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EVIDENCE BASED PRACTICE

Which is more effective for ventilation in the prehospital setting during cardiopulmonary resuscitation, the laryngeal mask airway or the bag-valve-mask? - A review of the literature

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Abstract

Background

Prehospital care providers are responsible for providing adequate ventilation during cardiopulmonary resuscitation (CPR). Endotracheal intubation (ETI) is widely accepted as the 'gold standard' for airway protection and the preferred method for ventilation. However, most Australian paramedics are not trained to perform ETI. Laryngeal Mask Airway (LMA) and Bag-Valve-Mask (BVM) are seen as adequate alternatives to ETI as recommended by the International Liaison Committee of Resuscitation (ILCOR). The objective of this study was to identify which airway device LMA or BVM (with OPA/NPA) is more effective in airway patency and ventilation during cardiopulmonary resuscitation in the prehospital environment.

Method

A literature search was conducted using medical electronic databases, MEDLINE CINHAL, EMBASE, Meditext, Cochrane Central Register of Controlled Trials (CENTRAL), and Scopus. These databases were searched from January 1996 until the end of January 2010. Articles were included if the principal objective was to compare ventilation efficiency of the LMA against the BVM in the prehospital setting. References from articles retrieved were reviewed.

Results

There were 2937 articles located by the search. Of these, 30 articles met the inclusion criteria with twelve relevant to the prehospital environment. In the twelve prehospital studies, two involved the use of mannequins, four were retrospective, five were observational, and there was one a literature review.

Conclusion

The findings from this review suggest that the LMA is more effective at ventilations over time during CPR in adults, as there is less risk of gastric regurgitation and pulmonary aspiration. The BVM is quicker at performing the first ventilation but there is a loss of effectiveness over time. BVM is considered the best method for ventilating children and neonates.

Keywords

airway management; bag-valve-mask; cardiopulmonary resuscitation; emergency medical systems; laryngeal mask airway; out-of-hospital; paramedic; prehospital; ventilation

Background
Airway management and oxygenation are vital in all areas of paramedic practice, are essential during ventilations and imperative to the overall outcome of patients. Cardiopulmonary resuscitation (CPR) is a basic skill for all paramedics, including the performance of appropriate ventilation strategies.

Alexander et al and Bobrow et al indicate that long term survival rates (return to premorbid function) for prehospital cardiac arrests continues to poor.[1,2] Bobrow et al further highlights that survival rates could be less than 10%.[2] CPR is a complex part of paramedic practice, with many known complications, both in cardiac perfusion and ventilation of the patient. Complications resulting from inaccurate ventilations such as gastric regurgitation, pulmonary aspiration, ventilation of the oropharynx, over-zealous ventilations (rate, volume and/or force), decrease in cerebral perfusion and disruption to external chest compressions (ECC) have previously been highlighted.[3]

There are numerous devices available to assist paramedics with efficient airway management. These include oropharyngeal airway (OPA), cuffed oropharyngeal airway (COPA), nasopharyngeal airway (NPA), laryngeal mask airway (LMA), bag-valve-mask (BVM), and endotracheal tube (ETT). There are numerous variations on the original LMA - Classic™(ILMA™ [LMA PacMed, Burnley, Victoria, Australia], LMA-CTrach™ [LMA PacMed, Burnley, Victoria, Australia], LMA-Fastach™ [LMA PacMed, Burnley, Victoria, Australia], Soft Seal- LM [Smiths Medical Australasia, Eight Mile Plains, Queensland, Australia], LM-Supreme™ [LMA PacMed, Burnley, Victoria, Australia], and LMA-unique™ [LMA PacMed, Burnley, Victoria, Australia]) and there are many other Supraglottic/Extraglottic airway (SGA/EAD) devices emerging (iGel® [Intersurgical Ltd, Berkshire, UK], KING LT® Supraglottic Airways [Critical Assist, Mt. Waverly, Australia], SLIPA™ [Allied Medical Limited, East Perth, Australia]). This literature review examines LMAs collectively due to the limited prehospital literature available on individual devices.

Each airway device (OPA/COPA/NPA/LMA/BVM and ETT) have their individual benefits and effectiveness. However, ETT is the only airway device currently available that completely protects the airway (when inserted correctly) ensuring full airway patency and control. All other devices have varying risks of pulmonary aspiration following passive gastric regurgitation.

Endotracheal intubation (ETI) is the most preferred airway management strategy for the oxygenation and ventilation of patients who are unable to maintain their own airway. It allows the greatest airway protection by reducing pulmonary aspiration and gastric regurgition.[1] ETI is considered the "gold standard" for ventilation in CPR, both for the in hospital and prehospital settings.[1,4-9]

To combat the need for adequate oxygenation and ventilation of patients, with minimal risks and resources, Dr Archie Brain developed the prototype for the LMA in 1981.[10] The LMA is essentially a short tube with a slightly modified inflatable mask that surrounds the glottis opening, supporting the epiglottis and tongue in a position that enables airway patency. The first clinical trial was in 1983, in the operating theatre as an intermediate device between the ETT and BVM.[11] This supraglottic airway device enables ventilation of patients who are unable to breathe adequately for themselves or require moderate airway protection whilst spontaneously ventilating. The LMA is widely accepted in all fields of medicine including paramedicine.[1,4-9] The LMA was first recommended as an alternative airway management device to ETI in adults by the International Liaison Committee on Resuscitation (ILCOR) in their 1997 resuscitation recommendations.[12]

The 1990's saw the emergence of the LMA in prehospital practice. It is currently being used in the prehospital setting as a rescue airway when ETI fails (difficult patient conditions), or when the paramedic is not trained in its use (basic life support providers).

Grein and Weiner indicate there is no distinct evidence that supports the LMA or BVM in all areas of airway management during CPR, whilst highlighting that ETI remains the best method of ventilation.[13]

The Australian Resuscitation Council (ARC), the European Resuscitation Council (ERC) and ILCOR concur that ventilations can be directly related to the overall outcome of the patient. It has been noted by these bodies that the risk of incorrect ventilations may in fact be detrimental to the patient.[14] Hence, ILCOR has addressed inaccurate ventilations by the decreasing ratios of ventilations to compressions in the 2005 ILCOR CPR algorithm.[14] This algorithm focuses on quality ventilations (rate, volume, pressure) and their importance to CPR success. This algorithm is reflective of the most up-to-date literature, and emphasises reducing no-flow-time (NFT) during CPR.[14] NFT is when the there is a disruption to external chest compressions (ECC), such as for inserting airway devices and/or ventilations. To reduce NFT, any airway device used in CPR must be both easy to use and be able to be rapidly inserted.[15]

In accordance with the CPR algorithm, LMA and BVM are accepted and recommended alternatives for ventilations when ETI is unavailable.[14, 16, 17] The objective of this study was to determine which airway device LMA or BVM (with OPA/NPA) is more effective in airway patency and management during cardiopulmonary resuscitation in the prehospital environment.

Methods

A literature search was conducted utilising the medical electronic databases of Ovid MEDLINE (1950 to the end of January 2010), CINHAL (1982 to the end of January 2010), EMBASE (1966 to the end of January 2010), Meditext (1970 to the end of January 2010), Cochrane Central Register of Controlled Trials (Central) (1950 to the end of January 2010, and Scopus (1996 to the end of January 2010).

The MeSH headings and keywords used include; laryngeal mask airway, LMA, bag-valve-mask, BVM, airway management, prehospital, out-of-hospital, Australian, emergency medical systems, EMS, emergency medical technicians, EMT, paramedic, resuscitation, CPR, ventilation, arrest, ambulance, end-tidal volumes, regurgitation, aspiration, airway equipment, and return of spontaneous circulation (ROSC). These MeSH headings and keywords were used individually and in combination to identify relevant articles.

Articles of any study design were included if the principal objective was to compare or investigate ventilation efficiency and dissimilarity of the LMA against the BVM (with or without OPA/NPA) in humans or stimulated CPR on mannequins in the prehospital setting. Articles were also included if they utilised stimulated or actual emergency situations, in assessing ventilation efficiency. Articles were excluded if they were not written in English, or focused entirely on other devices like the Combitube or COPA.

The reference lists of the located articles were also examined to identify any articles not found in the initial electronic search.

Results
There were 2,937 articles located in the search. Of these 31 articles met the inclusion criteria, with twelve articles directly relevant to the prehospital setting. Refer to Table 1 for the article breakdown.

Table 1: List of studies by area

Prehospital Studies	n
Paramedic – Adult mannequin[7]	1
Paramedic – Retrospective Study on 92 cardiac arrest patients[9]	1
Paramedic - On Admittance to ED – A Prospective Non-Randomised Study on witnessed VF and pulseless VT prehospital arrests[28]	1
Paramedic – Retrospective Adult Study in ventilation of out- of-hospital VF cardiac arrest[2]	1
Paramedic – Randomised Crossover Trail regarding effectiveness of airway on arrival to ED[32]	1
Paramedic – Observation Study – Training on mannequins and subsequent adult cardiac arrest patients[5]	1
Paramedic – Adult Prospective Study on airway management in out-of-hospital[6]	1
Paramedic Students – Paediatric Mannequin following training[27]	1
Paramedic/Emergency Physician Clinical Control Trial regarding paediatric ventilation[31]	1
Prehospital Case Studies based in London[15]	1
Review on Prehospital Airway Management[29]	1
Audit – S.A. Ambulance[30]	1
In hospital Studies	
Nurses and Medical Students - Adults in Operating Theatre (OT)[1]	1
Nurses - Ward & Paediatric Critical Care[18]	1
Nurses - Paediatric in OT[4]	1
Nurses – Intensive Care - Mannequin study on LMA v. BVM in cardiac arrest[8]	1
Resuscitation Team – Prospective study on inhospital cardiac arrest[3]	1
Anaesthetist/Airway Management Team – Adults in OT[20]	1
Anaesthetist – Paediatric/Infant in minor surgery in OT[19]	1
Hospital Workers (HMO, Nurses and volunteers) Mannequin (Adult[16] & Neonate[22])	2
Multi- Centre Questionnaire (LMA v. Combitube)[17]	1
Inhospital Case Study (Adult)[21]	1
Other Studies	
Medical Students (1^{st} year) - Adult Mannequin Study on successful ventilation[1, 25]	2
Cochrane Review of Randomised and Quasi-randomised Trials [13]	1
HMO & EMT Prospective Randomised Cohort Study[24]	1
Review on LMA[10, 11, 23]	3
Airway Algorithm[26]	1
TOTAL	**31**

Of the 31 articles that met the inclusion criteria, twelve were from the prehospital environment and the remainder included hospital/laboratory or other environment (eleven in hospital and seven laboratory/other).

The in-hospital studies were mainly centred in the emergency department (ED) and operating theatre (OT). Three in hospital studies focused of nurses' (ward and critical/intensive care) ability to ventilate patients (adult and paediatric).[1,4,18] There was one prospective study that utilised an in hospital resuscitation team,[3] whilst two studies, one adult and one paediatric, that used anaesthetists as their participants.[19,20] The remaining five studies include a multi-centre questionnaire,[17] in hospital case study,[21] and three hospital workers (Hospital Medical Officers [HMO]), nurses and/or volunteers) mannequin studies, two adult[8, 16] and one paediatric.[22]

The seven laboratory/other studies included three reviews on LMA and airway management, highlighting the benefits and indications for LMA in CPR.[10, 11, 23] A Cochrane Collaboration systematic review was also highlighted.[13] One study used a combination of the in hospital HMO and prehospital paramedics in a prospective cohort study.[24] The final two studies included a medical student adult mannequin study[25] and an airway management algorithm.[26]

The twelve prehospital studies investigated airway management, including LMA and/or BVM, and effective ventilations. In the prehospital studies; there were one adult mannequin study utilising paramedics[7] and one paediatric mannequin study utilising paramedic students.[27] There were two retrospective studies conducted in the prehospital setting; one focusing on 92 cardiac arrest patients,[9] and the second principally concerning prehospital VF arrests.[2] There were two prospective studies, one focusing on airway management,[6] and one witnessed cardiac arrests in the prehospital setting.[28]

One observational study,[5] one case study,[15] one prehospital airway management review,[29] and one ambulance clinical audit[30] were located. Two high level studies were found in this review, the first being a paramedic/physician controlled clinical trial,[31] with the second being a randomised cross-over based trial.[32] There were no human studies identified that used paediatric patients or adult mannequin studies utilising paramedic students.

The studies used various methods to assess efficiency of ventilations, such as tidal volumes, arterial oxygen saturations, rise and fall of the chest, the amount of gastric regurgitation and pulmonary aspiration the patient experienced. Currently there is no consensus in the literature concerning a definition of successful ventilation.

Discussion

Endotracheal Intubation (ETI) remains the "gold standard" for airway management and ventilation. It is the only device currently available that allows complete control of the airway with no gastric regurgitation or pulmonary aspiration, whilst maintaining adequate ventilation of the patient.

When ETI is not available, the Australian Resuscitation Council (ARC), European Resuscitation Council (ERC) and International Liaison Committee on Resuscitation (ILCOR) advocate the use of the LMA or BVM in CPR.[14,30] The LMA has been shown to have a reduced risk of gastric regurgitation and pulmonary aspiration compared to the BVM in adults.[9] Conversely, one study has demonstrated the BVM to be more effective in ventilating children and neonates.[4]

Green and Green highlight that difficult airway management can have significant impact on the patient's morbidity and mortality.[26] A secure airway and effective ventilations early in patient management is said to improve long term patient outcomes.[29] Bickenbach et al also support the notion of preventing hypoxia by securing the airway and proving adequate ventilations to maintain perfusion is most beneficial for the patient.[25]

Wiese et al suggests adequate management of a patient's airway includes successful oxygenation and reducing no-flow-time (NFT) especially in cardiac arrest situations.[9] NFT is minimal disruption to ECC, as a disruption to ECC reduces vital organ perfusion. Murdoch and Cook support the concept of rapid airway management and ventilation being important to maintain cardiac output during CPR.[21]

The consensus in the scientific literature is that ETI is the most effective and preferred method of providing airway protection and optimal ventilation for both the in-hospital and prehospital settings.[1, 4-9, 18, 32] ETI is a very intricate and precise skill to master and as such is reserved for the most experienced and highly trained healthcare providers.

Rechner et al suggests the LMA be used as the first line device for airway management by personnel untrained in ETI, such as paramedics.[18] Stone et al state in their study that there was no evidence of regurgitation following CPR when the LMA was used as the first line airway device.[3] The LMA does not secure the airway to the same degree as the ETT, however, it is fast and easy to insert following adequate training. Hoyle et al and Hein suggest that the LMA can be used without the need for laryngoscopy and is considered the 'gold' standard of supraglottic airway devices.[11, 24]

Barata and Nickel et al conclude that the LMA is ideal for those patients who have a difficult airway, as it can also be used for patients who need airway protection but who can spontaneously ventilate.[6,23] Parmet et al also suggests that the LMA is advocated in the algorithm for the management of difficult airways.[20] Alexander et al suggest that a LMA be used in hypoxic life-threatening conditions such as cardiac arrest/resuscitation.[1]

There is immense support for the initial effectiveness of the LMA. Nickel et al suggest in their study that the LMA was placed and utilised correctly at the first attempt in 94% of cases.[6] This high success rate is further supported by Bickenbach et al with 98% to 100%,[19] Parmet et al with 94%,[20] Hein with 90%,[11] and Hein et al with 75%.[30] Only, Murray et al challenges these positive statistics with a 64% success rate, in a conflicting study.[5] The literature collectively agrees that successful application of the LMA on the second, or more attempts, occurred in almost every case studied. Grayling et al concludes that the literature has "demonstrated the superiority of the LMA to BVM in airway management" for adults.[17]
The lack of consistency in the scientific literature for a definition of ventilation success after LMA placement was highlighted by Hein et al.[30] Alexander et al and Parmet et al employ arterial oxygen saturations of greater than 90 % as a guide for successful ventilations,[1, 20] whilst other studies utilise expired oxygen tidal volumes to determine success[7,18,27] Given this variation it is difficult to compare results between the articles as each study has different standards for successful ventilation.

Gastric regurgitation and pulmonary aspiration are well-documented side effects of incorrect ventilations. Ocker et al suggests that gastric regurgitation and inflation are greater with the BVM in direct comparison with the LMA.[7] Wiese et al further indicates that regurgitation could be as little as 2% with the LMA,[9] whilst Murray et al suggest the LMA is used with the knowledge of low risk of regurgitation when used appropriately.[5] Bickenbach et al suggests the LMA and Combitube reduce the risk of gastric regurgitation and pulmonary aspiration, thus allowing more effective ventilations.[25] Pulmonary aspiration can be as low as 2.3 in 10,000, when the LMA is used correctly.[23]

However ventilation with the BVM with an OPA or NPA, has been shown to be quicker for initiating the first ventilation.[1, 7] Rechner et al suggests that it takes longer to get the initial breath into the patient using the LMA.[18] Ocker et al has extended this suggesting that BVM is known to be associated with significant risk when used in Adult CPR.[7] These risks include; ventilation of the oropharynx, inadequate tidal volumes, hand fatigue, ineffective seal, repeat hand positioning and eventually increased NFT.[32]

Fatigue in the hand whilst holding the mask in position, is a factor in the effectiveness of ventilations, especially when the BVM is used as the primary method for ventilation. Thus increasing NFT in long periods of ventilation. Alexander et al suggest in their study that those patients who were ventilated by the LMA, 90% were still ventilated adequately at the end of the study, in comparison to only 40% when the BVM was used.[1] Once the LMA is inserted correctly it can be more time efficient as less skill is required to maintain the airway. Thereby allowing less experienced personnel such as firefighters or first responders to adequate ventilate the patient during CPR.[1]

The time it takes to get an adequate seal around the patient's mouth with the BVM when ventilations are required or the extra length of time to initially insert the LMA should not be the only component for assessing the overall efficiency of either airway device. This could be just one reason why the SOS-KANTO study group recommends the delayed placement of the LMA in witnessed VF arrests.[28] Additionally, Rumball and Macdonald imply that the training required for LMA is directly related to the overall success of the device.[32] Conversely, Blevin et al indicates that the BVM is considered the first line device for paediatric ventilation including during CPR.[4] This is due to faster initial ventilations and increased ability to maintain an adequate seal in paediatric patients.[4]

In paediatrics, the LMA's efficiency is also very much in debate. Rechner et al indicates that there were approximately double the successful ventilations with the LMA versus the BVM.[18] Conversely, Blevin et al suggests that the results were very similar, 75% to 77% successful ventilations with LMA and BVM.[4] The preference is for the BVM in young children and neonates, as it is quicker to initiate the initial breathe and easier to operate in this group. Finer et al indicate that in 2001 resuscitation is higher in "neonates than in any other age group", which is reflected in the 2005 ILCOR guidelines.[22] Harnett et al advocate that the LMA is widely used in paediatric, age > 1 year, airway management, but there is also significant complications associated with its use.[19]

Gausche et al has suggested that healthcare providers be taught to provide effective ventilations with the BVM and not LMA in paediatrics.[31] Guyette et al conclude that currently there is no research on paediatric LMA and BVM ventilations in cardiopulmonary resuscitation in the prehospital environment.[27]

There is a significant deficit in high quality research pertaining to LMA and BVM, particularly in the prehospital environment. To date there is only one randomised controlled trial on LMA versus BVM. This trail utilised critical care nurses and was conducted by Rechner et al, it concluded the LMA ventilations were successful in 77% of patients in the study.[18] The study by Rechner et al provides a foundation for further research in the comparison of LMA and BVM ventilations during CPR in the prehospital setting.

This study is potentially limited by the lack of hand searching for journal articles not listed in the electronic databases. There is also the potential that journal articles published in languages other than English may have been missed. The findings of this study should be interpreted with caution as there was a lack of high quality studies located and those studies which were located had small sample sizes.

Conclusion

This literature review has shown that the literature reporting on the effectiveness of LMA assisted ventilations in comparison to BVM ventilations during CPR in the prehospital setting is limited. The LMA has been shown in the limited studies available to provide better quality ventilations over time and have less risk of gastric regurgitation and pulmonary aspiration than the BVM during CPR. This is not the case for paediatrics and neonates, where the BVM is suggested to be a better alternative. There is still a need for further research into the efficiency of the LMA compared to BVM in adult and paediatric patients, particularly in the prehospital environment.

Competing Interests

The authors declare that there are no competing interests.

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