Comparing No-Flow Time During Endotracheal Intubation Versus Placement of a Laryngeal Mask Airway During a Simulated Cardiac Arrest Scenario

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Introduction: Traditionally, pausing chest compressions during airway management in a cardiac arrest has been the accepted norm. However, updated American Heart Association and the European Resuscitation Council guidelines for Advanced Cardiac Life Support emphasize reducing pauses in chest compressions, often referred to as ''no-flow time,'' to improve return of spontaneous circulation. We used simulation to evaluate whether placing a laryngeal mask airway versus endotracheal intubation via direct laryngoscopy would reduce no-flow times during a simulated cardiac arrest.

Methods: A crossover trial of 41 respiratory therapists (RTs) performed airway management in a simulated cardiac arrest. The RTs were told that bag mask ventilation was inadequate, and either an endotracheal tube or laryngeal mask airway was needed. They were informed to request the cessation of chest compressions only if needed to complete the airway maneuver. The study was terminated when ventilation was achieved. The scenario was repeated with the same RT placing the alternative airway. Insertion time and no-flow times were recorded.

Results: Neither endotracheal intubation via direct laryngoscopy nor laryngeal mask airway placement increased no-flow time. Only 1 participant requested cessation of chest compressions during direct laryngoscopy for 2.3 seconds (P = 0.175). However, ventilation was established significantly faster with a laryngeal mask airway compared with endotracheal intubation (49.2 vs. 31.6 seconds, respectively, P < 0.001).

Conclusions: We conclude that although neither device was superior to the other with respect to the primary outcome of reducing no-flow time, effective ventilation was established more rapidly with the laryngeal mask airway in the hands of the RTs who participated in this study. These results may be affected by the differences between simulated and human airways.

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Key Words: Cardiac arrest, Airway management, Endotracheal intubation, Direct laryngoscopy, Laryngeal mask airway, No-flow time.

In 2010, the American Heart Association (AHA) and the European Resuscitation Council (ERC) released revised Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. The most notable AHA change is the basic life support sequence steps from "A-B-C" (airway, breathing, chest compressions) to "C-A-B" (chest compressions, airway, breathing).[1] Emphasis has been placed on adequate chest compressions and limiting the amount of no-flow time to 10 seconds or less. Regarding airway management, the guidelines stress that it is important that the achievement of an advanced airway does not significantly delay the administration of chest compressions or shocks. The guidelines endorse the use of supraglottic airway (SGA) devices as an alternative to endotracheal intubation for advanced airway management during cardiopulmonary resuscitation. Our study evaluates the efficacy of placing both laryngeal mask airways (LMAs) and endotracheal tubes (ETTs) in the midst of ongoing, adequate chest compressions, to eliminate or minimize no-flow time, by respiratory therapists (RTs).

METHODS

We obtained approval for this study from our institutional review board. The study was designed as a crossover trial. During 3 weeks, 41 RTs from a level 1 trauma center with a wide range of experience (0.5–37 years) participated in the study. They were placed in groups of 2 to 5 to receive standardized instruction from a single senior anesthesia resident on orotracheal intubation and LMA insertion. In addition, all subjects viewed short instructional videos on placement of LMAs and ETTs via direct laryngoscopy before the hands-on component of the didactic session. A prescenario questionnaire that included questions regarding demographic information and quantification of the

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individual's level of confidence in their ability to place both ETTs and LMAs was completed.

A GlideScope (Verathon Incorporated) was used to demonstrate laryngeal anatomy of Laerdal's SimMan3G before laryngoscopy. The instructor demonstrated insertion techniques of both a #4 LMA (AmbuAuraStraight) and 7.0 ETT with a Macintosh #3 blade for all participants. Laryngeal mask airway insertion was taught using a standard midline digital insertion technique. Each participant was allowed up to 5 attempts at inserting both the LMA and ETT.

Once volunteers completed the 5 practice attempts, placement of each device was attempted during a simulated code. In the simulation, volunteers arrived to find a patient in either asystole or pulseless electrical activity. They were instructed that bag mask ventilation (BMV) was inadequate and an advanced airway was needed.

One participant was assigned to administer chest compressions at a rate of greater than or equal to 100 per minute, according to advanced cardiac life support guidelines. Another participant was directed to intubate or place an LMA during the scenario. Immediately after the first scenario, a second simulated cardiac arrest was presented, with the participants playing the same role and were asked to place the alternative advanced airway. That is, if they placed an ETT during scenario 1, then they were asked to place an LMA in scenario 2 and vice versa. Time started at designation of airway intervention. Adequacy of chest compressions was assessed by the simulator software (Laerdal's SimMan3G software). If chest compressions were inadequate, the scenario was restarted and resumed only if chest compressions were adequate in both depth and rate.

The airway managers were instructed to request cessation of chest compressions, only if needed, to place the advanced airway. Any pause in chest compressions were recorded as no-flow time. Compressions continued until ventilation was established, according to the software, even if multiple attempts were required. Once ventilation was detected by the simulator the scenario ended.

After each subject had attempted to place both an LMA and ETT in a code scenario, they completed a postscenario questionnaire assessing their confidence levels in their ability to place each device.

RESULTS

The median times for volunteers to insert both airway devices are shown in Table 1. We excluded the data from 1 subject because an advanced airway was not obtained. The authors justified excluding the aforementioned data because the participant had been in a nonclinical position for the last 19 years. This information only became available after the study was completed.

The mean time for the insertion of an ETT during adequate chest compressions was 49.2 seconds. The mean time for inserting an LMA during adequate chest compression was 31.6 seconds. Insertion of an LMA was significantly faster ($P < 0.001$). There was also a substantial difference in range of times to place each device (ETT, 14.9–249 seconds vs. LMA, 14.5–60.4 seconds).

In the ETT group, only 1 subject requested chest compressions be stopped to intubate, for 2.3 seconds. There were no requested interruptions in chest compressions in the LMA group. A Wilcoxon signed rank test was used to compare the time to ventilation with ETTs and LMAs because the 2 groups were not evenly distributed.

QUESTIONNAIRE RESULTS

Prequestionnaire and postquestionnaire results are displayed in Table 2. A t test was used to compare pretest and posttest comfort levels placing both LMAs and ETTs in a simulated code situation. The mean comfort level of placing an ETT increased from 2.8 to 3.6 ($P < 0.001$). The mean comfort level of placing an LMA increased from 2.4 to 3.8 ($P < 0.001$).

DISCUSSION

Limiting the pauses in chest compressions before and after delivering a shock increases the likelihood of a successful shock and patient survival. The updated AHA and ERC guidelines reflect this knowledge by encouraging the practice of continuous, adequate chest compressions, resulting in reduced no-flow time. The criterion standard of advanced airway management remains endotracheal intubation because it secures the airway and protects against aspiration. Direct laryngoscopy with a standard blade is arguably the most used method for endotracheal intubation during a code; however, it is a skill that many code team members may not possess. Notably, the AHA guidelines specify that endotracheal intubation be conducted by proficient laryngoscopists because it is a difficult skill to obtain, and an improperly placed ETT can result in increased morbidity or mortality.

Few studies have attempted to define competence in direct laryngoscopy and maintenance of proficiency with

TABLE 1. Placement of an ETT Versus an LMA During a Simulated Cardiac Arrest Scenario

	Overall (n = 41)	ETT		LMA		P
		Mean (range)	95% CI	Mean (range)	95% CI	
Age, mean (range)	39 (21–56)					
Sex, male/female, %	49/51					
Years as an RT, mean (range)	9.7 (0.5–37)					
Insertion time, s		49.2 (14.9–249)	38.0–60.4	31.6 (14.5–60.4)	28.3–34.9	<0.001

CI indicates confidence interval.

TABLE 2. Comfort Level With Airway Device Insertion, Before and After Teaching Session

	Comfort Level Preeducation Session		Comfort Level Posteducation Session		P
Overall (n = 41)	Mean	95% CI	Mean	95% CI	
ETT insertion (range 1–5)	2.8	2.5–3.1	3.6	3.4–3.9	<0.001
LMA insertion (range 1–4)	2.4	2.1–2.7	3.8	3.6–3.9	<0.001

Comfort level assessed on a Likert scale: 1, none; 2, low; 3, somewhat; 4, very; 5, absolutely. CI indicates confidence interval.

this technique. An early study on this subject demonstrated a 90% success rate in first-year anesthesia residents after a mean of 57 attempts.[2] A later study attempted to define competency of endotracheal intubation in anesthetized patients among respiratory, medical, and paramedic students.[3] After 20 successful attempts on manikins, the results of 35 attempts on patients in optimal, controlled conditions were recorded. Intubation in this group took, on average, more than 1 minute to perform. Statistical analysis predicted from this crossover study demonstrated that approximately 47 laryngoscopies would be required to assure competence under these conditions.

On the other hand, supraglottic devices, which are considered to be advanced airways, offers the advantage of being easier to place compared with direct laryngoscopy. This was demonstrated by a manikin study among anesthetists, nurses, physicians, and paramedics. The time and success rate of tracheal intubation and placement of various supraglottic devices (Classic LMA, ProSeal LMA, laryngeal tube, and combitube) were compared. The study revealed that anesthetists performed tracheal intubation significantly faster among the groups studied. However, the time to place the supraglottic devices were not significantly different among the groups.[4] Further establishing the ease and success of LMA placement, a study among RTs in anesthetized, paralyzed patients demonstrated that after a brief audiovisual tutorial, LMAs were placed faster and with no failures compared with ETT placement.[5]

In vivo evidence of the effectiveness of LMAs during cardiac arrest exists. A case report has documented the effectiveness of ventilation via an LMA in a code situation in the operating room when an LMA was already in place and oxygenation and end-tidal carbon dioxide were monitored from the onset.[6] A study among nurses in hospital wards demonstrated that after brief training in LMA placement, satisfactory insertion rates and airway management were observed with a low incidence of complications.[7] Interestingly, in this study, the authors noted that the LMA remained in place with chest compressions.

In response to the new AHA and ERC guidelines, studies have emerged examining no-flow time and placement of advanced airways. In physicians and paramedics unfamiliar with endotracheal intubations, Wiese et al[8,9] demonstrated that laryngeal tubes and laryngeal tube suction devices were placed faster in manikins than ETTs, thus limiting no-flow time. The laryngeal tube suction devices and I-gel seem to equally limit no-flow time in a similar setting.[10] In all of these studies, placement of advanced airways occurred during pauses in chest compressions (ie, during no-flow time).

The ease and reliability of placing supraglottic devices have been demonstrated in many studies, but few have studied the feasibility of placing the devices during chest compressions. Only 2 studies have evaluated the placement of supraglottic devices during chest compressions. Both studies revealed that supraglottic devices could be inserted with speed and reliability in manikins by physicians, many of whom are involved with airway management on a daily basis.[11,12] Our study is novel in this area because it examines the placement of these devices among RTs, the majority of which are not involved in placing advanced airways on a regular basis.

The majority of RTs in our institution have not performed enough intubations to be considered proficient yet are often among the first to arrive to a code or emergency call. The lack of advanced airway management experience in this group is caused by our hospital's policy that the RT will provide BMV until anesthesiology or a more experienced provider arrives to place an ETT. An advanced airway is often required in these situations when BMV, a difficult skill in itself, is not adequate. Placement of an LMA in these situations is ideal because it may establish more effective ventilation and oxygenation compared with BMV with no added risk of aspiration.[13]

Our study evaluated placement of an ETT and LMA in a manikin among RTs during adequate, continuous chest compressions. Although our study data did not demonstrate that the LMA was superior to endotracheal intubation in terms of the primary outcome of reducing no-flow time, it did show that ventilation was established faster when an LMA was used. In addition, a substantial range in intubation time was found (Table 1). The wide range in intubation time is likely secondary to the inherent difficulty of direct laryngoscopy. Therefore, our study demonstrates that ventilation can be established faster with an LMA compared with placing an ETT during ongoing chest compressions, which may have clinical implications in situations where hypoxemia is the primary etiology of the arrest or a confounding variable.

Because the participants had a wide range of experience as practicing RTs (0.5–37 years), we performed a regression analysis between years of experience as an RT and the time needed to place an advanced airway. Based on an R^2 value of 0.0033, we believe that there is no correlation between years of experience and ability to place an advanced airway in our sample.

There are several limitations to this study. First, we evaluated comfort level of the participants rather than determine competence. We did not believe it was a feasible goal to ensure the participants establish competence because this is a difficult standard to achieve in a short period. To simplify the study design, we decided to provide a standard practice session of 5 attempts or fewer regardless if competence or comfort level was achieved. It is likely that all the participants would be able to establish an airway 100% of the time and more rapidly if competence was established before the cardiac arrest scenario.

One confounding variable for the success of endotracheal intubation is the study group. Although our RTs do not intubate regularly, most have had formal training intubating

TABLE 3. Insertion Time and Preeducation Level of Comfort With Airway Devices

ETT Preeducation Comfort Level	No. Responses	Mean Insertion Time, s	LMA Preeducation Comfort Level	No. Responses	Mean Insertion Time, s
1	4	101.0*	1	6	31.6
2	9	41.8	2	16	34.5
3	20	45.1	3	16	30.5
4	7	35.2	4	3	19.1
5	1	42.0	5	0	

*Average is skewed owing to 1 RT who required 249 seconds to place ETT.
Comfort level assessed on a Likert scale: 1, none; 2, low; 3, somewhat; 4, very; 5, absolutely.

manikins and are, therefore, more familiar with the device than the LMA. This is apparent by comparing the mean comfort level of ETT and LMA insertion before the simulation session (Table 2). Therefore, the results of this study may not have relevance to clinicians who have not had previous airway management experience.

Another limitation is the absence of data considering the number of intubations and LMA insertions annually for each study subject. The questionnaire was limited to the total number of insertions in manikins and humans during their lifetime. One could make the assumption that insertion times would be faster in participants who have recently managed the airway or do it more regularly compared with participants who have not managed the airway in months to years (Table 3).

Moreover, we did not collect data on the number of practice attempts made by each individual and associate them with time to ventilation. Despite the limited practice allowed, only 1 participant stated that he would have wanted more time allotted for prescenario hands-on practice despite establishing ventilation in both techniques fairly rapidly (LMA, 28.5 seconds; ETT, 43.6 seconds) and without requesting cessation in chest compressions.

Another weakness is that we used only 1 SGA device, LMA #4 (AmbuAuraStraight), and one manikin from a single manufacturer (Laerdal SimMan 3G). One study evaluated the performance of 4 manikins with 8 SGA devices and showed that no one manikin performed best for all individual SGA devices.[14] This evidence suggests that we may have had a different outcome if we used an alternative SGA device and/or manikin in our study.

Lastly, like all manikin studies, it is difficult to predict if we would obtain similar results if performed on human subjects. Although manikins are frequently used for medical training and studying the performance of new and existing airway devices, there is evidence that they do not mimic the anatomy of actual patients. A recent study used computed tomographic scans of 20 adult patients with trauma without head or neck injuries and compared them with computed tomographic scans of 4 high-fidelity patient simulators and 2 airway trainers. They found that the calculated volume of the pharyngeal space in the manikins varied from 2.2 to 5.1 times that of the human subjects.[15] Because the pharyngeal space is of particular importance for the fit of any SGA device, this anatomic discrepancy questions the validity of using standard manikins for airway training.

Despite the imperfections of using manikins for training, the authors believe there is value in such training. Manikins provide a means of practicing manual skills without placing a human subject in danger of potential harm.

The AHA acknowledges that laryngoscopy performed by unskilled providers results in an unacceptably high rate of complications. With this in mind, health care providers not proficient in endotracheal intubation should not attempt to establish an advanced airway in this manner. Our study further establishes that the LMA seems to be a reasonable option, during a code while performing chest compressions, to establish an advanced airway, especially in those unfamiliar with endotracheal intubation. However, in vivo studies should be performed to determine if these findings are transferrable to the clinical environment.

CONCLUSIONS

We conclude that although neither device was superior to the other with respect to the primary outcome of reducing no-flow time, effective ventilation was established more rapidly with the LMA in the hands of the RTs who participated in this study.

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