

Evaluating the Efficacy of Pre-hospital Endotracheal Intubation in Cardiac Arrest: A Meta-Analysis.



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ABSTRACT: The optimal airway management strategy during cardiac arrest remains a subject of ongoing debate. This study aims to contribute to the literature on pre-hospital endotracheal intubation (ETI) during cardiac arrest by assessing its association with improved patient outcomes, specifically a higher incidence of return of spontaneous circulation (ROSC). Additionally, the study seeks to determine if ETI remains the best practice for airway management.

Methods: A comprehensive literature review was conducted using the Medline Complete and CINAHL Complete databases. The PICOT formula guided the selection of search terms, and a systematic search strategy was employed. Inclusion criteria focused on English-language, peer-reviewed, full-text articles published between 2010 and 2020, with a preference for studies conducted in pre-hospital settings. The search identified 78 eligible articles, with six high-quality studies included in the final analysis.

Results: The included articles, primarily from the United States, Europe, the United Kingdom, and Japan, involved a total of 341,286 participants. Meta-analysis results indicated no significant difference between ETI and control groups for 96.63% of pre-hospital cardiac arrests. The study participants received either ETI or basic airway management techniques, such as bag valve masks and supraglottic airway devices. The data suggests that ETI does not provide a substantial advantage over basic airway management techniques in terms of improving patient outcomes.

Conclusion: This meta-analysis supports the growing body of evidence suggesting that pre-hospital endotracheal intubation is not significantly associated with better outcomes in cardiac arrest cases compared to basic airway management techniques. While ETI is not linked to poorer patient outcomes, the study recommends further investigation to definitively confirm whether pre-hospital endotracheal intubation increases a patient's chances of survival after cardiac arrest.

KEYWORDS: Pre-hospital care, Endotracheal intubation, Cardiac arrest, Airway management, Return of spontaneous circulation, Meta-analysis

1. BACKGROUND

Best practices in advanced airway management strategies for both pre-hospital cardiac arrest and in-hospital cardiac arrest remain a topic of controversy and debate (1, 2). Specifically, the use of endotracheal intubation (ETI) as the primary means for airway management for cardiopulmonary resuscitation (CPR) during the treatment of a cardiac arrest has had significant inquiry relating to the intervention's association with a favourable outcome, such as the return of spontaneous circulation (ROSC), when compared to more conservative airway measures (1).

Endotracheal intubation has been considered the most advanced airway management technique and is used in many critical care environments such as in severe trauma situations, peri-operative procedures, and during resuscitation efforts (3). This is attributed to the technique's ability to optimally oxygenate, ventilate, and protect critically ill patients from aspiration during times of respiratory compromise or decreased levels of consciousness (4).

The modern use of endotracheal intubation in the pre-hospital setting has progressed in popularity since its conception in 1957 in Heidelberg, Germany (2). Historically, prehospital ETI was not available until a collection of emergency medical physicians commenced manning a pre-hospital mobile intensive care unit that provided a higher calibre of emergency medical service (EMS) to the population surrounding Heidelberg, Germany (2). Due to the documented success of life-saving outcomes, the use of ETI as an advanced airway management technique has quickly evolved and been engrained into modern EMS programs around the globe (5).

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With this evolution, dawned the introduction of specially trained emergency medical technicians branded as paramedics. Although not physicians, these paramedics were formally educated to be able to perform an advanced skill portfolio that rivals that of the physician within the pre-hospital context (5).

Early studies have concluded that following a comprehensive training program and on-scene physician supervision high rates of successful ETI were achievable by paramedics for both adult and paediatric patients. In most of these studies, a successful ETI was defined by the accurate anatomic placement of the endotracheal tube with the absence of significant complications (5). This definition is justified as endotracheal intubation when performed in the pre-hospital environment is associated with an array of detrimental complications that include tracheal tube misplacement, oesophageal intubation, vomiting aspiration, hypoxia, hypotension, cardiac arrhythmia, tracheal trauma, and dental damage (6). Although these early studies have indicated the positive effects of pre-hospital ETI in certain situations, a growing body of studies has revealed the detrimental effects of pre-hospital ETI or, at a minimum, that the advantages are insignificant (5, 7).

This study aims to contribute to the breadth of literature in the field of pre-hospital endotracheal intubation during cardiac arrest, to firstly, identify if an association between ETI and improved patient outcomes exist, such as higher incidences of the return of spontaneous circulation, and secondly, to determine if ETI remains the best practice for airway management.

2. SEARCH STRATEGY

When choosing the appropriate database to conduct a literature review from, it is important to evaluate the database by its appropriateness of the literature produced and by assessing the search systems used (8). This is an essential first step for meta-analysis research as the selection of relevant studies to sample determines a review's outcome, validity, and explanatory power (8). The key concepts used in the assessment of a database include its scope of accessible information and scale of recall or replication (9). For this literature review, The Medline Complete database and the CINAHL Complete database have proven worthy of producing a broad scope of credible literature within the healthcare context thus adequate to conduct the literature search for the proposed research question (10).

Following database selection, the search terms need to be contemplated to ensure the relevance of the results being produced. To achieve this, a PICOT formula was utilised to outline the key components of the hypothesis being tested (11). This was further refined and displayed in Table 1 to determine the most appropriate terminology to be used.

Keywords/search terms/phrases		Alternative words/terms considered
P	Pre-hospital patients	out of hospital/ community; victims/ people/ cases.
I	Intubation during cardiac arrest resuscitation	Advanced airway/ endotracheal tube/ tubing; during a heart attack/ cardiopulmonary resuscitation/ CPR.
C	No intubation during cardiac arrest resuscitation	Advanced airway/ endotracheal tube/ tubing; during a heart attack/ cardiopulmonary resuscitation/ CPR.
O	Ascertain if there is a relationship between the intervention and cardiac arrest survival rates.	Intubation improves/reduces the chances of cardiac arrest survival.
T	During the time frame of 2010-2020	20100101-20200921

From this, select Boolean operators and truncation methods were used as a strategic means to produce the maximum search results for possible inclusion whilst remaining within the desired search field (12). This resulted in the following action:

(Patient OR case*) AND ("cardiac arrest" OR resus* OR treat*) AND ("pre-hospital" OR "out-of-hospital") AND (intubation OR "endotracheal tube" OR "advanced airway")*

3. INCLUSION AND EXCLUSION CRITERIA

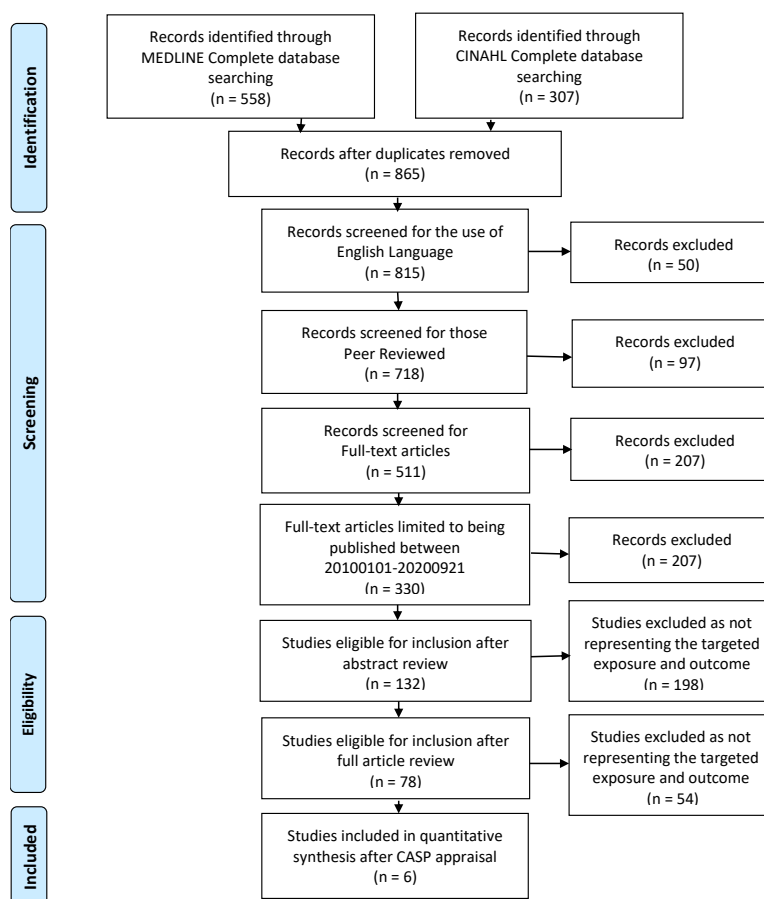
Inclusion screening was possible by using the search engine limiters for literature published in the English language for the ability to read, peer-reviewed full-text academic journals to ensure quality and relevance and published since 1st January 2010 producing a ten-year timeframe. This duration was selected as it commences shortly before the consensus of Fevang et al. (2) who identified

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advanced airway management, such as endotracheal intubation, as one of the top five research priorities in pre-hospital critical care. It should be noted that, although considered, the geographical location or the number of participants within the study was not used as an inclusion or exclusion criterion.

Inclusion into the literature review was permitted following the article was not excluded during the screening process. Furthermore, the literature must be in the pre-hospital or similar setting, contain intubation or terms implying the key exposure of interest, include cardiac arrest or terms implying the primary treated condition, and include the participant's survival status such as the achievement of the return of spontaneous circulation. Furthermore, the literature must be of a case-control quantitative study design to ensure the consistency of terms and figures used throughout.

The following PRISMA Diagram (13) represents the process listed above within the Search Strategy. The diagram displays the stages of literature searching, the quantity, and the type of literature included and excluded from the review.



4. RESULTS

During the preliminary literature search, 865 articles were identified. No duplicates required elimination. Of these, initial screening meant 50 articles were excluded as not published in the English language, 97 were excluded as not being peer-reviewed, 207 were excluded as not being a full-text article, and 207 were excluded as published before 1st January 2010. Subsequently, 330 papers were further screened by reading the abstracts to determine if the eligibility for inclusion was met. This process found 198 articles which were not included because of noncompliance with the inclusion criteria. During the selection stage, 132 articles were fully reviewed and a further 54 articles were excluded because of noncompliance with inclusion criteria.

In total, 78 articles were considered as eligible for inclusion in the literature review. These articles were published between April 2010 and May 2020, and their research was predominantly published in the United States of America (n=41), followed by Europe (n=20), the United Kingdom (n=12), and Japan (n=5). Study quality was evaluated using the Critical Appraisal Skills Programme (14) appraisal methodology. From this, six of the highest-quality articles were included in the present literature review. This was sufficient due to the high volume of participants included in the overall review.

Included Articles

1. Wang HE, Benger JR. Endotracheal intubation during out-of-hospital cardiac arrest: New insights from recent clinical trials. *Journal of the American College of Emergency Physicians Open*. 2019;1(1):24–9. doi:10.1002/emp2.12003.

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- Jabre P, Penaloza A, Pinero D, Duchateau F-X, Borron SW, Javaudin F, et al. Effect of bag-mask ventilation vs endotracheal intubation during cardiopulmonary resuscitation on neurological outcome after out-of-hospital cardiorespiratory arrest. *JAMA*. 2018;319(8):779. doi:10.1001/jama.2018.0156
- Bramer WM, De Jonge GB, Rethlefsen ML, Mast F, Kleijnen J. A systematic approach to searching: An efficient and complete method to develop literature searches. *Journal of the Medical Library Association*. 2018;106(4). doi:10.5195/jmla.2018.283
- Yuksen C, Phattharapornjaroen P, Kreethep W, Suwanmano C, Jenpanitpong C, Nonnongku R, et al. Bag-valve mask versus endotracheal intubation in out-of-hospital cardiac arrest on return of spontaneous circulation: A national database study. *Open Access Emergency Medicine*. 2020;12:43–6. doi:10.2147/oaem.s229356
- Wang C-H, Lee A-F, Chang W-T, Huang C-H, Tsai M-S, Chou E, et al. Comparing effectiveness of initial airway interventions for out-of-hospital cardiac arrest: A systematic review and network meta-analysis of Clinical Controlled Trials. *Annals of Emergency Medicine*. 2020;75(5):627–36. doi:10.1016/j.annemergmed.2019.12.003
- Izawa J, Komukai S, Gibo K, Okubo M, Kiyohara K, Nishiyama C, et al. Pre-hospital advanced airway management for adults with out-of-hospital cardiac arrest: Nationwide cohort study. *BMJ*. 2019;l430. doi:10.1136/bmj.l430.

The following details the included articles with the characteristics of each article outlined in Table 2.

	Author; Year Published; Country	Study Design	Number of Participants	Setting of Participant	Control Group Exposure	Finding in favour of
1.	Wang et al; 2018; USA	Cluster-crossover randomized trial	Total = 3004 ETI = 1499 Control = 1505	Non-traumatic Cardiac arrest	Laryngeal tube	Control Group
2.	Jabre et al; 2018; USA	Randomized parallel-group trial	Total = 2043 ETI = 1023 Control = 1020	Non-traumatic Cardiac arrest	Bag Valve Mask	No significant difference
3.	Bramer et al; 2015; Germany	Registry-based case-control analysis	Total = 8512 ETI = 657 Control = 1855	Traumatic and Non-traumatic Cardiac arrest	Supraglottic airway devices	ETI intervention
4.	Yuksen et al; 2020; USA	Retrospective analytical study	Total = 1070 ETI = 270 Control = 800	Traumatic and Non-traumatic Cardiac arrest	Bag Valve Mask	No significant difference
5.	Wang et al; 2019; USA	Meta-analysis of RCTs	Total = 16,037 ETI = 7,361 Control = 14,836	Traumatic and Non-traumatic Cardiac arrest	Bag Valve Mask (n=1201) and Supraglottic airway devices (n=7475)	No significant difference
6.	Izawa et al; 2019; England	Cohort study	Total = 310, 620 ETI = 130,349 Control= 180,271	Traumatic and Non-traumatic Cardiac arrest	Supraglottic airway devices	No significant difference

In total, 341,286 patients were included of which 140,502 received endotracheal intubation and 200,784 were treated as controls. All six studies evaluated the efficacy of ETI in improving the return of spontaneous circulation in pre-hospital cardiac arrests. With reference to the number of study participants, the meta-analysis has demonstrated that there is no significant difference between ETI and a control population for 96.63% of pre-hospital cardiac arrests. This is significant as the data suggests in favour of ETI at 2.49%, and in favour of the control at 0.88%. For the control exposure, supraglottic airway devices inclusive of laryngeal tubes, were utilised in four studies compared to bag valve masks in three. This highlights that ETI when compared to basic airway management techniques is inefficient in providing significantly better patient outcomes.

5. CONCLUSIONS

In conclusion, the literature review conducted supports the currently growing body that suggests that pre-hospital intubation is not associated with a significant advantage over basic airway management techniques in the treatment of cardiac arrest (5). The review does however demonstrate that, although not of significant benefit, ETI is not likely to be associated with poorer patient outcomes when compared to bag valve masks and supraglottic airway devices. As a result, it can be concluded that further investigation is required to definitively confirm that pre-hospital endotracheal intubation increases a patient's chances of survival after a cardiac arrest.

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Author Statement: This study did not require ethical approval as it involved a retrospective analysis of publicly available and anonymized data, with no direct involvement of human subjects.

Declaration of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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