

## Review Article

# Comparison of tracheal intubation and alternative airway techniques performed in the prehospital setting by paramedics: a systematic review

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## ABSTRACT

This systematic review included controlled clinical trials comparing tracheal intubation (TI) with alternative airway techniques (AAT) (bag-mask ventilation and use of extraglottic devices) performed by paramedics in the prehospital setting. A priori outcomes to be assessed were survival, neurologic outcome, airway management success rates and complications. We identified trials using EMBASE, MEDLINE, CINAHL, The Cochrane Library, Web of Science, author contacts and hand searching. We included 5 trials enrolling a total of 1559 patients. No individual study showed any statistical difference in outcomes between the TI and AAT groups. Because of study heterogeneity, we did not pool the data. This is the most comprehensive review to date on paramedic trials. Owing to the heterogeneity of prehospital systems, administrators of each system must individually consider their airway management protocols.

**Keywords:** paramedic, prehospital, airway, tracheal intubation, extraglottic, supraglottic, bag-mask ventilation

## RÉSUMÉ

Cette analyse systématique portait sur les essais cliniques contrôlés comparant l'intubation trachéale aux techniques alternatives de prise en charge des voies respiratoires (ventilation avec masque et ballon et utilisation de dispositifs extraglottiques) réalisées par le personnel paramédical en préhospitalier. Les résultats *a priori* à évaluer étaient la survie, les résultats neurologiques, les taux de réussite de la prise en charge des voies respiratoires et les complications. Les essais ont été recensés en interrogeant les bases de données EMBASE, MEDLINE, CINAHL, la Bibliothèque Cochrane, Web of Science, en communiquant avec les auteurs et en effectuant

une recherche manuelle. Nous avons inclus 5 essais auxquels ont participé 1559 patients en tout. Il n'y avait pas de différence statistique entre les résultats des groupes d'intubation trachéale et de techniques alternatives de prise en charge des voies respiratoires dans aucun des essais. En raison de l'hétérogénéité de l'étude, les données n'ont pas été mises en commun. C'est l'analyse la plus détaillée à ce jour sur les études relatives aux interventions paramédicales. En raison de l'hétérogénéité des systèmes préhospitaliers, les administrateurs de chaque système doivent examiner leur propre protocole de prise en charge des voies respiratoires.

## INTRODUCTION

With widespread support,<sup>1,2</sup> prehospital tracheal intubation (TI) by paramedics has rapidly expanded among North American emergency medical services (EMS) systems. Indeed, prehospital TI has been associated with improved outcomes in traumatic brain injury,<sup>3</sup> near-drowning<sup>4</sup> and pediatric resuscitation.<sup>5</sup> However, recent studies have questioned the effectiveness of this intervention. In the Ontario Prehospital Advanced Life Support Study, outcomes were similar for trauma and cardiac arrest patients treated by advanced life-support paramedics compared with those treated by basic life support paramedics.<sup>6,7</sup> Furthermore, 3 recent trials on prehospital patients with traumatic brain injury have demonstrated that prehospital TI was associated with increased mortality when compared with emergency department TI.<sup>8-10</sup> Other studies have suggested that increased mortality

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may not be related to prehospital intubation per se, but rather to prehospital hypocarbia and/or hypercarbia,<sup>11</sup> or hypoxia.<sup>12</sup> This systematic review is a comprehensive analysis of paramedic trials comparing prehospital TI with alternative airway techniques (AAT).

## **METHODS**

We conducted a comprehensive search of the following databases: EMBASE (1974–January 2009), MEDLINE (January 1966–January 2009), CINAHL (1982–January 2009), The Cochrane Library (Issue 4, 2008) and Web of Science (1980–January 2009). We used no language or publication restrictions.

### **Search strategy**

The search strategy consisted of the following terms: (intubation OR intratracheal intubation [medical sub-heading, MeSH] OR endotracheal intubation) AND (emergency medical services [MeSH] OR emergency medical technicians [MeSH]) OR emergenc\* OR pre-hospital OR paramedic\* OR emergency care. We assessed reference lists of literature reviews, position statements and included studies, and contacted authors of included studies for additional studies.

### **Study selection**

We pulled full-text articles whose titles or abstracts indicated they were systematic reviews, consensus statements, randomized controlled trials, quasi-randomized controlled trials or cohort studies that involved advanced airway management by paramedics in the pre-hospital setting, comparing TI with AAT. We limited AAT interventions to bag-mask ventilation or extraglottic devices (EGDs). We defined “paramedic” as any clinician (including all levels of emergency medical technicians) who provides prehospital care, excluding physicians, nurses and respiratory therapists. Included studies had to report one of the following outcomes: survival, neurologic outcomes, airway management success rates or complications. We assessed the following complications: rates of hypoxemia (SaO<sub>2</sub>, PO<sub>2</sub>), hypercarbia (PCO<sub>2</sub>), hypotension and aspiration. Final inclusion was limited to randomized controlled trials and quasi-randomized controlled trials. Two investigators (J.L.J., K.C.) independently selected citations for full-text review and final inclusion. Disagreement was resolved by third party adjudication.

### **Validity assessment**

Two reviewers independently assessed the methodological quality of each included study using the criteria by Jadad and colleagues<sup>13</sup> and the risk of bias assessment with Review Manager 5.0 software (Cochrane Collaboration).<sup>14</sup> The Jadad scale (0–5) determines quality of clinical trials based on study randomization, presence of double-blinding, description of withdrawals and process of randomization and blinding.<sup>13</sup>

### **Data abstraction and analysis**

The following data were abstracted from each included study: location of study, details of the prehospital system, paramedic training, population studied, intervention, comparison and our predefined outcomes. Two reviewers independently extracted data from all included studies and double entered the data into the Review Manager 5.0 software.

For dichotomous outcomes, we calculated statistics as odds ratios with 95% confidence intervals (CIs). For continuous outcomes, we calculated statistics as standardized mean differences with 95% CIs. We assessed heterogeneity using the *I*<sup>2</sup> statistic<sup>15</sup> and the Breslow–Day  $\chi^2$  test<sup>16</sup> with significance denoted by *p* < 0.10. We visually examined the presence of publication bias using a funnel plot.<sup>17</sup>

## **RESULTS**

### **Selection of studies**

The search resulted in 4408 citations, of which 257 full-text articles (or abstracts when full-text articles were unavailable) were retrieved for review. Five randomized controlled trials or quasi-randomized controlled trials met inclusion criteria (Fig. 1).

### **Description of included studies**

Five studies involving a total of 1559 patients were included. Included studies are summarized in Table 1. The majority of patients in each study<sup>18–22</sup> were in cardiac and/or respiratory arrest. Four trials<sup>19–22</sup> included only adult patients and one trial<sup>18</sup> included only pediatric patients. Four trials compared TI to an EGD,<sup>19–22</sup> and one study<sup>18</sup> compared TI to bag-mask ventilation. Extraglottic devices used in the 4 studies were the Combitube,<sup>21,22</sup> the pharyngeotracheal lumen airway<sup>19</sup>

and the esophageal gastric tube airway.<sup>20</sup> All studies provided additional airway training to paramedics for the purposes of the study. Only one trial<sup>21</sup> was conducted in a rural setting.

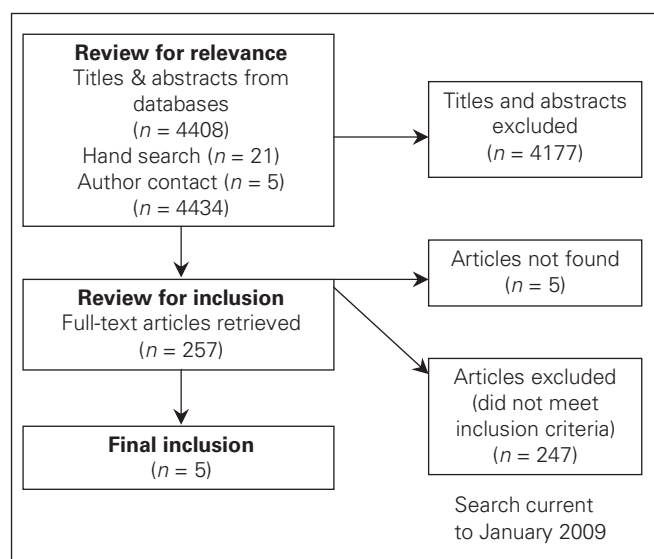
### Methodological quality assessment

We used the Jadad scale (included in Table 1) and risk of bias assessment (Table 2) to determine the methodological quality of all included studies. All included studies had methodological limitations. Only the trial by Goldenberg and colleagues<sup>20</sup> was a true randomized controlled trial design. However, incorrect randomization occurred in 17% of patients, and age was significantly higher in the AAT group.<sup>20</sup> In the study by Gausche and coauthors,<sup>18</sup> only 42% of patients in the TI group actually received TI. The study by Staudinger and colleagues<sup>21</sup> used an as-treated analysis and did not describe baseline characteristics.

### Effect of interventions

Owing to study heterogeneity as a result of dissimilar prehospital systems, we did not pool data on variation in paramedic training, enrolled patients and airway devices used.

Individually, however, each study had similar results. Airway management success rates, as determined by the paramedic, were measured in 4 trials.<sup>18,20-22</sup> The study by Rumball and colleagues<sup>22</sup> also measured success as determined by the receiving emergency physician.



**Fig. 1.** Flow chart for titles and abstracts included in the review.

Individually, no study showed any difference in success rates between the TI and AAT groups.

Hypoxemia ( $\text{PaO}_2$ ,  $\text{SaO}_2$ ) and/or hypercarbia ( $\text{PaCO}_2$ ) were measured in 3 studies.<sup>18-20</sup> The trials by Bartlett and colleagues<sup>19</sup> and Goldenberg and coauthors<sup>20</sup> measured arterial blood gas, and the trial by Gausche and coauthors<sup>18</sup> measured oxygen saturation on arrival to the emergency department. No individual study demonstrated any mean difference in arterial blood gas results.

Aspiration rates, measured in 2 studies,<sup>18,20</sup> were also similar between the TI and AAT groups. The study by Gausche and colleagues<sup>18</sup> measured aspiration rates and the trial by Goldenberg and coauthors<sup>20</sup> measured aspiration pneumonia rates in patients admitted to hospital.

Good neurologic outcome at discharge was similarly defined in the studies that included this outcome. In the study by Gausche and coworkers,<sup>18</sup> good neurologic outcome was defined as normal, no change from baseline or mild deficit, using a modified Pediatric Cerebral Performance Category Scale. In the studies by Goldenberg and coworkers<sup>20</sup> and Staudinger and colleagues,<sup>21</sup> good neurologic outcome was defined as no neurologic residual. No study demonstrated a significant difference in rates of good neurologic outcome at discharge between the TI and AAT groups.<sup>18,20,21</sup>

Finally, survival to hospital admission, measured in the studies by Goldenberg and colleagues<sup>20</sup> and Staudinger and coauthors,<sup>21</sup> and survival to discharge, measured in the studies by Gausche and colleagues,<sup>18</sup> Goldenberg and coworkers,<sup>20</sup> and Staudinger and coauthors,<sup>21</sup> did not differ between the TI and AAT groups in any of the studies. Individually, no included study demonstrated any difference between the TI and AAT group in any of our a priori outcomes.

### Subgroup analysis

As studies were not pooled, insufficient data was available for subgroup analyses.

### DISCUSSION

This is the most comprehensive review to date on paramedic prehospital TI versus AAT. Using our inclusion criteria, we included 2 more studies than a recently published Cochrane systematic review comparing TI with other airway management techniques.<sup>23</sup> We found no significant differences in our a priori outcomes comparing TI with AAT. However, it is noteworthy that outcomes

**Table 1. Description of included studies**

Study	EMS system	Paramedic training	Patients	Intervention/ comparison	Outcomes measured	Results	Notes	Jadad score
Gausche et al. <sup>18</sup>	2 urban EMS sites	<ul style="list-style-type: none"> <li>• TI introduced as part of study</li> <li>• BMV and TI taught in study-related educational sessions</li> </ul>	830 pediatric patients (≤ 12 yr or estimated weight < 40 kg) requiring advanced prehospital airway management (all-comers)	Prehospital BMV v. prehospital TI alternated based on odd or even day	<ul style="list-style-type: none"> <li>• Success of airway management (determined by paramedic by chest rise)</li> <li>• Complications (aspiration)</li> <li>• Neurologic outcome at discharge (no. of patients with no or mild deficit)</li> <li>• Survival to discharge</li> </ul>	<ul style="list-style-type: none"> <li>• AAT: 332/398 (83%); Ti: 315/382 (82%)</li> <li>• AAT: 51/364 (14%); Ti: 53/363 (15%)</li> <li>• AAT: 92/404 (23%); Ti: 85/416 (20%)</li> <li>• AAT: 123/404 (30%); Ti: 110/416 (26%)</li> </ul>	—	1
Bartlett et al. <sup>19</sup>	4 urban EMS sites	PTLA introduced and taught as part of study	111 adult patients in cardiac arrest (all-comers)	PTLA and TI alternated as airway device of first choice within each ambulance unit	<ul style="list-style-type: none"> <li>• PaO<sub>2</sub> measured on arrival in ED</li> <li>• PaCO<sub>2</sub> measured on arrival in ED</li> </ul>	<ul style="list-style-type: none"> <li>• AAT: 162.56 ± 179.62; Ti: 155.75 ± 178.21</li> <li>• AAT: 57.8 ± 31.67; Ti: 53.35 ± 29.3</li> </ul>	In 17 cases, PTLA was replaced with TI in ED	1
Goldenberg et al. <sup>20</sup>	1 urban EMS site	TI and EGTA introduced and taught as part of study	175 patients (≥ 5 ft tall) in cardiac arrest (all-comers)	EGTA v. TI, randomized with card	<ul style="list-style-type: none"> <li>• Success of airway management* (determined by paramedic)</li> <li>• PaO<sub>2</sub> measured in ED</li> <li>• PaCO<sub>2</sub> measured in ED</li> <li>• Neurologic residual at discharge (no. of patients without neurologic residual)</li> <li>• Complications (aspiration pneumonia)</li> <li>• Survival to admission</li> <li>• Survival to discharge</li> </ul>	<ul style="list-style-type: none"> <li>• AAT: 54/77 (70%); Ti: 118/132 (89%)</li> <li>• AAT: 149 ± 132; Ti: 121 ± 127</li> <li>• AAT: 46 ± 29; Ti: 51 ± 34</li> <li>• AAT: 7/85 (8.2%); Ti: 5/90 (5.5%)</li> <li>• AAT: 8/85; Ti: 5/90</li> <li>• AAT: 23/85 (27.1%); Ti: 23/90 (25.6%)</li> <li>• AAT: 11/85 (12.9%); Ti: 10/90 (11.1%)</li> </ul>	<ul style="list-style-type: none"> <li>• Incorrect randomization in 17.1% of patients</li> <li>• Age was higher in AAT group</li> </ul>	3
Staudinger et al. <sup>21</sup>	1 rural EMS site	Combitube taught as part of study	86 patients in cardiac arrest (all-comers)	Combitube v. TI, used on alternate days	<ul style="list-style-type: none"> <li>• Success of airway management (determined by paramedic)</li> <li>• Neurologic outcome at discharge (no. of patients without neurologic residual)</li> <li>• Survival to admission</li> <li>• Survival to discharge</li> </ul>	<ul style="list-style-type: none"> <li>• AAT: 27/38 (71%); Ti: 34/48 (71%)</li> <li>• AAT: 3/52 (6%); Ti: 3/59 (5%)</li> <li>• AAT: 9/52 (17%); Ti: 10/59 (17%)</li> <li>• AAT: 3/52 (6%); Ti: 3/59 (5%)</li> </ul>	As treated analysis used for neurologic outcome and survival	1
Rumball et al. <sup>22</sup>	4 EMS sites, primarily suburban	<ul style="list-style-type: none"> <li>• Basic attendants</li> <li>• Combitube and TI taught as part of study</li> </ul>	357 adult patients in cardiac and/or respiratory arrest	Combitube v. TI, cycling sequence of 2 wk of TI followed by 1 wk of Combitube use	<ul style="list-style-type: none"> <li>• Success of airway management (determined by receiving physician)</li> </ul>	<ul style="list-style-type: none"> <li>• AAT: 62/95 (65%); Ti: 175/250 (70%)</li> </ul>	—	1

AAT = alternative airway technique; BMV = bag-mask ventilation; ED = emergency department; EGTA = esophageal gastric tube airway; EMS = emergency medical services; PaO<sub>2</sub> = partial pressure of oxygen in arterial blood; PaCO<sub>2</sub> = partial pressure of carbon dioxide in arterial blood; PTLA = pharyngotracheal lumen airway; TI = tracheal intubation.  
 \*Numbers include crossover patients.

**Table 2. Risk of bias assessment (methodological quality summary). Review of authors' judgments about each methodological quality item for each included study**

Study	Adequate sequence generation	Allocation of concealment	Blinding	Incomplete outcome data addressed	Free of selective reporting	Free of other bias
Gausche et al. <sup>18</sup>	No	No	?	Yes	Yes	Yes
Bartlett et al. <sup>22</sup>	No	No	?	Yes	Yes	?
Goldenberg et al. <sup>20</sup>	Yes	?	?	Yes	Yes	?
Staudinger et al. <sup>21</sup>	No	No	?	Yes	Yes	Yes
Rumball et al. <sup>22</sup>	No	No	?	No	Yes	?

may not be associated with the actual performance of TI, but may be related to the specific prehospital system and factors such as mastery of the skill,<sup>24</sup> paramedic practice<sup>25</sup> and cognitive decision-making during the procedure.<sup>26</sup> Further study is indicated to determine whether specific subgroups may benefit from either prehospital TI or AAT. The administrators of individual EMS systems must assess factors including patient volume and paramedic training to determine optimal management of prehospital patients requiring advanced airway management.

### Limitations

Our review has several important limitations. There are very few randomized or quasi-randomized controlled trials on this topic, and included studies scored low on the Jadad scale.<sup>13</sup> Two of the studies<sup>19,20</sup> included EGDs that are currently not in use: the pharyngeotracheal lumen airway and the esophageal gastric tube airway. The included studies often did not fully describe EMS systems. Tracheal intubation was introduced in 3 of the studies<sup>18,20,22</sup> and the use of the EGD was taught as part of 4 studies.<sup>19-22</sup> The skill of TI is generally considered to be more difficult than the skill of EGD insertion,<sup>24</sup> and similar outcomes between the TI and AAT groups may indicate that TI in the hands of skilled paramedics may be superior to the use of EGDs. Consequently, results may not be reflective of prehospital systems where TI and AAT have been more established. Trauma patients made up a small minority of the total included patients, and we did not find any studies involving air medical transport or rapid sequence intubation that met inclusion criteria. Although there was no statistically significant heterogeneity between the studies, important differences existed so we did not pool data.

### CONCLUSION

We have conducted a systematic review comparing TI with the use of alternative airway devices in the prehos-

pital setting by paramedics. Existing data are limited. This review demonstrates that current evidence does not support a difference in outcome between TI and AAT.

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