Keep pushing! Limiting Interruptions to CPR; Bag-valve mask versus I-gel® airway ventilation

<Information removed for anonymity>

Abstract

Background: Recent recommendations made by ILCOR have de-emphasised the role of advanced airway management such as 'Endotracheal Intubation' (ETI) during cardiac arrest in favour of maximising the number of chest compressions performed by rescuers. Maximising time available for compressions is achieved by minimising 'hands off time' (HOT). This has led to first responders and paramedics performing single rescuer CPR using a 'Bag-Valve-Mask' (BVM) device as opposed to the historical practice of intubating and ventilating via an endotracheal tube. Bag-Valve-Mask ventilations, especially during single rescuer CPR, are however associated with complications potentially resulting in increased ventilation times. More time spent on ventilations in the single rescuer scenario naturally leads to an increase in HOT and less time being available for compressions. It is postulated that the use of an appropriate supraglottic airway device (SAD) may decrease the time spent on the ventilation component of CPR and result in a decrease in HOT.

Objectives: This pilot study evaluated how interruptions to chest compressions or "Hands Off Time" (HOT) are affected by the placement of an i-gel® airway vs. simple BVM ventilation during single rescuer CPR.

Method: 16 participants performed two, ten minute single rescuer CPR simulations, firstly using the BVM and later the i-gel® airway for ventilation. Data pertaining to ventilations and HOT in each scenario was statistically analysed and compared.

Results: The i-gel® airway demonstrated a superior ease of ventilation compared to BVM alone and resulted in a reduction of time spent on ventilations overall. The i-gel® however took a mean of 29s ± 10s to secure which contribute considerably to HOT.

Conclusion: The use of the i-gel® airway, resulted in a considerable decrease in the amount of time spent on ventilations, as well as resulting in more compressions being performed. The overall reduction in HOT was however offset by the time it took to secure the device. Further investigation into the use and securing of the i-gel® airway in single rescuer CPR is recommended.

Abstract

Agtergrond: Onlangse aanbevelings deur die ILCOR het die rol van gevorderde lugweg administrasie soos "Endotrageale Intubasie" (ETI) gedurende hartstilstand onder-beklemtoon en het eerder die maksimale aantal bors kompressies wat deur reddingswerkers gedoen word beklemtoon. Hierdie het daartoe gelei dat eerste reaksie personeel en paramedisie enkel redding kardio-pulmonêre opwekking doen deur 'n "bag-valve-mask" (BVM) toestel te gebruik in plaas van die historiese praktyk van intubasie en ventilasie vir n endotragiale buis. 'Bag-valve-mask' ventilators, veral gedurende 'n enkel redding kardio-pulmonêre opwekking word egter geassosieër met potensieële komplikasies wat verhoogde ventilasie tyd veroorsaak. Hoe meer tyd spandeer word op 'n ventilator gedurende 'n enkel redding scenario hoe minder tyd is beskikbaar vir kompressies.

Objektiewe: Hierdie studie evalueer hoe onderbreking van bors kompressies of "hande-af-tyd" (HOT) geaffekteer word deur die plasing van 'n i-gel® lugweg teenoor eenvoudige BVM ventilasie gedurende enkel redding kardio-pulmonêre opwekking.

Metode: Sestien deelnemers het twee tien minute enkel redding kardio-pulmonêre opwekking simulasies uitgevoer, eerstens deur die BVM en later die i-gel® lugweg vir ventilasie. Data ten opsigte van die ventilasie en HOT in elke scenario is statistiese ontleed en vergelyk.

Resultate: Die i-gel® lugweg demonstreer 'n superieure gemak van ventilasie in vergelyking met BVM alleen en lei tot 'n vermindering in tyd wat gespandeer word op ventilasies algeheel. Die i-gel® neem egter 'n gemiddeld van 29 sekondes ± 10 sekondes om te beveilig wat aansienlike bydrae lewer tot HOT.

Gevolgtrekking: Die gebruik van die i-gel® lugweg het 'n aansienlike vermindering in die totale tyd wat gespandeer word op ventilators tot gevolg gehad wat ook meer kompressies wat gedoen moet word. Die algehele vermindering in HOT was in kontras met die tyd wat dit geneem het om die toestel te beveilig. Verdere ondersoek na die gebruik en van die i-gel® lugweg in enkel reddings kardio-pulmonêre opwekking word aanbeveel.

Introduction

Problem statement

Evidence indicates that interruptions to chest compressions or "Hands Off Time" (HOT) during single rescuer CPR are undesirable and negatively impacts on cardiac output (Hazinski et al.

2010). The time spent securing the airway and providing ventilations during CPR serve as a source of interruption to chest compressions or HOT. Limited data currently exists to support one form of airway management above the other during CPR, and that airway management strategies should be adapted to the specific circumstances surrounding CPR. Increases in HOT during CPR lowers the likelihood of achieving a Return of Spontaneous Circulation (ROSC) and survival. CPR techniques where HOT is minimised are preferable and certain ventilation techniques may be beneficial to decreasing time spent on ventilations. Prior to this study no data existed comparing HOT during CPR with BVM ventilation to HOT during CPR using a Supraglottic Airway Device.

Aim

The aim of this study was to determine whether or not the insertion of an i-gel® airway during single rescuer CPR would minimise HOT compared to single rescuer CPR, using only a BVM.

Background

In South Africa, heart disease and sudden cardiac arrest is on the increase. When cardiac arrest occurs the prognosis is poor unless effective resuscitation measures are rapidly initiated. The 'International Liaison Committee on Resuscitation' (ILCOR) strives towards the promotion of prompt and skilful responses to cardiac arrest that can make the difference between life and death. Every five years ILCOR convenes to review the latest literature and science regarding CPR and to reach consensus on treatment recommendations (Hazinski et al. 2010). Over the past five years, ILCOR has de-emphasised the role of 'Endotracheal Intubation' (ETI) in CPR, and re-emphasised the importance of maximising the number of chest compressions and limiting sources of 'Hands-Off Time' (HOT) during CPR (Berg et al. 2010).

The above recommendations however, assume that a single rescue scenario is unlikely to persist for a considerable length of time. The South African scenario is somewhat different to both the American and European models, in that many 'Advanced Life Support' (ALS) Paramedics work alone on a 'Primary Response Vehicle' (PRV) and are therefore, commonly required to manage cardiac arrest cases alone until the ambulance crew arrives. Taking the recent ILCOR recommendations into account, local ALS paramedics are performing single rescuer ventilations during CPR with a BVM apparatus as opposed to the historical practice of ETI which is seen to create an opportunity for significant HOT.

Having said this, 'Bag-Valve-Mask' (BVM) ventilations, especially those being performed during single rescuer CPR, are associated with many complications. These include; gastric insufflation, aspiration and delays associated with repeated attempts at positioning an opening the airway together with difficulties in obtaining an appropriate facemask seal. All of the aforementioned complications may result in an increase in the time spent attempting to provide rescue breaths during CPR. More time spent on ventilations in the single rescuer scenario naturally leads to less time being available for compressions (Berg et al. 2010).

Research objectives

The objectives of this study were to ccompare the differences in HOT between single rescuer CPR using a BVM and single rescuer CPR using the i-gel® airway with reference to a) chest compressions, b) cycles of CPR, and c) time taken to assess and secure the airway and ventilate using an i-gel® SAD.

Contribution to the field

Many health care professionals will, at some time or another, have to deal with the arrest or peri-arrest patient. Survival from cardiac arrest statistics in the local setting compare poorly with a number of international studies, specifically in the pre-hospital environment. Initiating effective CPR and minimising interruptions to CPR are linked to increased chances of obtaining ROSC. This study provides valuable information on airway management strategies in single rescuer CPR for all health care professionals.

Literature review

'Hands off time'

'Hands-Off-Time' is defined as any period of time during CPR that there is a cessation in the performance of chest compressions'(Nolan et al. 2010). End organ perfusion pressure decreases with the cessation of chest compressions and it may take a significant number of compressions to regain adequate end organ perfusion after a period of HOT. Disruptions to chest compressions should therefore be limited as far as possible in order to promote blood flow and adequate end organ perfusion (Perkins et al. 2012).

A direct correlation exists between the fraction of each minute of CPR spent performing chest compressions and the incidence of ROSC (Christenson et al. 2009). Limiting the frequency and duration of interruptions in chest compressions may improve the incidence of ROSC and clinically meaningful outcomes in cardiac arrest patients (Eftestol 2002; Christenson et al. 2009; Abella et al. 2005). Similarly, findings suggest that CPR should focus primarily on chest compressions and that time taken for airway management during CPR may have a negative effect on ROSC (Bobrow et al. 2008).

Airway management during CPR

Periodic ventilation during CPR is an important component of the resuscitation sequence, as it brings about oxygenation of lung tissue (Perkins et al. 2012). However, during cardiac arrest, a lower minute volume is required to achieve normal oxygenation of organ tissues. This is based on the fact that pulmonary perfusion is only 25%-30% of normal during optimal CPR, resulting in oxygen uptake from the pulmonary circuit being significantly reduced (Perkins et al. 2012) A literature shift regarding the importance of ventilation in CPR has occurred, with the emphasis falling on the circulation component (Berg et al. 2010). Excessive ventilation during CPR has been proven to be detrimental to patients, resulting in poorer outcomes (Aufderheide et al. 2004). Another function of airway management during CPR, is the protection of the airway against pulmonary aspiration of gastric contents. It has been reported that as many as 12% of patients aspirate at some point during the resuscitation effort (Stone et al. 1998; Berg et al. 2010).

Preceding 2005, ETI was regarded as the gold standard for airway management during CPR (Zaritsky & Morley 2005). The importance of ETI during CPR has however recently been de-emphasised as it was not shown to improved outcome (Hazinski et al. 2010; Zaritsky & Morley 2005). 'Endotracheal Intubation' performed during CPR is not associated with an improved outcome with regards to ROSC, and has been shown to increase HOT significantly (Wang et al. 2009; Don Michael 1985). Today, airway devices such as SAD are viewed as acceptable alternatives to ETI during CPR, as they provide easy and rapid insertion with good seal pressures (Hazinski et al. 2010; Ruetzler et al. 2011; Don Michael 1985; Yannopoulos & Aufderheide 2007).

The NCBI database was searched using the terms 'randomised' and 'controlled' and 'ventilation' and 'CPR'. No randomised trials could be found to support one form of airway

management strategy above the other during patient CPRThe only clear recommendation made by ILCOR regarding airway management strategies during CPR is that these strategies should be adapted to the specific circumstances surrounding CPR, and that airway management should not prolong HOT (Hazinski et al. 2010).

Single rescuer CPR and HOT

Single rescuer CPR should be aimed at good quality CPR with minimal interruptions in chest compressions occurring (Hazinski et al. 2010; Eftestol 2002; Bobrow et al. 2008; Abella et al. 2005). The 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Carehighlight that the provision of quality compressions that are minimally interrupted remain the main objectives of single rescuer CPR (Berg et al. 2010).

Kern and Hilwig *et al* conducted an animal study in order to assess the effect that interruptions in chest compressions had on the incidence of ROSC in chemically induced ventricular fibrillation. The incidence of ROSC and 24 hour post resuscitation survival was measured with the application of a conventional single rescuer CPR protocol involving periodic ventilations, as well as a protocol focusing on compressions. The authors found that interruptions in chest compressions during single rescuer CPR were inversely related to incidence of ROSC, and that the incidence of 24 hour post resuscitation survival was three times higher in the protocol focusing on compressions. The conclusion was that during single rescuer CPR, rescue breaths may be detrimental to the incidence of ROSC and 24 hour survival, as the rescue breaths caused excessive HOT. The study concluded that any changes in CPR technique/sequence that minimised HOT in the first ten minutes of CPR, should be seriously considered, especially pertaining to airway management (Kern et al. 2002).

Through the use of a manikin based study, Wiese and Bartels *et al* measured the effect that an adaptation of airway management strategies had on HOT during single rescuer CPR (Wiese et al. 2008). Single rescuer CPR was performed using a BVM apparatus, and then again using a Laryngeal tube. HOT was found to decrease by 30% through the insertion of a laryngeal tube during single rescuer CPR (Wiese et al. 2008). This was the only study encountered that provided data on HOT during an entire single rescuer CPR sequence (Wiese et al. 2008). Other studies only measured insertion time of airway devices during active compressions and extrapolated the data to HOT (Ruetzler et al. 2011).

Bag-valve-mask ventilations during CPR

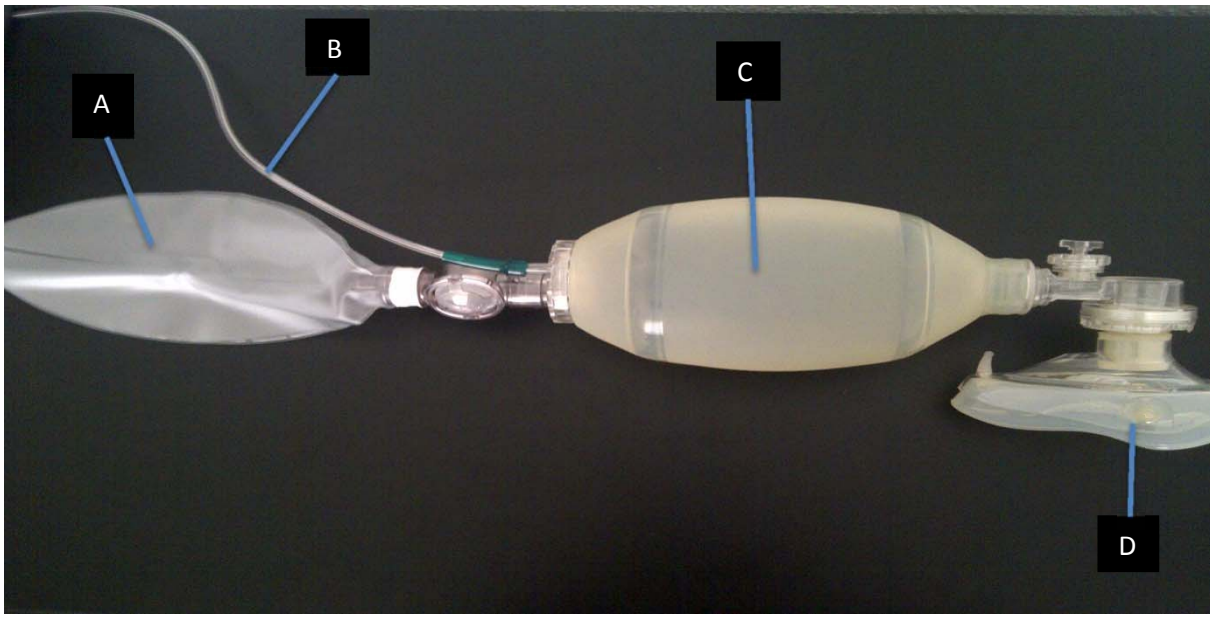

Figure 1.1: Standard Components of a Typical Bag-Valve-Mask Apparatus. A-reservoir bag; B-oxygen tubing; C-self-filling shell bag; D-flexible mask

Bag-Valve-Mask ventilation is associated with complications such as aspiration of gastric contents. Difficult Mask Ventilation (DVM) is described as '*difficulty in finding an appropriate seal between the mask and the patients face*' (Kovacs & Law 2007). During DMV, the rescuer has to repeatedly reposition the mask, hyperextend the patient's head (provided that there is no suspected neck injury) and adjust the pressure he or she applies to the facemask in order to provide an effective seal between the mask and the patient's face thereby assisting in the facilitation of effective ventilations. The incidence of DMV has been reported to be as high 5% in the general population undergoing routine anaesthesia in a controlled environment

(Langeron et al. 2000). DMV is more likely in the case of a single person resuscitation, as it becomes increasingly difficult to achieve an adequate seal between the mask and the patient's face with one hand and squeeze the bag with the other (Dörges et al. 2000) (Yannopoulos & Aufderheide 2007).

Bobrow and Ewy *et al* found that positive pressure ventilations performed during Out of Hospital Cardiac Arrest, may adversely affect outcome. In 1019 OHCA cases involving ventricular fibrillation, the authors found that CPR with passive oxygen insufflation had a 12.4% greater incidence of ROSC, than a conventional CPR protocol involving periodic positive pressure BVM ventilations (Bobrow et al. 2009).

CPR and Supraglottic Airway Devices (SADs)

The use of SADs during CPR provides an alternative form of airway management to BVM, as BVM is known to be associated with many complications such as DMV (Hazinski et al. 2010; Wiese et al. 2008; Stone et al. 1998; Yannopoulos & Aufderheide 2007; Dörges et al. 2000). Some of these SADs include the Laryngeal Mask Airway (LMA) and the laryngeal tube (Dörges et al. 2000). Such may serve as alternative means of providing ventilation, as they are associated with a lower incidence of complications such as DMV and gastric insufflation (Yannopoulos & Aufderheide 2007).

In 2008 Wiese and Bartels measured the effect that the insertion of a Laryngeal Tube had on HOT during single rescuer CPR and found that BVM ventilations increased ventilation time and gastric insufflation compared to ventilations via the Laryngeal Tube during single rescuer CPR (Wiese et al. 2008).

Dörges and Wenzel *et al* conducted a study aimed at determining the feasibility of alternative airway devices, including SAD, as well as ETI used during CPR. The conclusion was that ETI as well as SAD provide an acceptable alternative form of ventilation to BVM during CPR, based on the fact that SAD and ETI remove DMV and other complications such as gastric inflation. The study also concluded that ETI as well as SAD resulted in an overall decreased ventilation time by mitigating the effects of DMV (Dörges et al. 2000).

Insertion times of alternative airway devices and the endotracheal tube

In 2011, Ruetzler and Gruber *et al* conducted a study to measure the insertion time of different SADs during on-going chest compressions performed on manikins. They compared the insertion times of ETI, the LMA, the Easy Tube®, the Laryngeal tube as well as the i-gel® airway (Ruetzler et al. 2011). A measurement of the time taken to insert the various devices successfully during on-going chest compressions was performed and the data was extrapolated to HOT occurring during CPR. The authors concluded that all SADs used in the study, including the i-gel® airway could be used as alternative forms of ventilation and that the i-gel® airway was inserted in a mean time of only 15.9 seconds, which was more or less the same time it took to insert the LMA (Ruetzler et al. 2011).

Castle and Owen et el performed a manikin based study in which they measured the insertion times of different SADs and found that the devices ranked from fastest to slowest insertion times in the following order: i-gel® airway; laryngeal tube airway and lastly LMA. The median insertion times for the devices were as follows: 12.3s (i-gel® airway); 23.4s (Laryngeal Tube Airway); 33.8.s (LMA). The study concluded that the i-gel® airway is an acceptable alternative to BVM during CPR. In an interview, participants commented on the fact that they were impressed by the ease and speed at which the insertion of the i-gel® airway occurred. During the interview of the participants, the i-gel® airway was found to be the favourable option with 63% of the participants finding it as the easiest SAD to insert (Castle et al. 2010).

Gatward and Thomas *et al* found similar results in a manikin based study that measured insertion times of SADs during CPR in order to measure how airway placement is affected by active chest compressions. The insertion time for the i-gel® airway was found to be 50% shorter than that of an LMA Classic and the median insertion time for an i-gel® airway was found to be only 7s. The study also commented on the importance of minimising insertion time in order to minimise HOT during CPR. The conclusion was that the i-gel® airway served as a viable alternative to BVM during CPR (Gatward et al. 2008).

The i-gel® airway

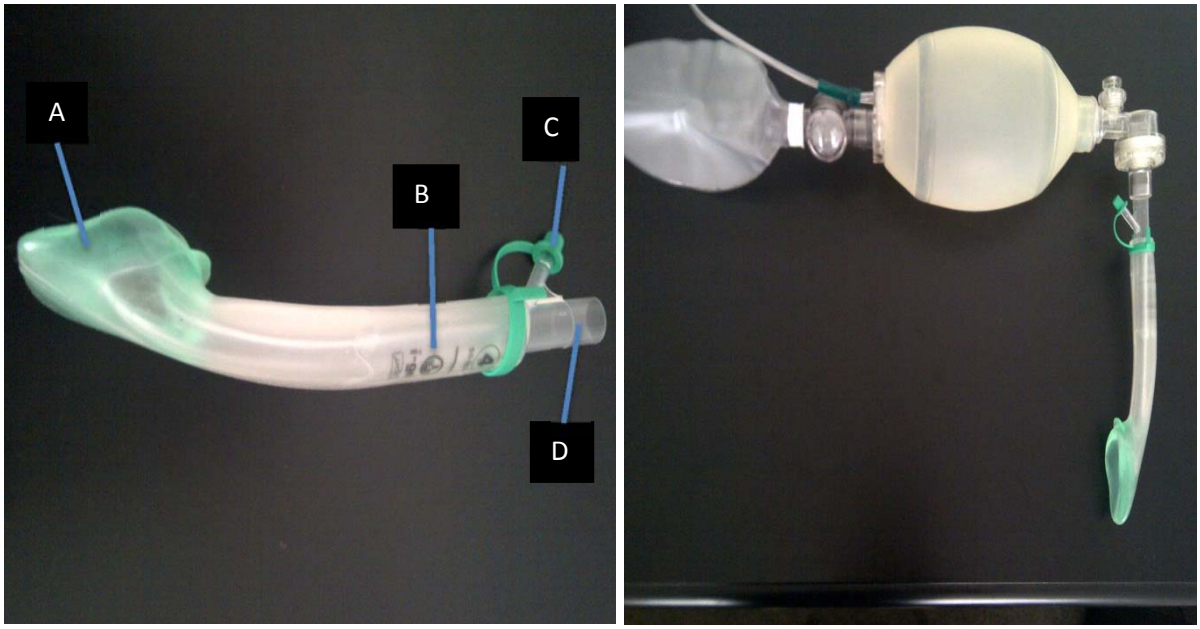

Figure 1.2: Standard Components of The I-Gel® Airway and Its Use As a Bag-Valve-Tube Device. A-gel based, non-inflatable cuff; B-bite block; C-adapter for orogastric tube; D- bag-valve-mask adapter

The above literature indicates that the i-gel® airway is associated with a significant ease of insertion and takes a significantly shorter time to insert compared to any other SAD (Gatward et al. 2008; Castle et al. 2010). The i-gel® airway is a single use SAD with a non-inflatable cuff ,relatively a new addition to the range of SAD available today (Richez et al. 2008; Levitan & Kinkle 2005; Jindal et al. 2009; Kannaujia et al. 2009; Asai & Liu 2010). The efficiency and safety of the i-gel® airway has been tested over the four years since its release onto the market (Richez et al. 2008). The i-gel® airway is made of a gel-like rubber compound that is designed to mold to the soft tissues of the perilaryngeal soft tissues in order to create an appropriate seal with the hypopharynx (Levitan & Kinkle 2005). The gel-like material that it is composed of conforms well to the perilaryngeal soft tissues, producing appropriate device placement and seal (Levitan & Kinkle 2005; Jindal et al. 2009). In a cadaver study, the i-gel® airway caused sufficient glottic opening in 83% of insertions and covered the laryngeal inlet in 100% of insertions performed (Levitan & Kinkle 2005). The position of the i-gel® has also been found to be consistently stable during movement of the patient's head and neck (Kannaujia et al. 2009).

Kannaujia and Srivastava *et al* found that in more than 100 cases of i-gel® airway insertion, successful first attempt insertion occurred in 90% of the cases and that in the other 10% of cases, only one more attempt was necessary for successful placement (Kannaujia et al. 2009).

Wharton and Gibbison also measured the safety and efficacy of the i-gel® airway and found that the i-gel® airway was inserted in manikins in a median time of 14s with good peak airway and seal pressures. The i-gel® airway was correctly placed within the first attempt in 88% of the participants. The study concluded that the i-gel® airway can safely be used as a SAD in patients but that its role in CPR requires further studying (Levitan & Kinkle 2005).

BVM versus i-gel airway ® during Single rescuer CPR

No literature could be found that compared BVM versus the i-gel® airway during the literature review. The 2010 ILCOR treatment guidelines states the following regarding airway management during CPR: "*There were no randomised trials that assessed the effect of airway management with bag valve mask versus any other form airway management including endotracheal intubation of adult victims in cardiac arrest*" (Hazinski et al. 2010) This statement indicates a void in available literature on airway management as a whole during CPR. This research report deals with this knowledge gap in that it provides new information regarding BVM versus the i-gel® airway and the effect that both techniques have on HOT during single recue CPR.

Research method and design

Design

The study was carried out as a prospective, non-randomised, paired design with self-controls. This particular design enabled each participant to act as his/her own control in two separate simulations. The design allowed the researcher to measure the difference in 'Hands-Off Time' (HOT) brought on by the insertion of the i-gel® airway, by comparing the HOT of each participant during two separate simulations. The 16 participants were registered third or fourth year students within the Department of Emergency Medical Care who had been approached and had consented to involvement in the study.

Population and Sample

The 16 participants were registered third or fourth year students within the Department of Emergency Medical Care who had been approached and had consented to involvement in the study. All participants were familiar with the SimMan 3G high fidelity manikin and its working and had been exposed to an i-gel® training video and had the same opportunity to practice its insertion. First and second year students were purposefully excluded as proficiency in the application and use of the i-gel® airway is only expected from the third year of study onwards.

The simulation containing single rescuer CPR with a BVM served as the 'control simulation'. The simulation using the i-gel® airway was considered the 'experimental simulation'. As rescuer fatigue may have influenced chest compression rate and quality the control- and experimental simulations were conducted on two separate days, at least one calendar week apart. (Wharton et al. 2008; Ashton et al. 2002; Sugerman et al. 2009; Manders & Geijsel 2009; Heidenreich et al. 2006) On the day of the experimental simulation, each participant was provided with a video tutorial on the use of the i-gel® airway. This video tutorial was that of the manufacturer and was in accordance with manufacturer guidelines. After viewing the video footage, the participant was provided an opportunity to have practice runs at insertion of the i-gel® airway using Laerdal® airway trainers.

Materials

A camera was placed at the simulation manikin's (SimMan® 3Gs) feet to record video footage of the simulation for retrospective analysis. During the simulations, participants were provided with a medical jump bag containing an ECG, adult BVM, appropriately sized oropharyngeal tubes (OPT) and an i-gel® airway placed in its packaging. A one-meter segment of 1.5cm thick, linen 'Trachy tape' as well as a tube of water-based lubricant was also provided to each of the participants.

Data collection

A personal computer was connected to the manikin. During the simulation, the SimMan® 3G software program provided the following information: a) the duration of the simulation, b) the number and quality of compressions completed, c) the number of ventilations provided, pulse

checks as well as d) the time that chest compressions were started and ended. Time from commencement to conclusion of each scenario was ten minutes.

Data analysis

Raw data was transferred onto Microsoft Excel® worksheets. The mean and standard deviation were calculated using the statistical functions of the Microsoft Excel program. The paired t-test was used to determine statistical significance as it was the most relevant test for the methodology of this study. A 95% confidence interval was used to determine the statistical value of the data.

Context of the study

The study was conducted during August 2012 at the University of Johannesburg in the Department of Emergency Medical Care's clinical training facilities.

Results

Duration of Various Activities During Control and Experimental Simulations

All participant data was combined and used to calculate a mean time spent on each activity. Each of the control simulations were divided into the activities of initial patient assessment, ventilations and compressions, whilst each of the experimental simulations were divided into initial patient assessment, ventilations, compressions as well as i-gel® related activities.

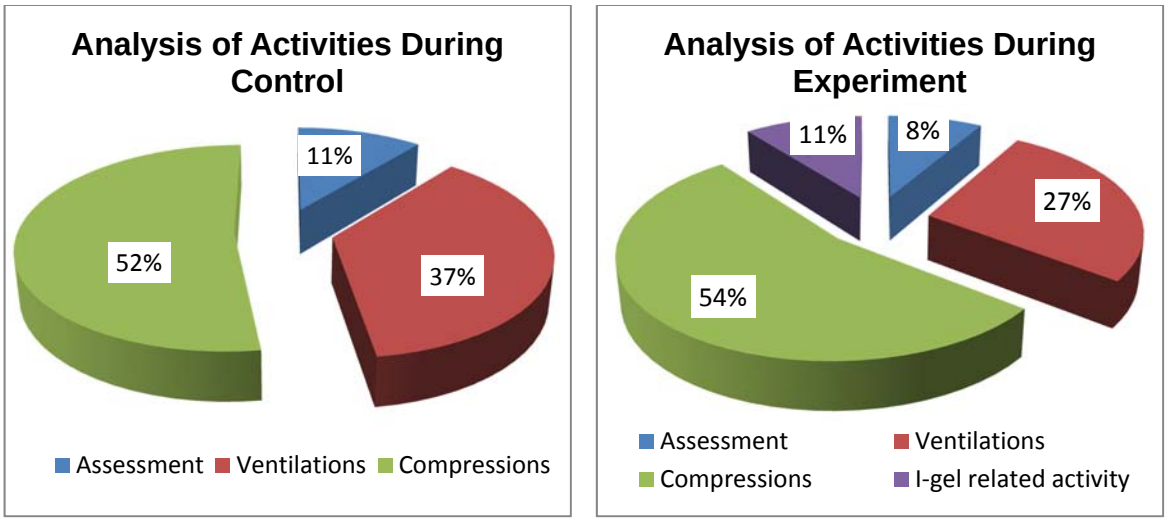

Figure 1: Comparison of Time Spent on Activities, Expressed as a Percentage

Fig 1 shows the time spent on assessment of the patient and decreased from 11% of the total simulation time in the control, to 8% of the total simulation time in the experiment. The time spent on ventilations decreased from 37% of the simulation in the control, to 27% of the simulation in the experiment. The time spent on the performance of chest compressions increased from 52% of the simulation in the control to 54% of the simulation in the experiment. A mean of 63s was used for i-gel® related activity in the experimental simulations. This correlates to 11% of experimental simulation time having been spent on preparing, inserting, securing and confirming the placement of the i-gel® airway device.

Overview of i-gel® related activity

Participants spent a mean of 63s ± 14s on i-gel® related activity. This translated to 11% of each experimental simulation involving some form of activity related to the i-gel® airway. All activity involving preparation, insertion, securing and confirmation of the i-gel®, was also included in HOT, as it directly resulted in the cessation of the performance of chest compressions.

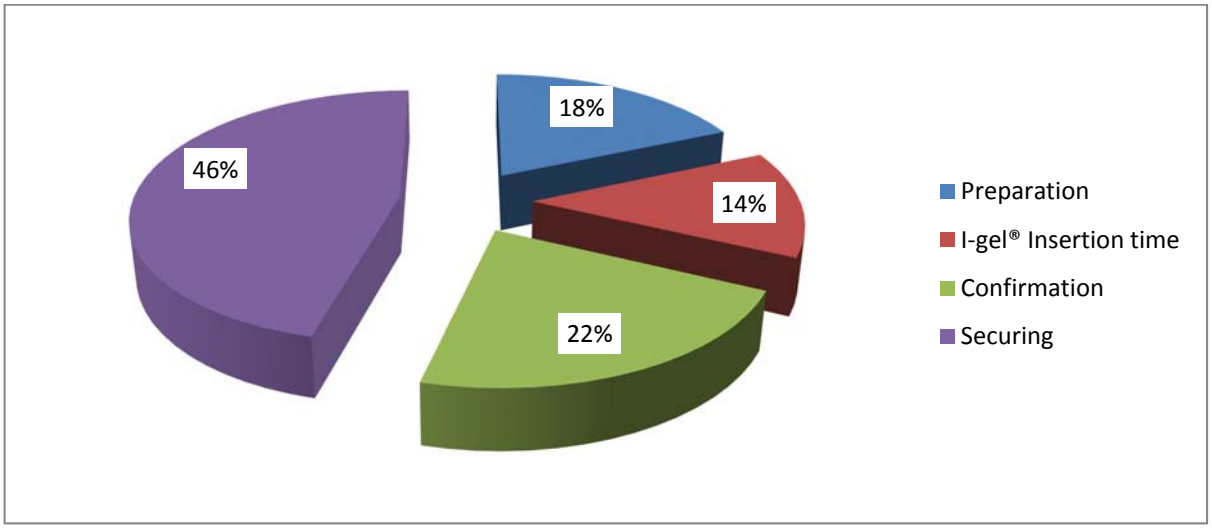

Figure 2: Analysis of Activities Related to I-Gel ® Insertion

I-gel® related activity was divided into four categories namely; preparation of the device for insertion purposes, the actual insertion of the device, the securing of the device as well as confirmation of its correct anatomical placement via auscultation with a stethoscope.

Figure 2 illustrates the percentage of time that each of the i-gel® related activities occupied within the overall i-gel® related activity. The percentage of the time used to prepare the device was calculated at 18%, with the percentage associated with device insertion, only totalling 14%. The percentage of the time associated with the confirmation of the device's placement, was calculated at 22%. Almost half of the overall time associated with i-gel® related activity occurred as a result of securing the device (46%).

Insertion of the i-gel®

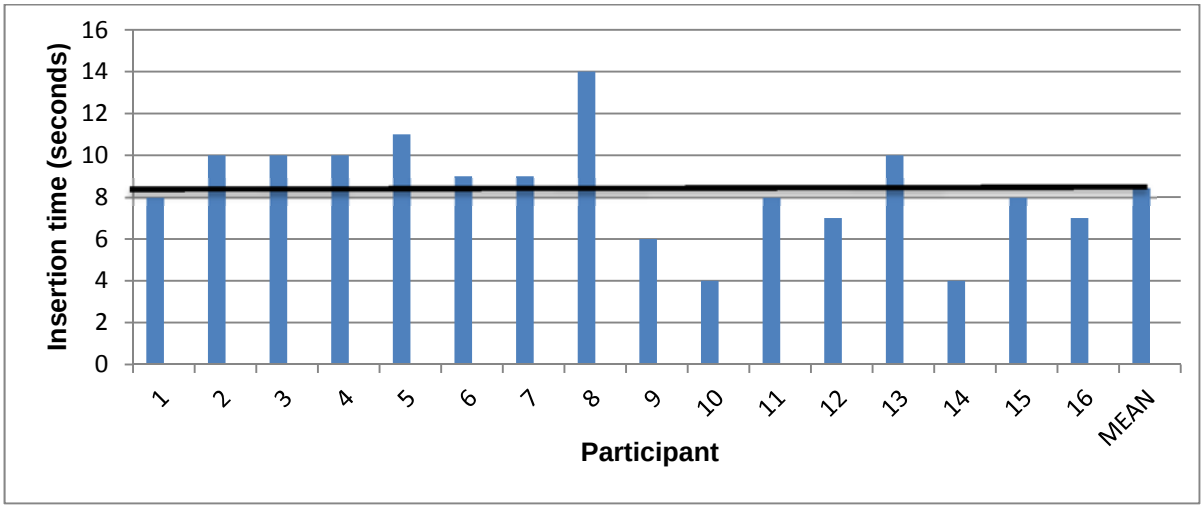

Figure 3: Insertion Time of the I-gel® by Each of the Participants

All participants (100%) inserted the i-gel® successfully on the first attempt. The mean insertion time for the i-gel® was found to be 8s ± 3s.

I-gel® airway and ventilation time

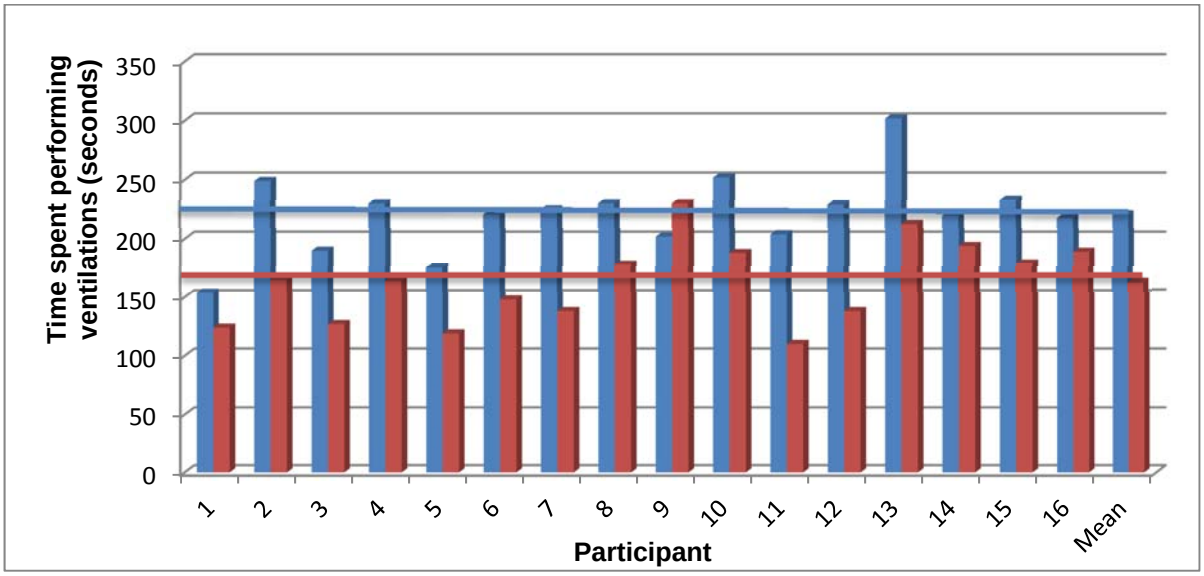

Figure 4: Mean Total Ventilation Time of Each Participant

Figure 4 illustrates the difference in time spent on ventilations during their control and experimental simulations respectively. The time spent performing ventilations, decreased by 10% from the control simulation using a 'Bag-Valve-Mask' BVM, to the experimental simulation using the i-gel®. With the insertion of the i-gel® the total time spent performing ventilations decreased from 221s ± 34s in the control simulation, to 163s ± 35s in the experimental simulation, a decrease of 58s. The mean time spent performing ventilations per cycle of CPR, also decreased form 10s ±2s during the control simulation, to 7s ±2s as recorded during the experimental simulations.

The I-gel® airway and compressions cycles

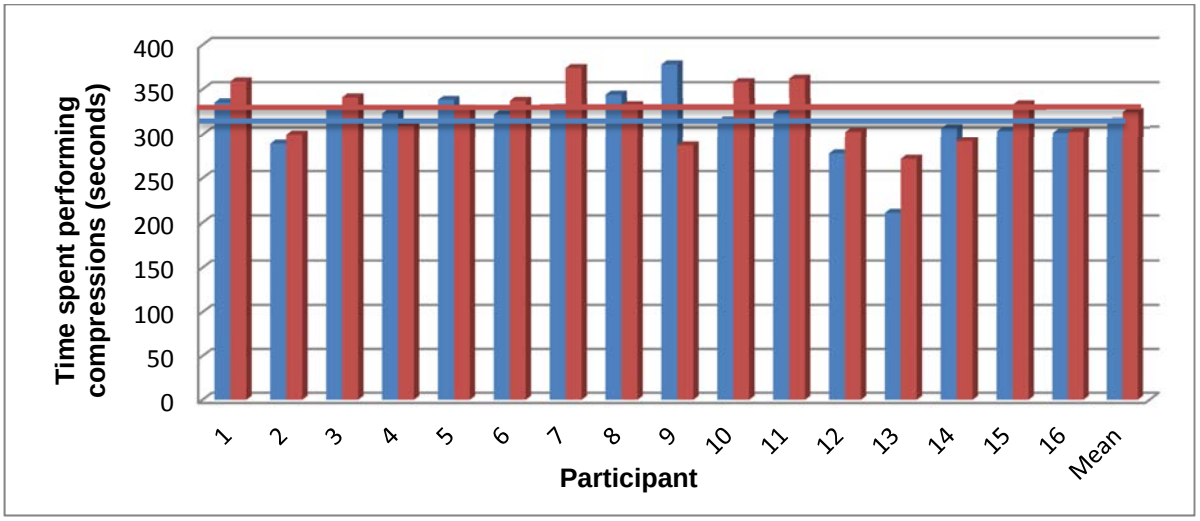

Figure 5: Mean Time Spent Performing Chest Compressions

The results of the study indicated that during the control simulations, participants performed compressions for a mean of 313s ±36s. During the experimental simulations, participant performed compressions for a mean of 324s ±30s. The participants therefore performed compressions for a total of 11s longer during the experimental simulations (2% of total simulation time).

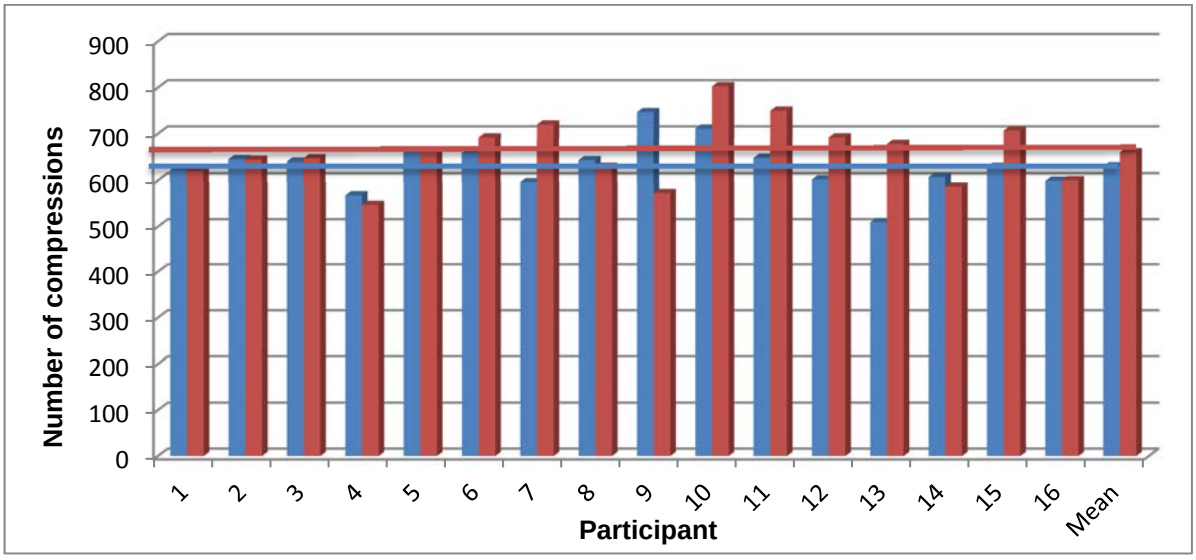

Figure 6: Mean of Total Number of Compressions Performed by Each Participant

Participants performed a mean of 21 ± 2 compressions cycles in the control, and a mean of 22 ± 2 compression cycles performed during the experiment. Participants performed a greater number of compressions during the experimental simulations. Participants performed a mean of 631 ± 54 compressions in the control and a mean of 660 ±67 compressions during the experiment.

Hands off time

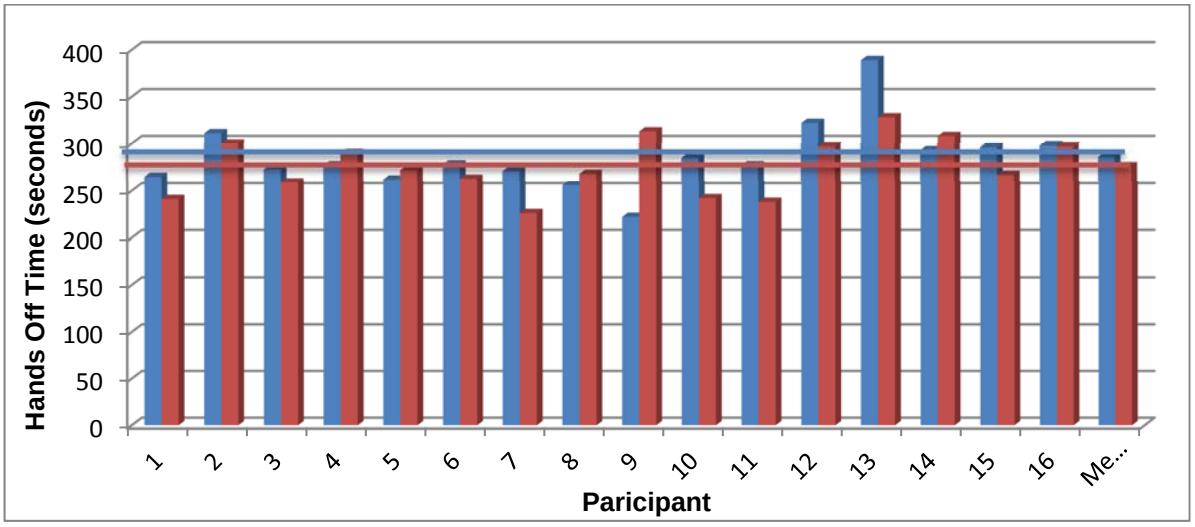

Figure 7: Mean of the Total HOT as Recorded for Each of the Participants

The values represented by the bars in figure 4.7, indicate the total HOT for each participant out of each of the ten minute simulations. The mean HOT calculated from the individual HOT of all the different participants was calculated to be 286s ± 36s during the control simulations. The mean overall HOT for all the participants, calculated during the experimental simulations was calculated to be 276s ± 30s (difference in overall HOT of 10s). The mean HOT per cycle of CPR was also calculated to have decreased from 13s ±3s in the control simulations to 12s ± 2s for the experimental simulations.

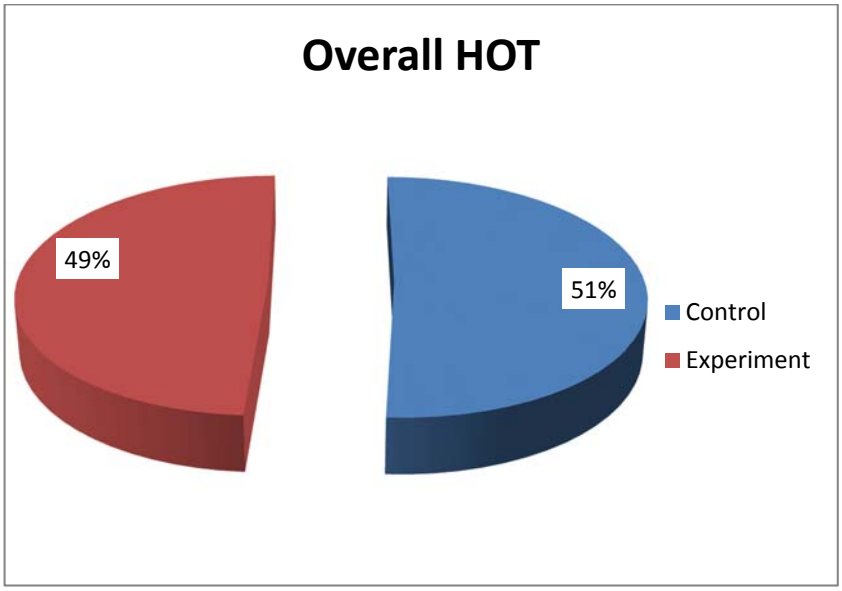

Figure 8: Percentage of Simulation Recorded as HOT During the Control- and Experimental Simulation

Figure 8 illustrates the overall percentage of each of the simulations consisting of HOT. It indicates that the insertion of the i-gel® during the experimental simulations, resulted in a decrease in overall HOT from 51% in the control simulations, to of 49% in the experimental simulations. Although this may not seem significant, it is the reasons for this similarity that are significant specifically those related to activities performed during the i-gel® insertion.

I-gel® and HOT

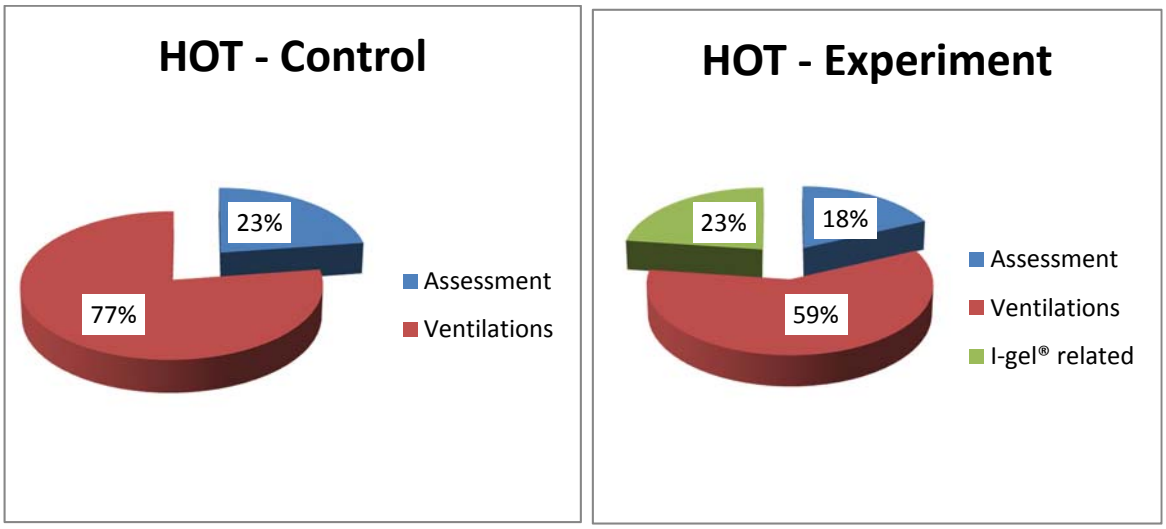

Figure 9: Comparison between Control and Experimental Activities comprising HOT

Time spent performing ventilations, decreased significantly during the experimental simulations. During the control simulations, 77% of HOT was attributed to the performance of ventilations. This is in comparison to the 59% of HOT that was attributed to the performance of ventilations during the experimental simulation.

The experimental simulation contained a segment of activity not contained within the control simulation. The experimental simulation contained a segment of activity that contributed to 23% of HOT which did not occur in the control simulations (i-gel® related HOT activity: 63s ± 14s). This means that the use of the i-gel® airway during the experimental simulations resulted in significant decreases in ventilation time (thereby decreasing HOT) but at the same time, introduced a new element of HOT in the form of i-gel® related HOT activity.

Ethical considerations

Ethical clearance for this study was granted by the Higher Degree and Ethics Committees of the Faculty of Health Sciences at the University of Johannesburg. (Ethical Clearance Number AEC01-73-2014)

Recruitment process

Participants were approached after class and were verbally briefed as to the project. Persons present received a written information and consent form inviting them to partake in the study. It was also explained to the participants, verbally and in writing, that they may withdraw their consent at any point during the research without any consequence.

Data protection

The video footage used during the study was used for retrospective analysis of the data only and was not seen by anyone other than the researcher. Any information from the study that was stored in electronic format, was kept in an appropriate storage medium with password protection

Reliability

Raw data captured by the researcher was independently verified by a second party who was a registered emergency care practitioner, knowledgeable about the study and associated research processes. In addition each simulation was audio and video recorded and the documented times were compared to the recording to further ensure they were accurately reflective of the participants actions.

Validity

The times and compressions recorded from direct observation of each participant's actions by the researcher, second party and video recording were finally compared to those registered via the SimMan® 3G software package which accurately records interventions such as ventilation, compression and hands off time. Data was analysed using standard formulae and functions available in Microsoft Excel®. Both of these packages have been commercially tested and are deemed to deliver valid results.

Discussion

Outline of results

The use of the i-gel® airway device introduced a new category of HOT during the experimental simulations

Participants spent a mean 63s ± 14s on i-gel® related activity. This translated to 11% of each experimental simulation involving some form of activity related the preparation, insertion, securing and confirmation of the i-gel®. All these activities were included in 'Hands-Off Time' (HOT), as this was a single-rescuer scenario, and all activity involving the airway device, directly resulted in a cessation in the performance of chest compressions. Participants took a mean of 12s ± 6s in order to prepare the device for insertion, whilst taking a mean time of 8s ± 3s to insert the device successfully. This translated to 18% of the overall i-gel® related HOT occurring as a result of preparation, with only 14% of the same total occurring as a result of the actual insertion of the device. Participants took a mean of 14s ± 5s to confirm the device's correct placement via auscultation (22% of overall i-gel® related HOT). A considerable amount of time was taken to secure the device using Trachy tape (mean of 29s ± 10s). The vast majority of HOT accumulated during i-gel® related activity, was as a result of securing the airway device (46% of total i-gel® related HOT).

The use of the i-gel® airway changed the distribution of time spent on the activities of assessment, ventilations and compressions

The insertion of the i-gel® airway in the experimental simulations changed the mean distribution of time that each participant spent on the various activities of assessment, ventilations and compressions.

The use of the i-gel® airway decreased the time spent on ventilations

With the insertion of the i-gel®, the total time spent on ventilations, decreased from a mean of 221s ± 34s in the control simulation, to 163s ± 35s in the experimental simulation, a decrease of 58s overall. During each cycle of ventilations, that the i-gel® decreased time spent on ventilations per cycle of CPR by 3s. Overall time spent on ventilations, as well as ventilation time per cycle of CPR, decreased quite considerably from the control, to the experimental simulations. The total time spent performing ventilations decreased by 10% from the control simulation using a BVM, to the experimental simulation using the I-gel®.

The above results seem to indicate that the decrease in time spent performing ventilations was caused by the i-gel® removing difficulties related to BVM ventilations. From the video footage gathered during data collection, it could easily be seen that the i-gel® simplified ventilation cycles, as the BVM was already attached to the airway device and did not have to be picked up off the floor. Also, no mask had to be positioned over that patient's face, due to the supraglottic placement of the airway device, further shortening ventilation time. No literature regarding the abovementioned inferences could be found, reinforcing the study's usefulness as a pilot study.

The use of the i-gel® airway resulted in a greater number of compressions being performed

The results indicate that the participants performed more compressions during the experimental simulation using the i-gel® airway. Latest international CPR guidelines have shifted their focus to the circulation component of the resuscitation sequence, placing an emphasis on the number of chest compressions performed (Hazinski et al. 2010). The use of the i-gel® thus reinforces latest CPR recommendations with regards to number of compressions performed, as it resulted in more compressions being performed during the experimental simulations using the i-gel ® despite the delays caused associated with securing the i-gel®

The impact of the i-gel® airway on overall HOT

Although the use of the i-gel® resulted in a decrease in time spent performing ventilations and HOT, the difference in overall HOT between the control and experiment groups over the 10 minute simulation was only 2%. This is because, as mentioned above, the use of the use of the i-gel® unexpectedly introduced a new category of HOT linked to the time taken to prepare, insert, secure and confirm placement of the i-gel® device. The benefits of i-gel® insertion and associated reduction in HOT however, become greater as the length of resuscitation time increases.

In essence over the 10 minute period, the i-gel® took almost as long to prepare, insert, secure and confirm, as the amount of time it removed from ventilation time and overall HOT. This study chose to use "trachy tape" as a means of securing the device as this is the most widely available and cost effective airway-securing device available to the South African EMS market. It is possible that should a different (faster) means of securing the i-gel® airway be used, HOT times may be further decreased.

Limitations of the study

This manikin-based pilot study included a relatively small sample. Even though all steps possible were taken to ensure that the simulation represented as far as possible real life CPR, the participant's familiarity with the manikin may have influenced the incidence of 'Difficult Mask Ventilation' (DMV) compared to that experienced in real patients. It is also possible that, as the manikin used is designed to create optimal conditions for airway management for training purposes, the insertion of the i-gel® airway may possibly have occurred with greater speed and ease than that encountered in real patients

Conclusion and Recommendations

No studies have proven the benefit of a single form of airway management strategy over the other, instead, literature indicates that airway management strategies in CPR should be adapted to the specific circumstances surrounding the CPR (Hazinski et al. 2010). In South Africa, ALS paramedics often have to perform single rescuer CPR on scene for several minutes. Latest ILCOR guidelines recommend that ALS practitioners should not be performing ETI when alone with a patient in OHCA, and that BVM ventilations should rather be performed as ETI is not associated with improved outcome (Hazinski et al. 2010). Single rescuer CPR using a BVM is associated with DMV which leads to increased ventilation time and increased HOT (Dörges et al. 2000; Kovacs & Law 2007).

SADs provide acceptable alternatives to BVM as they mitigate the effects of DMV by removing complications associated with finding an appropriate seal between the mask and the patient's face (Kovacs & Law 2007; Dörges et al. 2000). The i-gel® airway has been proven to be a safe addition to the range of SAD and is known to conform to the perilaryngeal soft tissues well, resulting in an appropriate placement and good seal pressures (Jindal et al. 2009; Abraham et al. 2012). The i-gel® airway is associated with short insertion time and significant ease of insertion and could provide a valid alternative to BVM ventilations during single rescuer CPR by mitigating the effect of DMV on HOT (Gatward et al. 2008; Castle et al. 2010).

As this study revealed that use of the i-gel® airway in single rescuer CPR can reduce overall ventilation time and decrease HOT, the authors recommend health care professionals consider the use of the i-gel® airway during single rescuer CPR as opposed to Bag Valve Mask

ventilation. Further research should be considered focusing on evaluating the impact of advanced airway management on HOT during CPR in the real clinical setting.

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