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The impact of the COVID-19 pandemic on airway management with supraglottic airway devices among out-of-hospital cardiac arrests: a systematic review and meta-analysis

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Medical Research Journal 2024;
Volume 9, Number 1, 82–89
DOI: 10.5603/mrj.98670

ISSN 2451-2591
e-ISSN 2451-4101

ABSTRACT

Introduction: The COVID-19 pandemic has led to increased cases of out-of-hospital cardiac arrest (OHCA), impacting emergency medical services and necessitating changes in resuscitation protocols to protect healthcare workers from virus transmission. Amidst these challenges, there's a shift in prehospital airway management techniques, with a renewed focus on endotracheal intubation over supraglottic airway devices for better protection against aerosol spread during cardiopulmonary resuscitation. This systematic review and meta-analysis aimed to examine the influence of the COVID-19 pandemic on the use of SGA as a method of securing the airway during out-of-hospital cardiac arrest.

Material and methods: PubMed Central, Scopus, EMBASE, and the Cochrane Library databases were systematically searched. English-language literature was searched up to December 5th, 2023. This search was conducted by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. Fixed and random effects models were used to undertake the meta-analysis when appropriate. The risk of bias was assessed through the Newcastle-Ottawa Scale.

Results: Fifteen studies met the inclusion criteria for the meta-analysis. Pooled analysis showed that SGAs were chosen as the method of airway protection in 46.3% and 49.8% of cases, pre- *vs.* during the COVID-19 pandemic (OR = 0.76; 95%CI: 0.65 to 0.90; p = 0.001). In the case of endotracheal intubation, statistically significant differences were also observed in the frequency of use during OHCA in the pre-pandemic period vs. during the COVID-19 pandemic period (19.0% *vs.* 14.2%, respectively; OR = 1.66; 95%CI: 1.20 to 2.28; p = 0.002).

Conclusions: The study's conclusions indicate a significant increase in the use of supraglottic airway devices during the COVID-19 pandemic for out-of-hospital cardiac arrests. Additionally, a decrease in the use of endotracheal intubation was observed. Effective airway management correlates with better outcomes after cardiac arrests, although the specific impact of these techniques during the pandemic remains unclear.

Keywords: COVID-19, pandemic, airway management, supraglottic airway devices, endotracheal tube, out-of-hospital cardiac arrests, systematic review, meta-analysis

Med Res J 2024; 9 (1): 82–89

Introduction

Since late 2019, the global community has been grappling with the SARS-CoV-2 virus and the resulting COVID-19 illness [1–3]. The COVID-19 pandemic leads to deaths and has significant effects on other health indicators, particularly in emergencies. Overburdened healthcare systems have had an impact on out-of-hospital cardiac arrest (OHCA) [4, 5]. There has been an increase in OHCA in recent years, which is believed to be linked to COVID-19-related illnesses, patients' difficulty getting preventive or general medical treatment, and their unwillingness to seek care due to the risk of COVID-19 transmission in hospitals [6, 7]. The challenge arises from the potential transmission of the SARS-CoV-2 virus to first responders who are engaged in administering cardiopulmonary resuscitation (CPR), necessitating careful consideration of how to effectively handle CPR during the pandemic [8, 9]. Emergency Medical Service (EMS) staff, in addition to traditional resuscitative techniques, carry out endotracheal intubation (ETI), which is a process that generates aerosols and may spread virus particles [10]. Furthermore, OHCA management standards have been altered to safeguard healthcare professionals from contracting COVID-19. As an example, EMS providers are already required to wear suitable personal protection equipment (PPE) [11–13]. An essential aspect of cardiac resuscitation is ensuring the openness of the airway and providing breathing assistance. Nevertheless, several studies have shown that the execution of medical treatments while wearing PPE for aerosol-generating procedures (AGP) is challenging and often necessitates much more time compared to doing the same procedures in normal settings without PPE-AGP [12–17]. Amidst the COVID-19 pandemic, it is crucial to minimize the production of aerosols and prevent healthcare workers from becoming contaminated. The CPR guidelines advise reducing interruptions in chest compressions to enhance the efficacy of CPR [18]. To achieve this objective, it is necessary to secure the respiratory tract using either an ETI or supraglottic airway device (SGA). In recent years, paramedics have shifted their approach to prehospital airway management, moving away from ETI and towards the use of SGA [19]. The learning and retention of skills for ETI have proved challenging, and data suggests that SGA is just as effective as ETI in cases of OHCA [20, 21]. However, in the backdrop of the COVID-19 pandemic, ETI has had a resurgence. When the requirement is satisfied, it is advised that a full seal of the trachea offers superior protection against the release of aerosols and reduces the risk of infection for healthcare professionals in comparison to SGA, or bag-mouth ventilation, during CPR [22, 23].

Therefore, it was chosen to examine the extent to which the use of SGA techniques has evolved throughout the current pandemic, relying on the existing body of research. The main objective of this research was to investigate the influence of the COVID-19 pandemic on the use of the SGA to maintain the potency of the respiratory tract during resuscitation. The secondary goal was to assess the correlation between these changes and ETI practice during the pandemic.

Material and methods

For the current systematic review and meta-analysis, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [24] were followed, and its protocol with PROSPERO (CRD42023489716) was pre-registered.

Eligibility criteria

Studies were included if they met the following eligibility criteria: (1) cohort studies or case-control studies; (2) the study population was composed of adult patients with out-of-hospital cardiac arrest; and (3) presenting data on the frequency of airway protection using SGA during resuscitation in the period before and during the pandemic. The following types of articles were excluded: articles other than original research (e.g., systematic reviews, review articles, case reports or series, letters to editors or commentaries, editorials), duplicate publications, and non-English articles.

Search strategy and study selection

Two authors (M.D. and M.P.) independently conducted the literature search. They systematically searched PubMed Central, Scopus, EMBASE, and the Cochrane Library with the search terms: "coronavirus disease 2019" OR "COVID-19" OR "COVID 19" OR "COVID19" OR "novel coronavirus" OR "2019 novel coronavirus" OR "2019-nCoV" OR "2019 nCoV" OR "severe acute respiratory syndrome coronavirus 2" OR "SARS-CoV "OR "SARS-CoV-2" AND "laryngeal mask" OR "laryngeal mask airway" OR "LMA" OR "LMA-C" OR "LMA ProSeal" OR "LMA Supreme" OR "i-gel" OR "IGEL" OR "I gel" OR "Cobra Perilaryngeal Airway" OR "CobraPLA" OR "Cobra PLA" OR "Streamlined Liner of the Pharynx Airway" OR "SLIPA" OR "laryngeal tube suction" OR "LTS" OR "Ambu AuraGain" OR "air-Q" OR "supraglottic airway device" OR "SGD" OR "supraglottic airway" OR "SGA" AND "out-of-hospital cardiac arrest" OR "out-of-hospital ventricular fibrillation/ventricular tachycardia/asystole/pulseless electrical activity" OR "OHCA". Studies were limited to those published in the English language and studies involving adult OHCA patients, inclusive of all studies published up to January 2020. Retrieved were all relevant literature up to December 5th, 2023, with an English language restriction. Additionally, a manual search of the article references was also performed.

Data extraction

Two independent reviewers (M.D. and K.B.) performed the data extraction. Data extraction was performed in Excel (Microsoft Corp., Redmond, WA, USA) format. The following data were extracted from the studies: first author, year of publication, study design, country, sample size, age, gender, comorbidities, SGA and ETI use, survival to hospital discharge (SHD), and survival to hospital discharge with good neurological outcome (defined as 1–2 grade according to the Cerebral Performance Categories Scale) [25]. For publications lacking sufficient information on predictive accuracy to calculate the 2×2 contingency tables, the corresponding authors were asked for help via email. Studies were excluded if a second email received no response. Any disagreements between the investigators were discussed, and an agreement was reached through consensus.

Quality assessment

The Newcastle-Ottawa Scale (NOS) was used to assess the quality of every included study. This scale considered factors such as the comparability of study groups, the selection of subjects, and the attainment of study outcomes [26]. Research with a total score of ≥ 7 was deemed to be of high quality [26], while the maximum possible score attained using this tool was 0–9. To rate the quality of the research included in this study, the Modified Newcastle-Ottawa Scale (modified NOS) was used, which is a variation of the original NOS that includes some changes to ensure a full assessment of cross-sectional studies [27]. The total scores ranged from 0 to 9, where a value ≥ 7 was considered good-quality research [27]. Two authors (MD and MP) independently assessed the risk of bias in the included studies. Any disagreements were resolved through a consensus between them or discussed with a third author (LS).

Statistical analysis

All statistical analyses were conducted with STATA V.18.0 (StataCorp, College Station, TX, USA) and Review Manager V.5.4 (RevMan, Cochrane Collaboration, Denmark). All tests were two-tailed, with a significance level of 0.05. The pooled odds ratio (OR) or mean difference (MD) and their 95% confidence intervals (CIs) were calculated for each outcome. In cases where continuous outcomes were reported as median, range, and interquartile range, means and standard deviations were estimated using the formula described by Hozo et al. [28]. The I^2 statistic was used to measure statistical heterogeneity between studies. Values of 25%, 50%, and 75% were used as cut-off points for low, moderate, and high levels of heterogeneity, respectively [29]. Egger's test and funnel plots were utilized to check for possible bias and funnel plot tests for asymmetry to assess potential publication bias if more than ten trials were included in a single meta-analysis. Additionally, a sensitivity analysis using leave-one-out was performed to test for the robustness of the findings.

Ethics statement

Due to the fact that this study utilized publicly available data, there was no need for protocol review or obtaining informed consent.

Results

A total of 1644 potentially relevant records were identified through the literature search, out of which 1629 were screened for eligibility using duplicates, abstracts and full texts. The search process is illustrated in Figure 1.

Overall, fifteen studies were included in the following meta-analysis, including 183,421 OHCAs [30–44]. Studies were published between 2020 and 2023 and were conducted in Australia, Canada, Taiwan, the USA, Japan, Thailand, Korea, and Spain. The detailed information for each included study is shown in Table 1. Based on NOS evaluation, all 15 studies were considered high quality (Tab. 1).

Fifteen studies reported SGA use as a method of OHCA airway management before and during the COVID-19 pandemic. Pooled analysis showed that SGAs were chosen as the method of airway protection in 46.3% and 49.8% of cases, pre- *vs.* during the COVID-19 pandemic (OR = 0.76; 95%CI: 0.65 o 0.90; p = 0.001; Fig. 2). Endotracheal intubation was used

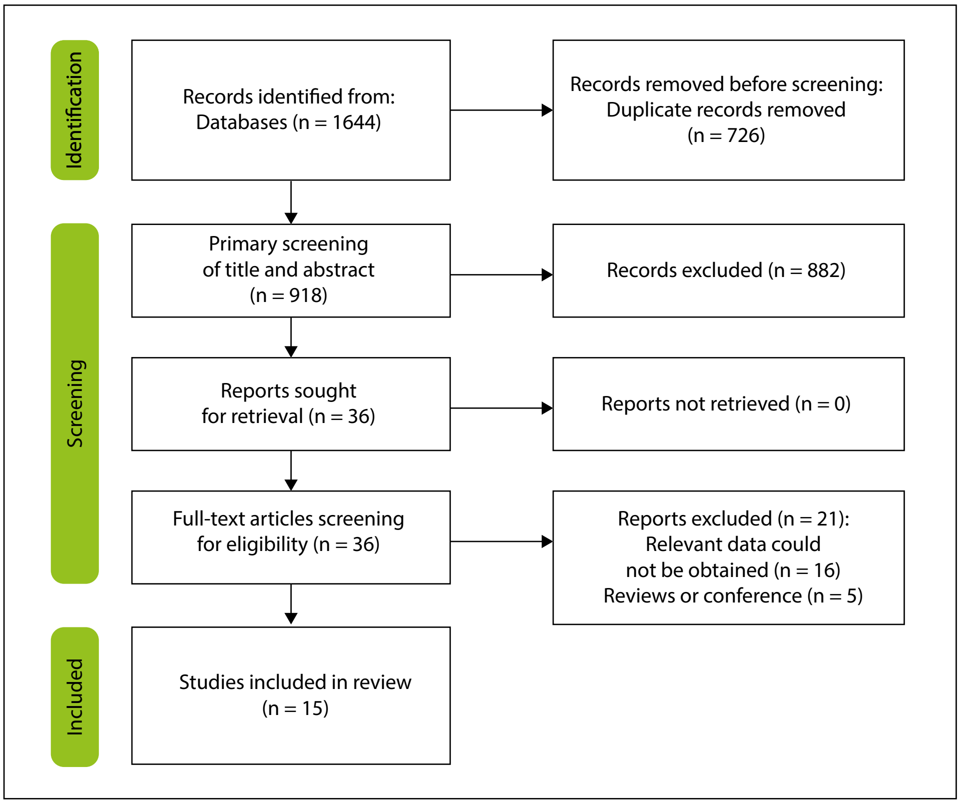

Figure 1. Flow diagram of the search strategy and study selection

19.0% more during OHCA in the pre-pandemic period than during the COVID-19 pandemic (19.0% *vs.* 14.2%, respectively; OR = 1.66; 95%CI: 1.20 to 2.28; p = 0.002; Fig. 3). Such differences were statistically significant.

Discussion

The following meta-analysis found a statistically significant rise in the frequency of SGA use during the COVID-19 pandemic compared to the time before the pandemic. Additionally, the research studies which were looked at indicated a decrease in the choice of ETI during the COVID-19 pandemic, according to the present meta-analysis. SGA devices play an important role in airway management, especially in emergencies. The choice between ETI and SGA depends on the circumstances in which the OHCA occurred, including the clinical context and the expertise of the paramedics. In safety-related aspects, SGA first pass success (FPS) was higher than that of ETI FPS, regardless of the patient's age [45]. Presently, according to existing knowledge, the authors are aware that both SGA and ETI provide similar levels of respiratory protection. This conclusion is based on the findings of a recently performed cluster randomized trial, which demonstrated equivalent outcomes in terms of favourable outcomes between SGA and ETI [46]. When comparing tracheal intubation to the use of an SGA, the SGA offers advantages such as quicker insertion, less coughing, resulting in a lower risk of aerosolization, and increased oxygen saturation throughout the recovery process [47]. In addition, while inserting an SGA, the EMS may position themselves at a greater distance from the patient's face compared to using direct laryngoscopy. The increase in the use of SGA at the expense of ETI may, therefore, be justified due to the protective measures taken by paramedics to protect against COVID-19 infection. It is also important that using SGA has a higher chance of first-attempt airway success, which may limit the spread of aerosols. Moreover, the mean scene time interval as well as the call-to-airway time are shorter when using SGA. All this minimizes the risk of aerosol dispersion, reducing paramedics' exposure to aerosols and thus increasing their safety. If the procedure is performed using SGA, it is recommended to use a HEPA filter [48].

Additionally, effective airway management increases the chance of positive outcomes after OHCA. During the COVID-19 pandemic, the prognosis after OHCA significantly worsened, i.e., the incidence of

Table 1. Baseline characteristics of included trials

Study	Country	Study design	Period group	No. of patients	Age [years]	Sex, male	SHD	SHD with good neuro-logical outcome	NOS score
Armour et al., 2023	Canada	Retrospective cohort analysis of prospective registry	BP	12,947	66 (52–78)	8693 (67)	NS	NS	8
			DP	17,488	65 (50–77)	10,563 (67)	NS	NS	
Fan et al., 2023	Taiwan	Retrospective cohort study	BP	1605	71.3 (16.1)	969 (60.4)	189 (11.8)	119 (7.4)	9
			DP	1214	70.5 (15.7)	747 (61.5)	134 (11.0)	71 (5.8)	
Glober et al., 2021	USA	Retrospective cohort study	BP	884	62.4 (48.8–73.2)	544 (61.5)	NS	NS	8
			DP	1034	60.3 (46.9–71.8)	622 (60.2)	NS	NS	
Hosomi et al., 2022	Japan	Population-based retrospective cohort study	BP	39,324	79 (69–87)	23,593 (60.0)	2457 (7.7)	NS	8
			DP	31,894	83 (76–89)	18,195 (57.0)	2096 (6.6)	NS	
Huabbangyang et al., 2023	Thailand	Retrospective observational study	BP	513	64.18 (19.94)	320 (62.4)	NS	NS	8
			DP	482	65.18 (18.16)	304 (63.1)	NS	NS	
Kennedy et al., 2023	Australia	Interrupted time-series analysis	BP	3976	69 (56–80)	2100 (64.5)	879 (30.3)	NS	8
			DP	1058	68 (56–80)	523 (64.1)	265 (32.8)	NS	
Kim et al., 2023	Korea	Cross-sectional, retrospective, observational study	BP	25,355	67.6 (17.0)	16,373 (64.6)	NS	NS	8
			DP	26,566	68.0 (16.9)	17,056 (64.2)	NS	NS	
Lai et al., 2020	USA	Population-based, cross-sectional study	BP	1336	68 (19)	752 (57.1)	NS	NS	8
			DP	3989	72 (18)	2183 (55.8)	NS	NS	
Liu et al., 2023	Taiwan	RS	BP	567	76 (64–85)	313 (55.4)	30 (5.3)	29 (5.1)	9
			DP	497	78 (65–85)	292 (59.0)	11 (2.2)	9 (1.8)	
Navalpotro-Pascual 2021	Spain	PS	BP	306	72 (60–83)	199 (65.0)	18 (8.7)	13 (4.8)	8
			DP	313	72 (62–81)	189 (60.4)	4 (1.3)	4 (1.3)	
Navalpotro-Pascual 2022	Spain	RS	BP	1781	72 (59–82)	1178 (66.1)	128 (12.9)	NS	8
			DP	1743	71 (57–81)	1117 (64.0)	91 (10.3)	NS	
Ortiz et al., 2020	Spain	RS	BP	1723	65.6 (16.9)	1208 (70.2)	168 (9.8)	NS	9
			DP	1446	64.4 (16.5)	1027 (71.1)	108 (7.5)	NS	
Riyapan et al., 2022	Thailand	RS	BP	341	62.7 (18.5)	210 (61.6)	25 (7.7)	NS	8
			DP	350	63.4 (19.4)	208 (59.4)	7 (2.2.)	NS	
Sugiyama et al., 2023	Japan	RS	BP	1637	80 (0–105)	918 (56.1)	93 (5.7)	27 (1.7)	8
			DP	1730	80 (0–104)	1018 (58.8)	64 (3.7)	12 (0.7)	
Yu et al., 2021	Taiwan	RS	BP	570	70.9 (16.5)	353 (61.9)	34 (5.96)	24 (4.2)	8
			DP	622	70.4 (16.2)	394 (63.3)	31 (4.98)	13 (2.1)	

BP — before pandemic; DP — during pandemic; NOS — Newcastle-Ottawa Scale; NS — not specified; PS — prospective study; RS — retrospective study; SHD — survival to hospital discharge

prehospital return of spontaneous circulation decreased and SHD decreased [49]. It is not known whether there is a relationship between the change in the frequency of ETI *vs.* SGA and the prognosis after OHCA during the COVID-19 pandemic. The results of studies aimed at comparing the effectiveness between ETI and SGA are contradictory; however, there are many variables influencing the worse prognosis of patients after OHCA during the COVID-19 pandemic, so the above-mentioned relationship seems unlikely. There is also no difference between SGA and ETI in terms of health-related quality of life or the cost-effectiveness of both procedures [50].

There are also some limitations, which should be highlighted. First, there is a large geographical spread among the studies included in this meta-analysis. Each healthcare system has its own specificity; therefore, there may be preferences among paramedics regarding

Study or subgroup	Before pandemic Events	Before pandemic Total	During pandemic Events	During pandemic Total	Weight	Odds Ratio M-H, Random, 95%CI
Armour 2023	3292	12947	5039	17488	8.3%	0.84 [0.80, 0.89]
Fan 2023	9	1605	52	1214	3.3%	0.13 [0.06, 0.26]
Glober 2021	379	884	725	1034	7.6%	0.32 [0.26, 0.39]
Hosomi 2022	13964	39324	14990	39170	8.4%	0.89 [0.86, 0.91]I
Huabbangyang 2023	54	513	24	482	4.8%	2.2S [1.36, 3.69]
Kennedy 2023	1280	3976	499	1058	7.9%	0.53 [0.46, 0.61]
Kim 2023	20997	25355	23312	26566	8.3%	0.67 [0.64, 0.71]
Lai 2020	193	1336	1385	3989	7.8%	0.32 [0.27, 0.37]
Liu 2023	478	567	358	497	6.6%	2.09 [1.55, 2.81]1
Navalpotro--Pascual 2021	32	306	33	313	4.7%	0.99 [0.59, 1.66]
Navalpotro--Pascual 2022	780	1781	642	1743	8.0%	1.34 [1.17, 1.53]
Ortiz 2020	103	1560	168	1423	7.0%	0.53 [0.41, 0.68]
Riyapan 2022	17	254	12	261	3.1%	1.49 [0.70, 3.18]
Sugiyama 2023	766	1637	829	1730	8.0%	0.96 [0.83, 1.09]
Yu 2021	499	570	537	622	6.2%	1.11 [0.79, 1.56]
Total (95% CI)		**92615**		**97590**	**100.0%**	**0.76 [0.65, 0.90]**
Total events	42843		48605			

Heterogeneity: Tau² = 0.09; Chi² = 504.28, df = 14 (P < 0.00001); I² = 97%
Test for overall effect: Z = 3.19 (P = 0.001)

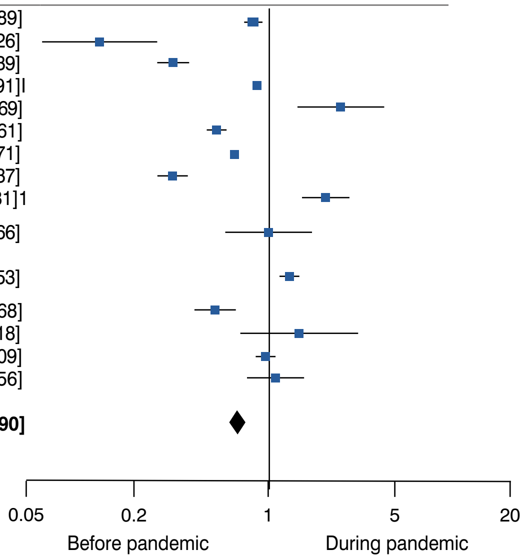

Figure 2. Forest plot of airway management with supraglottic airway devices (SGA) among COVID-19 pandemic vs. pre-pandemic periods. The centre of each square represents the odds ratios for individual trials, and the corresponding horizontal line stands for a 95% confidence interval. The diamonds represent pooled results.

Study or subgroup	Before pandemic Events	Before pandemic Total	During pandemic Events	During pandemic Total	Weight	Odds Ratio M-H, Random, 95%CI
Armour 2023	5248	12947	3308	17488	7.9%	2.92 [2.77, 3.08]
Fan 2023	973	1605	785	1214	7.8%	0.84 [0.72, 0.98]
Glober 2021	350	884	97	1034	7.6%	6.33 [4.94, 8.12]
Hosomi 2022	3540	39324	3565	39170	7.9%	0.99 [0.94, 1.04]
Huabbangyang 2023	236	513	250	482	7.6%	0.79 [0.62, 1.01]
Kennedy 2023	1480	3976	398	1058	7.8%	0.98 [0.85, 1.13]
Kim 2023	2067	25355	1557	26566	7.9%	1.43 [1.33, 1.53]
Lai 2020	1011	1336	1915	3989	7.8%	3.37 [2.93, 3.87]
Navalpotro--Pascual 2021	135	306	85	313	7.3%	2.12 [1.51, 2.96]
Navalpotro--Pascual 2022	780	1781	642	1743	7.8%	1.34 [1.17, 1.53]
Ortiz 2020	1224	1560	858	1423	7.8%	2.40 [2.04, 2.82]
Riyapan 2022	160	254	118	261	7.2%	2.06 [1.45, 2.93]
Sugiyama 2023	137	1637	158	1730	7.6%	0.91 [0.72, 1.15]
Total (95% CI)		**91478**		**96471**	**100.0%**	**1.66 [1.20, 2.28]**
Total events	17341		13736			

Heterogeneity: Tau² = 0.34; Chi² = 1337.47, df = 12 (P < 0.00001); I² = 99%
Test for overall effect: Z = 3.09 (P = 0.002)

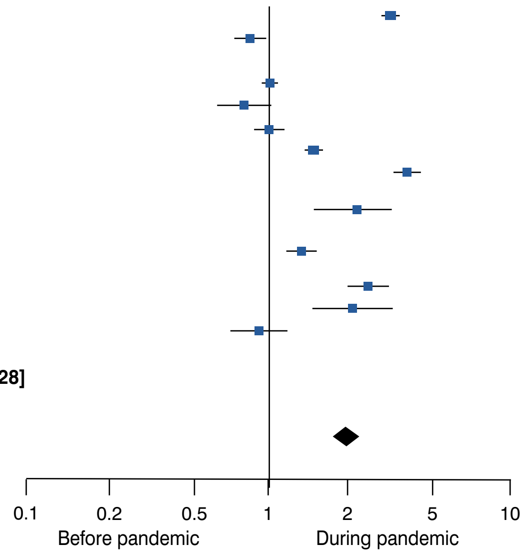

Figure 3. Forest plot of airway management with endotracheal intubation (ETI) among COVID-19 pandemic vs. pre-pandemic periods. The centre of each square represents the odds ratios for individual trials, and the corresponding horizontal line stands for a 95% confidence interval. The diamonds represent pooled results

the use of advanced respiratory management techniques. Moreover, the period of the COVID-19 pandemic is very heterogeneous. For example, during the initial period of the pandemic, the use of healthcare system resources was so high that it may have influenced paramedics' choice between SGA and ETI. Finally, the observational studies included in this meta-analysis may be at risk of bias and the presence of confounding factors. To minimize this impact, a quality assessment was performed.

Conclusions

The study's conclusions indicate a significant increase in the use of SGA during the COVID-19 pandemic for out-of-hospital cardiac arrests. Additionally, a decrease in the use of ETI was observed. Effective airway management correlates with better outcomes after cardiac arrests, although the specific impact of these techniques during the pandemic remains unclear.

Article information

Authors contributions: *Conceptualization — MD and LS; methodology — MD, KB and LS; software — NLB; validation — MD, KB, and LS; formal analysis — MD, NLB; investigation — MD, NLB, MP and LS; resources — MD, KB, MP, DK and LS; data curation — MD, NLB and LS; writing/original draft preparation — MD, MP, DS and LS; writing/review and editing — all authors; visualization — MD and LS; supervision — KB and LS; project administration — MD; all authors have read and agreed to the published version of the manuscript.*

Funding: *This research received no external funding.*

Institutional review board statement: *Not applicable.*

Informed consent statement: *Not applicable.*

Data availability statement: *The data that support the findings of this study are available on request from the corresponding author (LS).*

Acknowledgements: *No applicable.*

Conflicts of interest: *The authors declare no conflict of interest.*

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