thoracic musculature, leading to decreased pulmonary vital capacity. This subsequently puts patients at risk for rapid decompensation during airway management.[5,21,42,47] Although we have found that 14.3% of haloed patients with SCI suffered from death and failed airway, compared to a 10.3% airway failure and 2.6% associated mortality rate in haloed patients without SCI, the overall cohorts were not deemed to be sufficient in size for us to be able to draw any conclusions with regard to the effect of the presence of SCI in this population.

Airway management can also be affected by the setting in which it takes place, such as in emergent or non-emergent settings. Patients requiring emergent intubation are frequently managed with minimal information available to the clinician and are more likely to be hemodynamically unstable or hypoxic before the procedure.[16,25,27,30,37,38] Of note, only two airway failure-related mortalities occurred both in non-elective settings and, hence, outside the OR. Although similar anesthesia techniques were applied, it ultimately did not allow to establish a timely definitive airway or timely surgical airway, eventually leading to the demise of the patients. Our airway-related mortality rate was, therefore, 25% in non-elective intubations, which was statistically highly significant. This rate is similar to the 43% mortality rate reported by Sims and Berger[40] Due to these high mortality rates, thought should be given to consider an early tracheostomy in patients who are likely to remain in a halo for an extended period and are at risk of needing intubations, repeated intubations, or prolonged intubations. Furthermore, an attempt should be made to intubate before halo placement if subsequent intubations are likely. This was attempted in an hour-long study with 42 patients (48% of all patients that got intubated before or during halo fixation) being intubated before halo positioning, thereby avoiding intubating while the patients are in the halo. This may have contributed to keeping the number of airway failures to a minimum in this study.

Finally, the bulky halo itself may be a primary contributing factor complicating airway management in these patients. The fundamental structure of the orthosis obstructs the already limited workspace of the intubating physician. In fact, although the halo used with our patients is thought to be one of the most streamlined devices available, multiple metal struts still protrude anterolaterally and encompass the airway. This physical barrier, in conjunction with the obstacles, may have been a significant contributor to the markedly greater rate of unsuccessful intubations and deaths of our haloed patients.

There were limitations to our study. First, our sample size was limited due to the single site and author's experience reviewed in this study. This may have produced a seemingly greater proportion of poor outcomes than would have been seen with a larger number of patients. Not all patients could be followed till the removal of the halo. Without knowing their complete outcomes and the possibility of intubations while in halo occurring at outside facilities, the findings of this study do not represent the true complication rates. Finally, we did not explore the different techniques used to intubate as well as the sequence in which such techniques were applied during intubation, which may have influenced the patient's outcome in conjunction with the halo itself. The method used would be of particular interest given that most complications and deaths occurred during non-elective intubations and that advanced techniques such as planned fiberoptic intubation have been repeatedly shown to provide greater success in intubations that are expected to be difficult.[3,6,45]

CONCLUSION

With an immobile spine, limited respiratory reserve from SCI, and emergent airways, patients in halo fixation represent a culmination of individual factors that can make endotracheal intubation extremely challenging. The halo itself also appears to be an obstacle, contributing to the markedly increased failed intubation and mortality rates seen in this population. Considering early tracheostomy placement, as well as intubating before halo placement, may all prove to be strategies which could help to reduce the frequency of airway failure, its related morbidity, and mortality associated with intubations of patients in halo fixation.

Ethical approval

Institutional Review Board (IRB) permission obtained for the study, No: IRB # 2013-42 and approval date 3/8/2013.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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