Chapter 3. Prehospital airway management

I. RECOMMENDATIONS

A. Standards. There are insufficient data to support treatment standards for this topic.

B. Guidelines. Hypoxia must be avoided if possible and attempts made to correct it immediately. Supplemental oxygen should be administered.

There is no evidence to support an advantage of endotracheal intubation (ETI) over bag-valve-mask (BVM) ventilation for the prehospital management of the airway in pediatric patients with traumatic brain injury (TBI).

C. Options. If prehospital ETI is instituted for pediatric TBI patients, then specialized training and use of end-tidal CO_2 detectors is necessary.

D. Indications from Adult Guidelines. Under *Guidelines* (1), the authors state "hypoxemia must be avoided, if possible, or corrected immediately. . . .Hypoxemia should be corrected by administering supplemental oxygen." Under *Options*, the authors state that the "airway should be secured in patients who have severe head injury (GCS <9), the inability to maintain an adequate airway, or hypoxemia not corrected by supplemental oxygen. Endotracheal intubation, if available, is the most effective procedure to maintain the airway."

II. OVERVIEW

Large prospective randomized studies in the prehospital setting addressing the effects of hypoxia, abnormal ventilation, and inadequate airway and possible benefits of invasive airway management have not been conducted in either adult or pediatric populations. A large prospective observational cohort study using the Traumatic Coma Data Bank that included some prehospital information showed that hypoxemia in the prehospital setting was associated with worse outcomes in TBI patients (2).

Several studies suggest that hypoxia during prehospital care of children with severe TBI is common. A small study of 25 consecutive pediatric trauma patients showed that 16% had pulse oximetry readings <75% and an additional 28% had a readings of 75–90% during prehospital care (3). Another study also demonstrated the high frequency of hypoxemia in prehospital TBI patients. Of 131 patients who were retrospectively reviewed, 27% were hypoxic on arrival to the emergency department (4). A retrospective chart review of 72 pediatric patients admitted to a single level I pediatric trauma center with a postresuscitation Glasgow Coma Scale (GCS) score of 6–8 demonstrated that 13% had a documented hypoxemic episode somewhere during the continuum of care from the prehospital setting to the intensive care unit. However, the presence of hypoxia was not statistically related to outcome in this relatively small study (5).

III. PROCESS

We searched Medline and Healthstar from 1966 to 2001 by using the search strategy for this question (see Appendix A) and supplemented the results with literature recommended by peers or identified from reference lists. Of 35 potentially relevant studies, four were used as evidence for this question (Table 1).

IV. SCIENTIFIC FOUNDATION

Few studies have been conducted in the prehospital airway management of pediatric patients and only one that specifically evaluated the role of intubation in severe pediatric TBI patients. The only prospective class II study involved a randomized controlled trial of the airway management of all pediatric patients seen in two large urban emergency medical systems. A total of 830 patients ≤12 yrs of age were randomized to airway management by BVM vs. ETI on an odd-even day allocation with a total of 23 (2.8%) protocol violations. No pharmacologic adjuncts were used, and end-tidal CO_2 monitoring was documented in 77% of intubated patients. Of the 420 patients assigned to ETI, 115 (27%) only received BVM; 177 of the remaining 305 were successfully intubated (success rate 73%), and three had unrecognized esophageal intubations. Overall, no benefit was found in ETI in this study or in any of the prospectively derived patient subgroups. Among children with severe TBI, the subgroup analysis, using a strict intention-to-treat analysis, showed that eight of 25 in the BVM group vs. nine of 36 in the ETI group survived (odds ratio, 0.71; 95% confidence interval, 0.23–2.19), and two of 25 in the BVM vs. four of 36 in the ETI group had a "good neurologic outcome" (odds ratio, 1.44; 95% confidence interval, 0.24–8.52). Although this was the largest prospective prehospital study to date, there is significant risk of a type I error in the subgroup analysis for TBI patients alone (6).

A large retrospective study that used the National Pediatric Trauma Registry phase 3 abstracted all records of patients with Abbreviated Injury Severity score ≥4 if they received either BVM or ETI by prehospital providers. A total of 578 case records met this eligibility out of the total registry population of 31,464. Endotracheal intubation was used in 479 (83%) and BVM in 99 (17%). The two cohorts did not differ in injury severity or mechanism but did differ in age stratification (ETI group older), the use of intravenous fluids (81% of ETI, 71% of BVM, $p < .05$), the use of intravenous medications (39% of ETI vs. 23% of BVM, $p < .05$), and transport by helicopter (67% of ETI vs. 27% of BVM, $p < .01$). Forty-eight percent of each cohort died. Injury complications of any organ system were less frequent in the ETI group (58%) vs. BVM group (71%, $p < .05$). Functional outcome using the Functional Independence Measure in patients >7 yrs old showed a nonsignificant trend in improved outcome in the ETI patients.

Another smaller retrospective study at a single tertiary referral level I pediatric trauma center during 1987 evaluated ETI in patients in the field, at the referring facility, or in the institution's own emer-

Table 1. Evidence table

Reference	Description of Study	Data Class	Conclusion
Nakayama et al. (7), 1990	Trauma registry of all hospitalized patients at one tertiary pediatric center over 1 yr who underwent ETI of which 14 of 605 total were prehospital attempts.	II	Only 8/16 successful with two cricothyroidotomy attempts (1/2 successful), whereas 36/36 ($p < .0002$) at referring hospital and 17/17 ($p < .001$) at tertiary hospital were successful. Insufficient numbers to stratify by severity.
Gausche et al. (6), 2000	RCT of prehospital airway management alternating BVM vs. ETI by odd/even days over 3 yrs. Total 820 eligible patients, of which 61 were TBI alone.	II	Using intention-to-treat analysis, 8/25 BVM vs. 9/36 ETI survived (OR, 0.71; 95% CI, 0.23–2.19) and 2/25 BVM vs. 4/36 ETI had "good" neurologic outcome (OR 1.44, 95% CI 0.24–8.52).
Murray et al. (10), 2000	Retrospective registry-based review of all severe TBI patients (age ≥11 yrs, GCS ≤8 with head AIS ≥3) admitted to a single combined adult and pediatric level I trauma center over 3-yr period.	II	For patients 11–20 yrs non-risk-adjusted MR of prehospital intubated patients 19/22 vs. nonintubated 57/115 (MR, 1.74; 95% CI, 1.36–2.23; $p = .001$) and unsuccessful prehospital intubation 7/10 vs. nonintubated 57/115 (MR, 1.41; 95% CI, 0.90–2.21; $p = .325$). Risk adjustment only done for entire cohort. No survival benefit to attempted prehospital intubation in severe TBI patients.
Cooper et al. (11), 2001	Retrospective analysis of 31,464 records of NPTR-3 for severe TBI (head AIS ≥4,578 patients) stratified by field airway management ETI (479/578) vs. BVM (99/578).	II	Similar injury severity and mechanism, ETI group older, more often received intravenous fluids and medications, and more often transported by helicopter. MR 48% both groups; FIM <6 in ETI group 65.7% vs. BVM 65.2%, p = NS; ETI less complications (58%) vs. BVM (71%), $p < .05$.

ETI, endotracheal intubation; RCT, randomized controlled trial; BVM = bag-valve-mask intubation; TBI, traumatic brain injury; OR, odds ratio; CI, confidence interval; GCS, Glasgow Coma Scale; AIS, Abbreviated Injury Severity; MR = mortality ratio; NPTR-3, National Pediatric Trauma Registry phase 3; FIM, Functional Independence Measure; NS, nonsignificant.

gency department. The authors reported a success rate of only nine of 16 in the field (including one successful and one unsuccessful cricothyrotomy) compared with 36 of 36 at the referring facility ($p < .0002$) and 17 of 17 in a level I emergency department ($p < .001$). The authors attributed four deaths in patients who received prehospital ETI to "major airway mishaps." The small numbers did not allow adjustment for injury severity (7).

Another registry-based retrospective cohort study that used patients admitted to the 13 trauma centers in Los Angeles County from 1995 to 1997 evaluated prehospital ETI in patients with a GCS ≤8 and a head Abbreviated Injury Severity score ≥3. There were a total of 137 patients aged 11–20 yrs old (ETI was not allowed in younger patients), among whom 22 were successfully intubated. Mortality rate was 19 of 22 in successful ETI group vs. 57 of 115 in BVM group (unadjusted mortality rate, 1.74; 95% confidence interval, 1.36–2.23; $p < .001$), and mortality rate was seven of ten in unsuccessful intubation vs. 57 of 115 in the BVM group (unadjusted mortality rate, 1.41; 95% confidence interval, 0.90–2.21; $p = .325$). There was no risk stratification within this pediatric age cohort in the study.

Key Elements From the Adult Guidelines Relevant to Pediatric TBI

Several studies have documented that adult patients with severe TBI who develop hypoxia have decreased risk of survival. A large prospective observational study of 717 patients with severe TBI admitted to four level I acute trauma centers that participated in the Traumatic Coma Data Bank reported that an episode of hypoxia (Pa_{O_2} ≤60 mm Hg or apnea or cyanosis in the field) was independently associated with a significant increase in morbidity and mortality rates from severe head injury (2).

Another large retrospective cohort study of patients with severe TBI (GCS <9 and head or neck Abbreviated Injury Severity score >4) involved a total of 1,092 TBI patients of whom 351 had isolated TBI. The investigators found that 26% of patients intubated in the prehospital setting died compared with 36.2% of nonintubated patients ($p < .05$), and in the subgroup analysis of isolated TBI patients, 22.8% of patients who were intubated before admission to a hospital died compared with 49.6% of nonintubated patients ($p < 0.05$) (8).

A study of 50 consecutive TBI patients who were transported by an aeromedical service and were intubated (median GCS 7, SD 2, age 5–84 yrs) were prospectively evaluated by pulse oximetry. Among patients with a pulse oximetry reading >90%, 14.3% (three of 21) died and 4.8% had severe disability, whereas 27.3% (six of 22) of patients with a pulse oximetry of 60–90% died and 27.3% (six of 22) had severe disability. Finally, among patients with pulse oximetry <60%, the mortality rate was 50% (three of six) and severe disability rate was 50% (three of six, $p = .005$). This study reports a strong association of preintubation hypoxemia with poor neurologic outcome in severe TBI patients, but there was no evaluation of different methods for airway management. The outcomes of pediatric patients were not reported separately (9–11).

V. SUMMARY

There are no well-conducted, prospective outcome studies with sufficient power to evaluate the role of various airway maneuvers in pediatric prehospital TBI care. On one hand, there is clear evidence that hypoxemia leads to poorer neurologic outcome in both pediatric and adult TBI patients. There is ample evidence also that hypoxemia frequently occurs in the prehospital setting in this

> *Short of this type of study, clinicians will need to infer from smaller studies whether there is a role for prehospital intubation in pediatric patients with traumatic brain injury.*

patient population. On the other hand, there is evidence that successful prehospital intubation of infants and children requires specialized training, and reported success rates are generally less than in adults. Furthermore, there is much less evidence that aggressive prehospital airway management changes outcome for either adults or children. In the largest prospective airway study (adult or pediatric) yet, there was no benefit overall or to any subgroup analyzed (including TBI) attributed to endotracheal intubation by paramedics in pediatric patients (6).

VI. KEY ISSUES FOR FUTURE INVESTIGATION

As with most areas of clinical medicine, large randomized, controlled trials are lacking that would clearly define suitable interventions including prehospital airway management for the pediatric TBI patient. Given that the largest prehospital randomized, controlled trial study to date of pediatric emergency airway management included very few children with TBI, it is difficult to conceive that an even larger study of TBI patients will be accomplished soon.

Short of this type of study, clinicians will need to infer from smaller studies whether there is a role for prehospital intubation in pediatric TBI patients. The potential benefits of intubation in preventing and treating hypoxemia vs. the known risks (unrecognized esophageal or mainstem bronchus intubation) will need to be carefully balanced.

REFERENCES

1. Bullock R, Chesnut RM, Clifton G, et al: Guidelines for the management of severe traumatic brain injury. *J Neurotrauma* 2000; 17:451–553
2. Chesnut RM, Marshall LF, Klauber MR, et al: The role of secondary brain injury in determining outcome from severe head injury. *J Trauma* 1993; 34:216–222
3. Silverston P: Pulse oximetry at the roadside: A study of pulse oximetry in immediate care. *BMJ* 1989; 298:711–713
4. Cooke RS, McNicholl BP, Byrnes DP: Early management of severe head injury in Northern Ireland. *Injury* 1995; 26:395–397
5. Kokoska ER, Smith GS, Pittman T, et al: Early hypotension worsens neurological outcome in pediatric patients with moderately severe head trauma. *J Pediatr Surg* 1998; 33:333–338
6. Gausche M, Lewis RJ, Stratton SJ, et al: Effect of out-of-hospital pediatric endotracheal intubation on survival and neurological outcome: A controlled clinical trial. *JAMA* 2000; 283:783–790
7. Nakayama DK, Gardner MJ, Rowe MI: Emergency endotracheal intubation in pediatric trauma. *Ann Surg* 1990; 211:218–223
8. Winchell RJ, Hoyt DB: Endotracheal intubation in the field improves survival in patients with severe head injury. Trauma Research and Education Foundation of San Diego. *Arch Surg* 1997; 132:592–597
9. Stocchetti N, Furlan A, Volta F: Hypoxemia and arterial hypotension at the accident scene in head injury. *J Trauma* 1996; 40:764–767
10. Murray JA, Demetriades D, Berne TV, et al: Prehospital intubation in patients with severe head injury. *J Trauma* 2000; 49:1065–1070
11. Cooper A, DiScala C, Foltin G, et al: Prehospital endotracheal intubation for severe head injury in children: A reappraisal. *Semin Pediatr Surg* 2001; 10:3–6

APPENDIX: LITERATURE SEARCH STRATEGIES

SEARCHED MEDLINE AND HEALTHSTAR FROM 1966 TO 2001

Chapter 3. Prehospital Airway Management

1. exp craniocerebral trauma/
2. head injur$.tw.
3. brain injur$.tw.
4. 1 or 2 or 3
5. limit 4 to (human and English language and "all child <0 to 18 years>"
6. vascular access.mp.
7. bone marrow.mp.
8. intraosseous.mp.
9. exp intubation, intratracheal/ or "intratracheal intubation".mp.
10. exp Airway obstruction/th [Therapy]
11. "AIRWAY MANAGEMENT".mp.
12. 6 or 7 or 8 or 9 or 10 or 11
13. 5 and 12