

1 **Keep pushing! Limiting Interruptions to CPR; Bag-valve mask versus** 2 **I-gel® airway ventilation**

3
4 <Information removed for anonymity>

5 **Abstract**

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

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

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

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

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

32

33 **Abstract**

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

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

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

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

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

59

60 **Introduction**

61 **Problem statement**

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

64 2010). The time spent securing the airway and providing ventilations during CPR serve as a
65 source of interruption to chest compressions or HOT. Limited data currently exists to support
66 one form of airway management above the other during CPR, and that airway management
67 strategies should be adapted to the specific circumstances surrounding CPR. Increases in HOT
68 during CPR lowers the likelihood of achieving a Return of Spontaneous Circulation (ROSC) and
69 survival. CPR techniques where HOT is minimised are preferable and certain ventilation
70 techniques may be beneficial to decreasing time spent on ventilations. Prior to this study no
71 data existed comparing HOT during CPR with BVM ventilation to HOT during CPR using a
72 Supraglottic Airway Device.

73

74 **Aim**

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

77

78 **Background**

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

88

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

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

106 **Research objectives**

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

112 **Contribution to the field**

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

119 **Literature review**

121 **'Hands off time'**

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

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

138 **Airway management during CPR**

139 Periodic ventilation during CPR is an important component of the resuscitation sequence, as it
140 brings about oxygenation of lung tissue (Perkins et al. 2012). However, during cardiac arrest, a
141 lower minute volume is required to achieve normal oxygenation of organ tissues. This is based
142 on the fact that pulmonary perfusion is only 25%-30% of normal during optimal CPR, resulting
143 in oxygen uptake from the pulmonary circuit being significantly reduced (Perkins et al. 2012) A
144 literature shift regarding the importance of ventilation in CPR has occurred, with the emphasis
145 falling on the circulation component (Berg et al. 2010). Excessive ventilation during CPR has
146 been proven to be detrimental to patients, resulting in poorer outcomes (Aufderheide et al.
147 2004). Another function of airway management during CPR, is the protection of the airway
148 against pulmonary aspiration of gastric contents. It has been reported that as many as 12% of
149 patients aspirate at some point during the resuscitation effort (Stone et al. 1998; Berg et al. 2010).

151 Preceding 2005, ETI was regarded as the gold standard for airway management during CPR
152 (Zaritsky & Morley 2005). The importance of ETI during CPR has however recently been de-
153 emphasised as it was not shown to improved outcome (Hazinski et al. 2010; Zaritsky & Morley
154 2005). 'Endotracheal Intubation' performed during CPR is not associated with an improved
155 outcome with regards to ROSC, and has been shown to increase HOT significantly (Wang et al.
156 2009; Don Michael 1985). Today, airway devices such as SAD are viewed as acceptable
157 alternatives to ETI during CPR, as they provide easy and rapid insertion with good seal
158 pressures (Hazinski et al. 2010; Ruetzler et al. 2011; Don Michael 1985; Yannopoulos &
159 Aufderheide 2007).

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

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

167 168 **Single rescuer CPR and HOT**

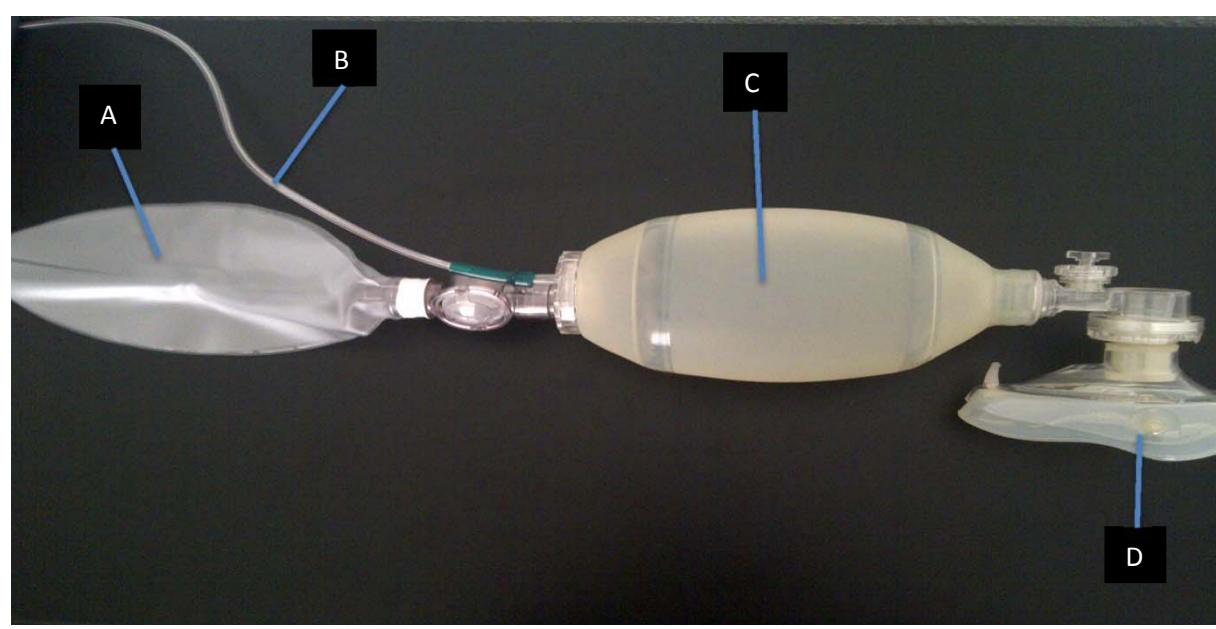
169 Single rescuer CPR should be aimed at good quality CPR with minimal interruptions in chest
170 compressions occurring (Hazinski et al. 2010; Eftestol 2002; Bobrow et al. 2008; Abella et al.
171 2005). The 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and
172 Emergency Cardiovascular Care highlight that the provision of quality compressions that are
173 minimally interrupted remain the main objectives of single rescuer CPR (Berg et al. 2010).

174
175 Kern and Hilwig *et al* conducted an animal study in order to assess the effect that interruptions
176 in chest compressions had on the incidence of ROSC in chemically induced ventricular
177 fibrillation. The incidence of ROSC and 24 hour post resuscitation survival was measured with
178 the application of a conventional single rescuer CPR protocol involving periodic ventilations, as
179 well as a protocol focusing on compressions. The authors found that interruptions in chest
180 compressions during single rescuer CPR were inversely related to incidence of ROSC, and that
181 the incidence of 24 hour post resuscitation survival was three times higher in the protocol
182 focusing on compressions. The conclusion was that during single rescuer CPR, rescue breaths
183 may be detrimental to the incidence of ROSC and 24 hour survival, as the rescue breaths caused
184 excessive HOT. The study concluded that any changes in CPR technique/sequence that
185 minimised HOT in the first ten minutes of CPR, should be seriously considered, especially
186 pertaining to airway management (Kern et al. 2002).

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

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196 **Bag-valve-mask ventilations during CPR**

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

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

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

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216
217 Bobrow and Ewy *et al* found that positive pressure ventilations performed during Out of
218 Hospital Cardiac Arrest, may adversely affect outcome. In 1019 OHCA cases involving
219 ventricular fibrillation, the authors found that CPR with passive oxygen insufflation had a
220 12.4% greater incidence of ROSC, than a conventional CPR protocol involving periodic positive
221 pressure BVM ventilations (Bobrow et al. 2009).

222 223 224 **CPR and Supraglottic Airway Devices (SADs)**

225 The use of SADs during CPR provides an alternative form of airway management to BVM, as
226 BVM is known to be associated with many complications such as DMV (Hazinski et al. 2010;
227 Wiese et al. 2008; Stone et al. 1998; Yannopoulos & Aufderheide 2007; Döriges et al. 2000). Some
228 of these SADs include the Laryngeal Mask Airway (LMA) and the laryngeal tube (Döriges et al.
229 2000). Such may serve as alternative means of providing ventilation, as they are associated with
230 a lower incidence of complications such as DMV and gastric insufflation (Yannopoulos &
231 Aufderheide 2007).

232
233 In 2008 Wiese and Bartels measured the effect that the insertion of a Laryngeal Tube had on
234 HOT during single rescuer CPR and found that BVM ventilations increased ventilation time
235 and gastric insufflation compared to ventilations via the Laryngeal Tube during single rescuer
236 CPR (Wiese et al. 2008).

237
238 Döriges and Wenzel *et al* conducted a study aimed at determining the feasibility of alternative
239 airway devices, including SAD, as well as ETI used during CPR. The conclusion was that ETI
240 as well as SAD provide an acceptable alternative form of ventilation to BVM during CPR, based
241 on the fact that SAD and ETI remove DMV and other complications such as gastric inflation.
242 The study also concluded that ETI as well as SAD resulted in an overall decreased ventilation
243 time by mitigating the effects of DMV (Döriges et al. 2000).

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246 **Insertion times of alternative airway devices and the endotracheal tube**

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

256

257 Castle and Owen et el performed a manikin based study in which they measured the insertion
258 times of different SADs and found that the devices ranked from fastest to slowest insertion
259 times in the following order: i-gel® airway; laryngeal tube airway and lastly LMA. The median
260 insertion times for the devices were as follows: 12.3s (i-gel® airway); 23.4s (Laryngeal Tube
261 Airway); 33.8.s (LMA). The study concluded that the i-gel® airway is an acceptable alternative
262 to BVM during CPR. In an interview, participants commented on the fact that they were
263 impressed by the ease and speed at which the insertion of the i-gel® airway occurred. During
264 the interview of the participants, the i-gel® airway was found to be the favourable option with
265 63% of the participants finding it as the easiest SAD to insert (Castle et al. 2010).

266

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

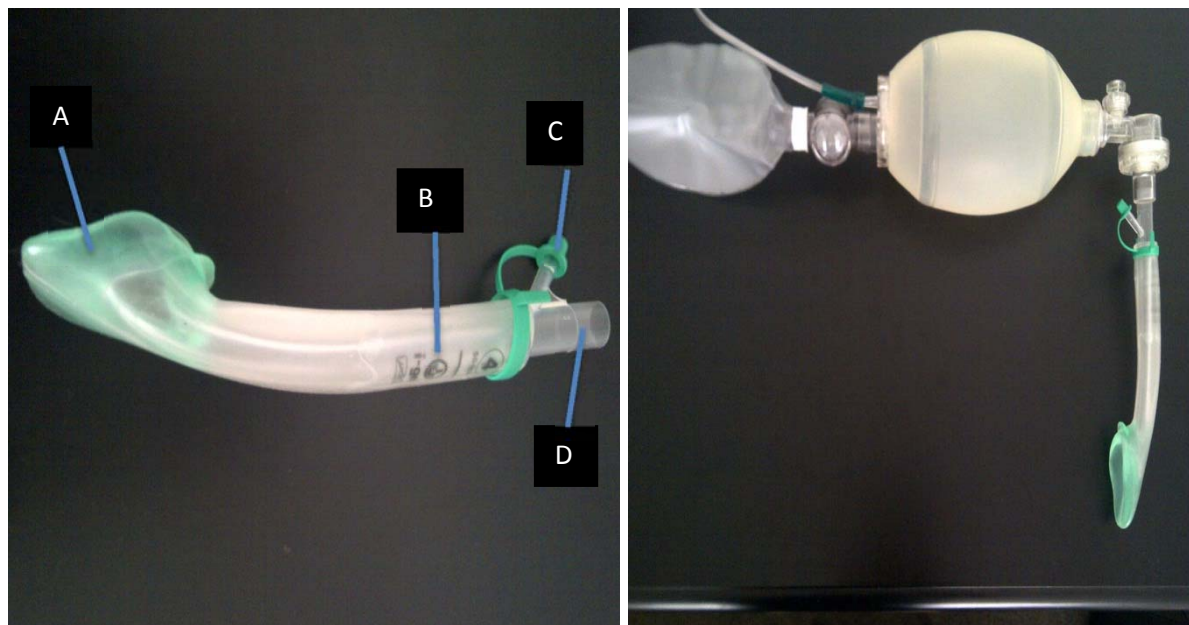
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285 **Figure 1.2: Standard Components of The I-Gel® Airway and Its Use As a Bag-Valve-Tube**
286 **Device. A-gel based, non-inflatable cuff; B-bite block; C-adapter for orogastric tube; D- bag-**
287 **valve-mask adapter**

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

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

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

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315 **BVM versus i-gel airway ® during Single rescuer CPR**

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

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325 **Research method and design**

326 **Design**

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

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336 **Population and Sample**

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

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

356 **Materials**

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

363 **Data collection**

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

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

369 **Data analysis**

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

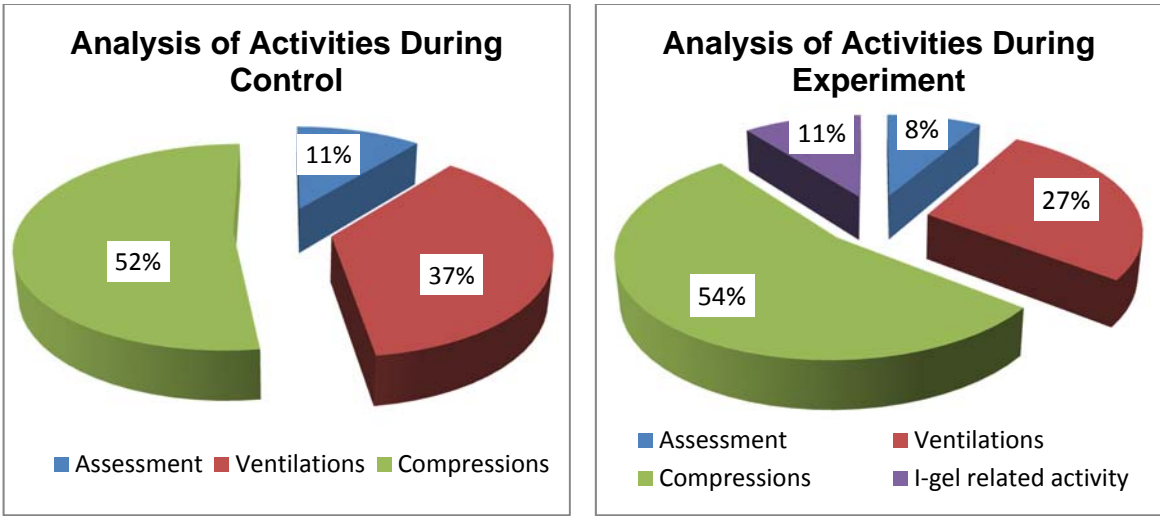
375 **Context of the study**

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

378 **Results**

379 **Duration of Various Activities During Control and Experimental Simulations**

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381 All participant data was combined and used to calculate a mean time spent on each activity.
382 Each of the control simulations were divided into the activities of initial patient assessment,
383 ventilations and compressions, whilst each of the experimental simulations were divided into
384 initial patient assessment, ventilations, compressions as well as i-gel® related activities.
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389 **Figure 1: Comparison of Time Spent on Activities, Expressed as a Percentage**

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

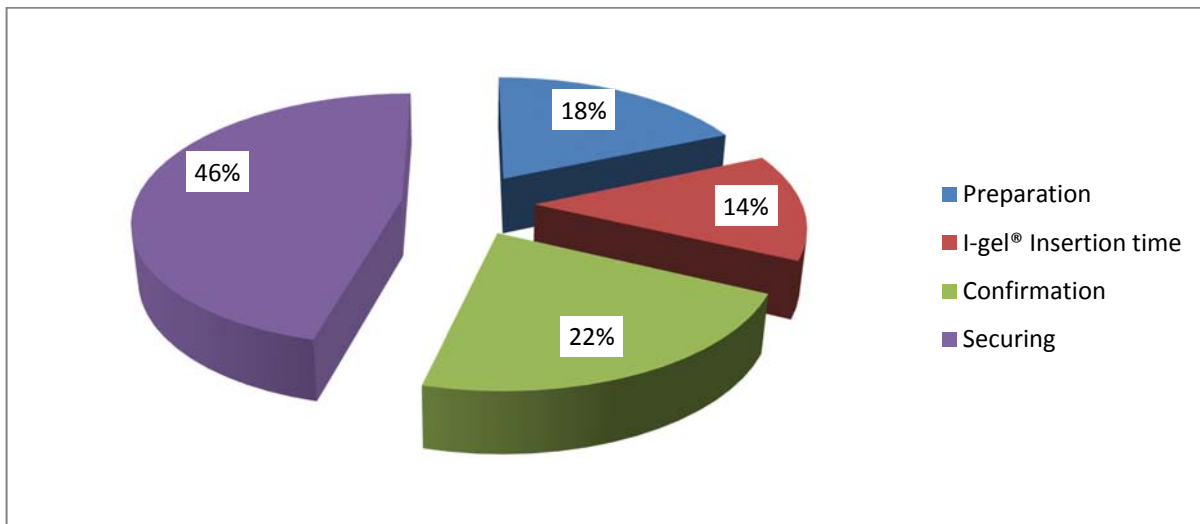
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400 **Overview of i-gel® related activity**

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

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

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

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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®

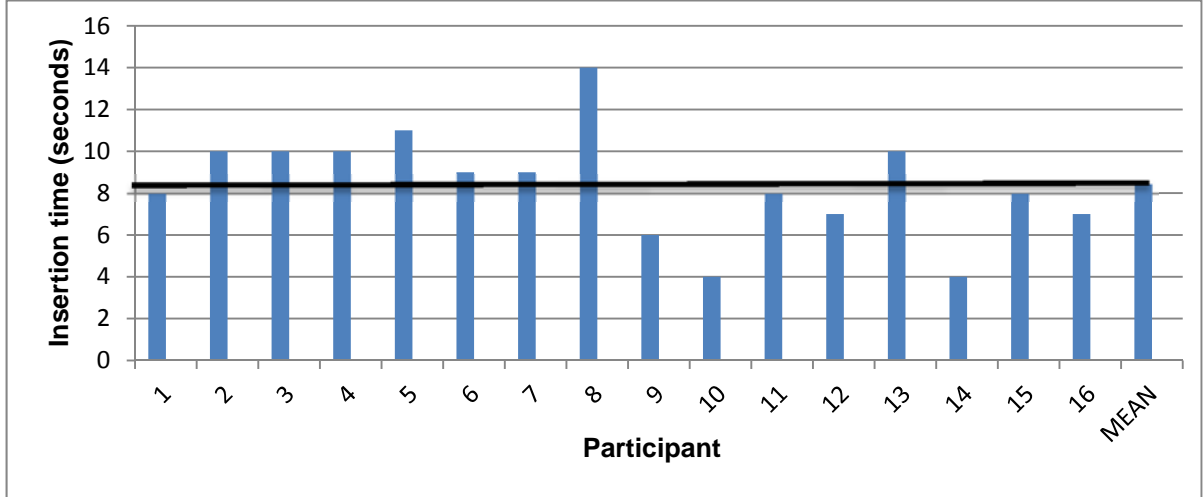
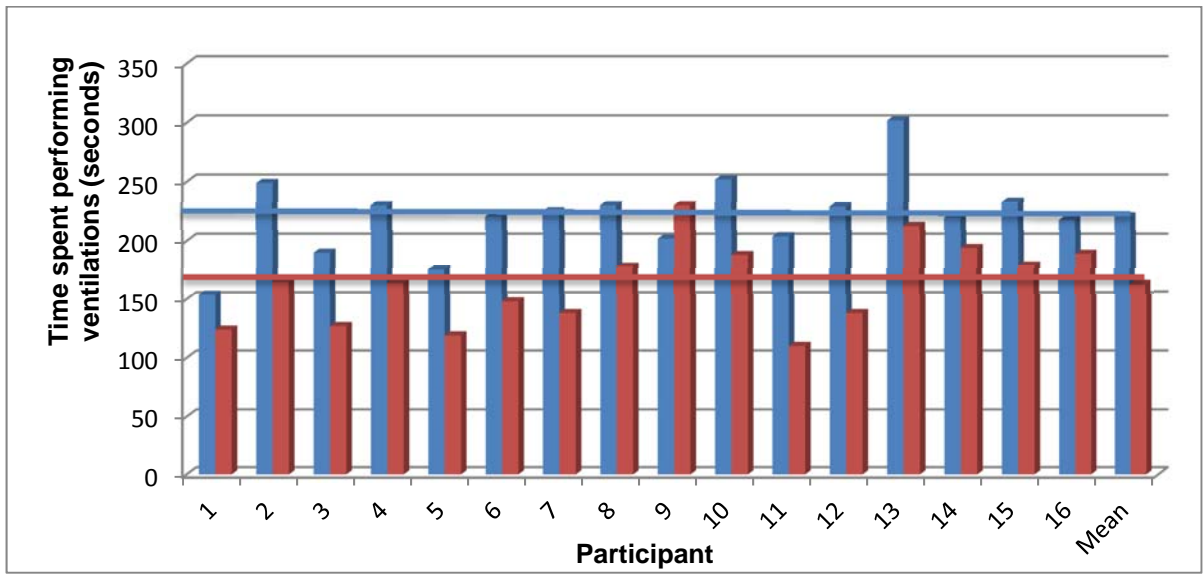


Figure 3: Insertion Time of the I-gel® by Each of the Participants

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



436

437

438 **Figure 4: Mean Total Ventilation Time of Each Participant**

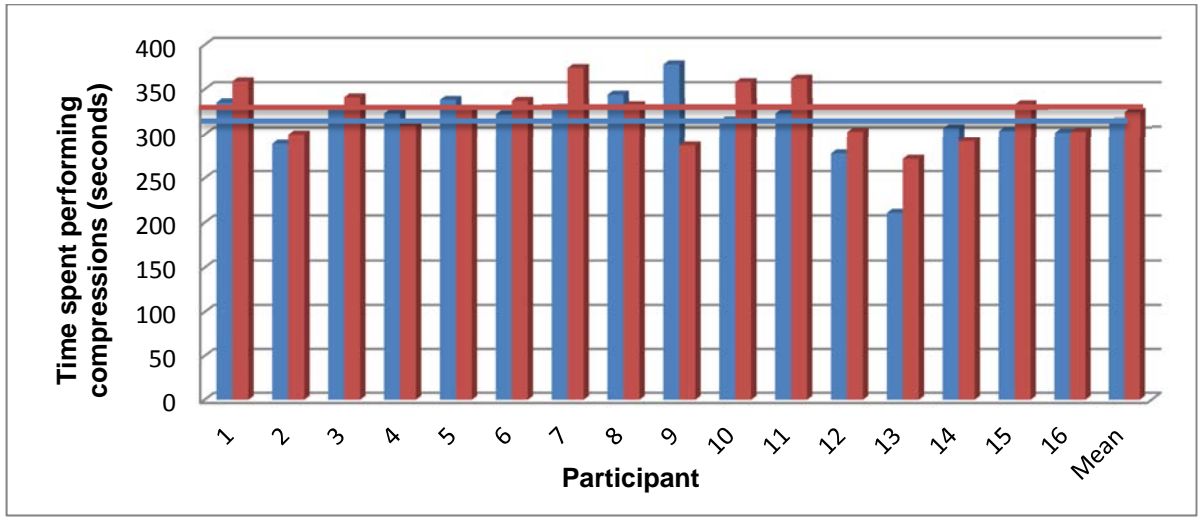
439

440 Figure 4 illustrates the difference in time spent on ventilations during their control and
 441 experimental simulations respectively. The time spent performing ventilations, decreased by
 442 10% from the control simulation using a 'Bag-Valve-Mask' BVM, to the experimental simulation
 443 using the i-gel®. With the insertion of the i-gel® the total time spent performing ventilations
 444 decreased from 221s ± 34s in the control simulation, to 163s ± 35s in the experimental
 445 simulation, a decrease of 58s. The mean time spent performing ventilations per cycle of CPR,
 446 also decreased form 10s ±2s during the control simulation, to 7s ±2s as recorded during the
 447 experimental simulations.

448

449 **The I-gel® airway and compressions cycles**

450



451

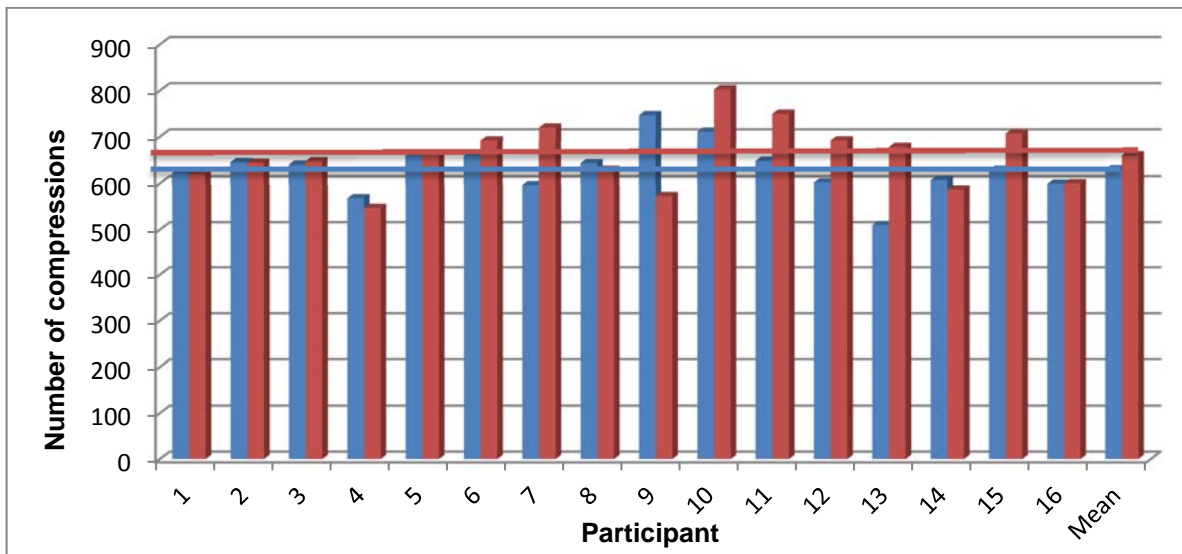
452

453 **Figure 5: Mean Time Spent Performing Chest Compressions**

454

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

460



461

462

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

464

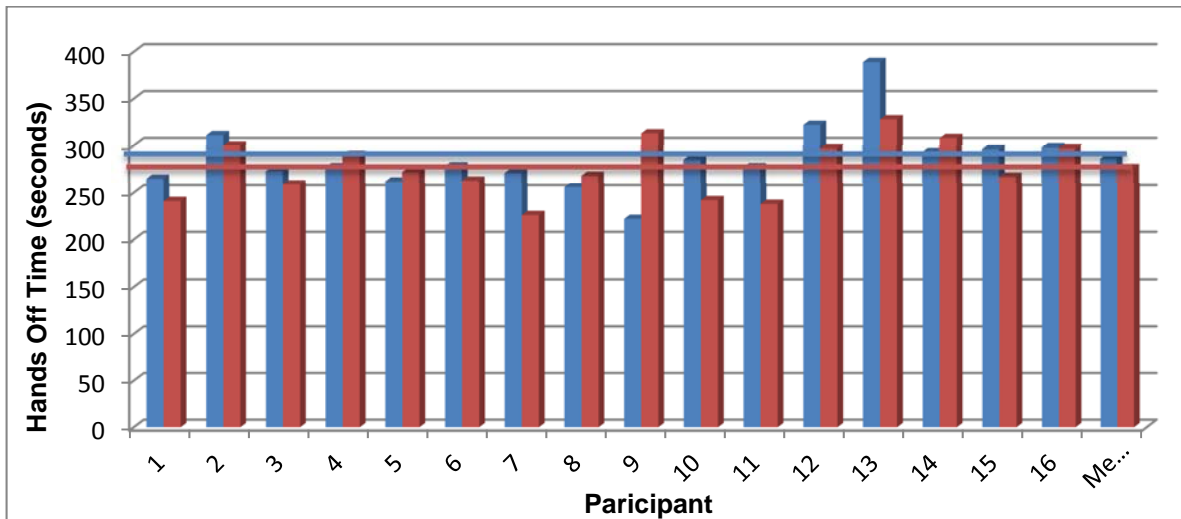
465 Participants performed a mean of 21 \pm 2 compressions cycles in the control, and a mean of 22 \pm 2
466 compression cycles performed during the experiment. Participants performed a greater
467 number of compressions during the experimental simulations. Participants performed a mean
468 of 631 \pm 54 compressions in the control and a mean of 660 \pm 67 compressions during the
469 experiment.

470

471

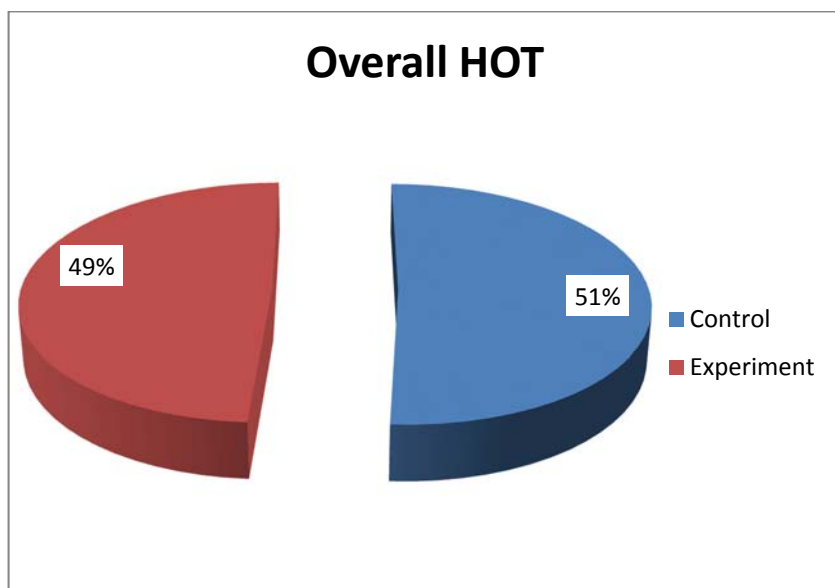
472 **Hands off time**

473



474
475
476 **Figure 7: Mean of the Total HOT as Recorded for Each of the Participants**

477
478 The values represented by the bars in figure 4.7, indicate the total HOT for each participant out
479 of each of the ten minute simulations. The mean HOT calculated from the individual HOT of
480 all the different participants was calculated to be $286s \pm 36s$ during the control simulations. The
481 mean overall HOT for all the participants, calculated during the experimental simulations was
482 calculated to be $276s \pm 30s$ (difference in overall HOT of 10s). The mean HOT per cycle of CPR
483 was also calculated to have decreased from $13s \pm 3s$ in the control simulations to $12s \pm 2s$ for the
484 experimental simulations.



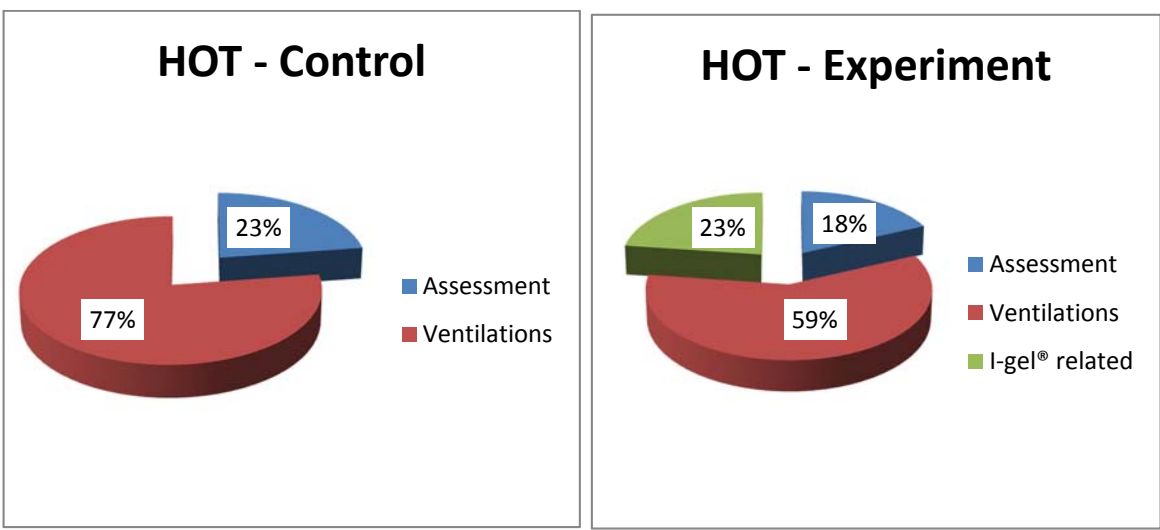
486
487
488 **Figure 8: Percentage of Simulation Recorded as HOT During the Control- and Experimental**
489 **Simulation**

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

496

497 I-gel® and HOT

498



499

500

501 **Figure 9: Comparison between Control and Experimental Activities comprising HOT**

502

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

507

508 The experimental simulation contained a segment of activity not contained within the control
509 simulation. The experimental simulation contained a segment of activity that contributed to
510 23% of HOT which did not occur in the control simulations (i-gel® related HOT activity: 63s ±
511 14s). This means that the use of the i-gel® airway during the experimental simulations resulted
512 in significant decreases in ventilation time (thereby decreasing HOT) but at the same time,
513 introduced a new element of HOT in the form of i-gel® related HOT activity.

514 **Ethical considerations**

515

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

519

520

521 **Recruitment process**

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

526 **Data protection**

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

531 **Reliability**

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

537 **Validity**

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

544 **Discussion**

545 **Outline of results**

546 **The use of the i-gel® airway device introduced a new category of HOT during the** 547 **experimental simulations**

548 Participants spent a mean $63s \pm 14s$ on i-gel® related activity. This translated to 11% of each
549 experimental simulation involving some form of activity related the preparation, insertion,
550 securing and confirmation of the i-gel®. All these activities were included in 'Hands-Off Time'
551 (HOT), as this was a single-rescuer scenario, and all activity involving the airway device,
552 directly resulted in a cessation in the performance of chest compressions. Participants took a
553 mean of $12s \pm 6s$ in order to prepare the device for insertion, whilst taking a mean time of $8s \pm$
554 $3s$ to insert the device successfully. This translated to 18% of the overall i-gel® related HOT
555 occurring as a result of preparation, with only 14% of the same total occurring as a result of the
556 actual insertion of the device. Participants took a mean of $14s \pm 5s$ to confirm the device's
557 correct placement via auscultation (22% of overall i-gel® related HOT). A considerable amount
558 of time was taken to secure the device using Trachy tape (mean of $29s \pm 10s$). The vast majority
559 of HOT accumulated during i-gel® related activity, was as a result of securing the airway
560 device (46% of total i-gel® related HOT).

561

562 **The use of the i-gel® airway changed the distribution of time spent on the activities of** 563 **assessment, ventilations and compressions**

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

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

568 With the insertion of the i-gel®, the total time spent on ventilations, decreased from a mean of
569 $221s \pm 34s$ in the control simulation, to $163s \pm 35s$ in the experimental simulation, a decrease of
570 58s overall. During each cycle of ventilations, that the i-gel® decreased time spent on
571 ventilations per cycle of CPR by 3s. Overall time spent on ventilations, as well as ventilation
572 time per cycle of CPR, decreased quite considerably from the control, to the experimental
573 simulations. The total time spent performing ventilations decreased by 10% from the control
574 simulation using a BVM, to the experimental simulation using the I-gel®.

575

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

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

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

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

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

600

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

607 **Limitations of the study**

608
609 This manikin-based pilot study included a relatively small sample. Even though all steps
610 possible were taken to ensure that the simulation represented as far as possible real life CPR,
611 the participant's familiarity with the manikin may have influenced the incidence of 'Difficult
612 Mask Ventilation' (DMV) compared to that experienced in real patients. It is also possible that,
613 as the manikin used is designed to create optimal conditions for airway management for
614 training purposes, the insertion of the i-gel® airway may possibly have occurred with greater
615 speed and ease than that encountered in real patients

616 **Conclusion and Recommendations**

617
618 No studies have proven the benefit of a single form of airway management strategy over the
619 other, instead, literature indicates that airway management strategies in CPR should be adapted
620 to the specific circumstances surrounding the CPR (Hazinski et al. 2010). In South Africa, ALS
621 paramedics often have to perform single rescuer CPR on scene for several minutes. Latest
622 ILCOR guidelines recommend that ALS practitioners should not be performing ETI when alone
623 with a patient in OHCA, and that BVM ventilations should rather be performed as ETI is not
624 associated with improved outcome (Hazinski et al. 2010). Single rescuer CPR using a BVM is
625 associated with DMV which leads to increased ventilation time and increased HOT (Döriges et
626 al. 2000; Kovacs & Law 2007).

627
628 SADs provide acceptable alternatives to BVM as they mitigate the effects of DMV by removing
629 complications associated with finding an appropriate seal between the mask and the patient's
630 face (Kovacs & Law 2007; Döriges et al. 2000). The i-gel® airway has been proven to be a safe
631 addition to the range of SAD and is known to conform to the perilaryngeal soft tissues well,
632 resulting in an appropriate placement and good seal pressures (Jindal et al. 2009; Abraham et al.
633 2012). The i-gel® airway is associated with short insertion time and significant ease of insertion
634 and could provide a valid alternative to BVM ventilations during single rescuer CPR by
635 mitigating the effect of DMV on HOT (Gatward et al. 2008; Castle et al. 2010).

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

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

641

642 **References**

- 643 Abella, B.S. et al., 2005. Quality of cardiopulmonary resuscitation during in-hospital cardiac
644 arrest. *JAMA*, 293(3), pp.305–310.
- 645 Abraham, J. et al., 2012. Ensuring Patient Safety in Care Transitions : An Empirical Evaluation of
646 a Handoff Intervention Tool Center for Cognitive Studies in Medicine and Public Health ,
647 The New York. In *AMIA Annual Symposium Proceedings 2012*. pp. 17–26.
- 648 Asai, T. & Liu, E., 2010. [The i-gel, a new supraglottic airway]. [Article in Japanese]. *Masui*,
649 59(6), pp.794–797.
- 650 Ashton, A. et al., 2002. Effect of rescuer fatigue on performance of continuous external chest
651 compressions over 3 min. *Resuscitation*, 55(2), pp.151–5. Available at:
652 <http://www.ncbi.nlm.nih.gov/pubmed/12413752>.
- 653 Aufderheide, T.P. et al., 2004. Hyperventilation-induced hypotension during cardiopulmonary
654 resuscitation. *Circulation*, 109(16), pp.1960–5. Available at:
655 <http://www.ncbi.nlm.nih.gov/pubmed/15066941> [Accessed August 14, 2013].
- 656 Berg, R. a et al., 2010. Part 5: adult basic life support: 2010 American Heart Association
657 Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care.
658 *Circulation*, 122(18 Suppl 3), pp.S685–705. Available at:
659 <http://www.ncbi.nlm.nih.gov/pubmed/20956221> [Accessed August 14, 2013].
- 660 Bobrow, B.J. et al., 2008. Minimally interrupted cardiac resuscitation by emergency medical
661 services for out-of-hospital cardiac arrest. *JAMA*, 299(10), pp.1158–1165.
- 662 Bobrow, B.J. et al., 2009. Passive oxygen insufflation is superior to bag-valve-mask ventilation
663 for witnessed ventricular fibrillation out-of-hospital cardiac arrest. *Annals of emergency*
664 *medicine*, 54(5), pp.656–662.e1. Available at:
665 <http://www.ncbi.nlm.nih.gov/pubmed/19660833> [Accessed August 14, 2013].
- 666 Castle, N. et al., 2010. Assessment of the speed and ease of insertion of three supraglottic airway
667 devices by paramedics : a manikin study. *Emergency Medicine Journal : EMJ*, 27, pp.860–863.
- 668 Christenson, J. et al., 2009. Chest compression fraction determines survival in patients with out-
669 of-hospital ventricular fibrillation. *Circulation*, 120(13), pp.1241–7. Available at:
670 [http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2795631&tool=pmcentrez&](http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2795631&tool=pmcentrez&rendertype=abstract)
671 [rendertype=abstract](http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2795631&tool=pmcentrez&rendertype=abstract) [Accessed August 14, 2013].
- 672 Don Michael, T., 1985. Comparison of the esophageal obturator airway and endotracheal
673 intubation in prehospital ventilation during CPR. *Chest*, 87(6), pp.814–819.

- 674 Döriges, V. et al., 2000. Emergency airway management by intensive care unit nurses with the
675 intubating laryngeal mask airway and the laryngeal tube. *Critical Care*, 4(6), pp.369–376.
- 676 Eftestol, T., 2002. Effects of Interrupting Precordial Compressions on the Calculated Probability
677 of Defibrillation Success During Out-of-Hospital Cardiac Arrest. *Circulation*, 105(19),
678 pp.2270–2273. Available at:
679 <http://circ.ahajournals.org/cgi/doi/10.1161/01.CIR.0000016362.42586.FE> [Accessed
680 August 14, 2013].
- 681 Gatward, J.J. et al., 2008. CRITICAL CARE Effect of chest compressions on the time taken to
682 insert airway devices in a manikin. *British Journal of Anaesthesia*, 100(3), pp.351–356.
- 683 Hazinski, M.F. et al., 2010. Part 1: Executive summary: 2010 International Consensus on
684 Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With
685 Treatment Recommendations. *Circulation*, 122(16 Suppl 2), pp.S250–75. Available at:
686 <http://www.ncbi.nlm.nih.gov/pubmed/20956249> [Accessed August 14, 2013].
- 687 Heidenreich, J. et al., 2006. Rescuer Fatigue: Standard versus Continuous Chest-Compression
688 Cardiopulmonary Resuscitation. *Academic Emergency Medicine*, 13(10), pp.1020–1026.
- 689 Jindal, P., Rizvi, A. & Sharma, J., 2009. Is i-Gel a new revolution among supraglottic airway
690 devices? *Middle East Journal of Anesthesiology*, 20(1), pp.53–58.
- 691 Kannaujia, A. et al., 2009. A Preliminary Study of I-Gel : A New Supraglottic Airway Device.
692 *Indian Journal of Anaesthesia*, 53(1), pp.52–56.
- 693 Kern, K. et al., 2002. Importance of continuous chest compressions during cardiopulmonary
694 resuscitation: Improved outcome during a simulated single lay-rescuer scenario.
695 *Circulation*, 105(5), pp.645–649. Available at:
696 <http://circ.ahajournals.org/cgi/doi/10.1161/hc0502.102963> [Accessed August 14, 2013].
- 697 Kovacs, G. & Law, J.A., 2007. *Airway Management in Emergencies*. Chicago. McGraw-Hill
698 Companies.,
- 699 Langeron, O. et al., 2000. Prediction of Difficult Mask Ventilation. *Anesthesiology*, 92(5), pp.1229–
700 1236.
- 701 Levitan, R.M. & Kinkle, W.C., 2005. Initial anatomic investigations of the I-gel airway: a novel
702 supraglottic airway without inflatable cuff. *Anaesthesia*, 60(10), pp.1022–6. Available at:
703 <http://www.ncbi.nlm.nih.gov/pubmed/16179048> [Accessed August 18, 2013].
- 704 Manders, S. & Geijsel, F.E.C., 2009. Alternating providers during continuous chest
705 compressions for cardiac arrest: every minute or every two minutes? *Resuscitation*, 80(9),
706 pp.1015–8. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/19576676> [Accessed
707 August 18, 2013].
- 708 Nolan, J.P. et al., 2010. European Resuscitation Council Guidelines for Resuscitation 2010
709 Section 1. Executive summary. *Resuscitation*, 81(10), pp.1219–76. Available at:
710 <http://www.ncbi.nlm.nih.gov/pubmed/20956052> [Accessed May 25, 2014].

- 711 Perkins, G.D. et al., 2012. Out-of-hospital cardiac arrest : recent advances in resuscitation and
712 effects on outcome. *Heart*, 98, pp.529–535.
- 713 Richez, B. et al., 2008. A New Single Use Supraglottic Airway Device with a Noninflatable Cuff
714 and an Esophageal Vent : An Observational Study of the i-Gel. *Anesthesia and Analgesia*,
715 106(4), pp.1137–1139.
- 716 Ruetzler, K. et al., 2011. Hands-off time during insertion of six airway devices during
717 cardiopulmonary resuscitation: a randomised manikin trial. *Resuscitation*, 82(8), pp.1060–3.
718 Available at: <http://www.ncbi.nlm.nih.gov/pubmed/21514986> [Accessed August 18,
719 2013].
- 720 Stone, B.J., Chantler, P.J. & Baskett, P.J., 1998. The incidence of regurgitation during
721 cardiopulmonary resuscitation: a comparison between the bag valve mask and laryngeal
722 mask airway. *Resuscitation*, 38(1), pp.3–6. Available at:
723 <http://www.ncbi.nlm.nih.gov/pubmed/9783502>.
- 724 Sugerman, N.T. et al., 2009. Rescuer fatigue during actual in-hospital cardiopulmonary
725 resuscitation with audiovisual feedback: a prospective multicenter study. *Resuscitation*,
726 80(9), pp.981–4. Available at:
727 [http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2746377&tool=pmcentrez&r
728 endertype=abstract](http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2746377&tool=pmcentrez&rendertype=abstract) [Accessed August 18, 2013].
- 729 Wang, H.E. et al., 2009. Interruptions in cardiopulmonary resuscitation from paramedic
730 endotracheal intubation. *Annals of emergency medicine*, 54(5), pp.645–652.e1. Available at:
731 <http://www.ncbi.nlm.nih.gov/pubmed/19573949> [Accessed August 18, 2013].
- 732 Wharton, N.M. et al., 2008. I-gel insertion by novices in manikins and patients. *Anaesthesia*,
733 63(9), pp.991–5. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18557971> [Accessed
734 August 18, 2013].
- 735 Wiese, C.H.R. et al., 2008. Influence of airway management strategy on “no-flow-time” during
736 an “advanced life support course” for intensive care nurses - a single rescuer resuscitation
737 manikin study. *BMC emergency medicine*, 8(4). Available at:
738 [http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2324096&tool=pmcentrez&r
739 endertype=abstract](http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2324096&tool=pmcentrez&rendertype=abstract) [Accessed August 14, 2013].
- 740 Yannopoulos, D. & Aufderheide, T., 2007. Acute management of sudden cardiac death in adults
741 based upon the new CPR guidelines. *Europace : European pacing, arrhythmias, and cardiac*
742 *electrophysiology : journal of the working groups on cardiac pacing, arrhythmias, and cardiac*
743 *cellular electrophysiology of the European Society of Cardiology*, 9(1), pp.2–9. Available at:
744 <http://www.ncbi.nlm.nih.gov/pubmed/17224415> [Accessed August 18, 2013].
- 745 Zaritsky, A. & Morley, P.T., 2005. Consensus Conference on Cardiopulmonary Resuscitation.
746 *Circulation*, 112, pp.III-128 – III-130.