Original Article

pISSN 2383-9309 eISSN 2383-9317
J Dent Anesth Pain Med 2021;21(3):227-236 https://doi.org/10.17245/jdapm.2021.21.3.227

Implementation of contextualized, emergency management cognitive aids in a periodontics clinic

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Background: Emergencies in outpatient clinics are rare. However, potentially catastrophic events can be challenging to manage due to a variety of factors, including limited equipment and staff. The purpose of this quality improvement project was to improve the staff knowledge and familiarity with critical performance elements for emergencies encountered in the setting of a periodontics clinic.

Methods: Emergency cognitive aids tailored to the clinic's resources were created for anaphylaxis, airway obstruction, and sublingual hemorrhage. The project pre-post-test repeated measures design evaluated the effectiveness of cognitive aids using a combination of hands-on simulation, written knowledge assessments, and self-efficacy surveys. Training sessions and simulations were provided to the clinic's existing care teams made up of a periodontist and two dental assistants with an anesthetist who was present for simulations involving sedation. Due to the small sample size (N = 14) and non-normal distribution, all metrics were evaluated using non-parametric statistics.

Results: Significant improvements were found in knowledge assessment (−2.310, P = 0.021) and self-efficacy (−2.486, P = 0.013) scores when retention after a training session before and after the introduction of cognitive aid was compared. The mean simulation scores and times improved steadily or reached maximum scores during the project progression.

Conclusion: Training sessions before and after cognitive aid introduction were effective in improving knowledge, self-efficacy, and simulation performance. Future projects should focus on validating the process for creating contextualized cognitive aids and evaluating the effectiveness of these cognitive aids in larger samples.

Keywords: Airway Obstruction; Anaphylaxis; Cardiac Arrest; Checklist; Emergencies; Hemorrhage.

INTRODUCTION

Delays in performing key tasks during emergencies can have serious negative implications on patients [1]. This is especially true in outpatient clinic environments. In these settings, staff and emergency equipment are often limited. Furthermore, in the event of an emergency, outpatient clinic sites often experience a significant lag time before emergency medical services arrive [2,3].

Accordingly, a timely and well-organized response by staff to these situations is crucial and even lifesaving [1,4]. However, medical emergencies in outpatient clinics are relatively rare, and staffs are often inexperienced and unfamiliar with appropriate procedures [5].

Periodontology focuses on the mitigation of oral inflammatory processes regarding the destruction of hard and soft tissues of the teeth. The treatment of periodontal disease involves less invasive procedures such as scaling and planning to more invasive procedures such as osseous

Received: March 1, 2021 • Revised: May 7, 2021 • Accepted: May 10, 2021
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surgery to eliminate bony defects caused by periodontal disease and tissue grafting to augment the soft tissues or provide root coverage. Periodontists are also trained in alveolar ridge augmentation and dental implant placement [6]. Although rare, dental implantation procedures are associated with serious complications, such as hemorrhage [7,8]. Generally, patients with periodontal disease are at high risk of having other significant comorbidities that increase the risk of pre-procedural emergencies [9,10]. This risk increases in the case of procedural sedation, where the potential for adverse reactions and airway obstruction is higher [1].

A cognitive aid (CA) is a tool designed to assist professionals during emergencies by providing a resource outlining critical steps [11]. Cognitive aids can take several different forms, including checklists, wall posters, emergency manuals, and even digital phone applications [12,13]. Cognitive aids are intended not to replace the knowledge and skills of a well-trained provider but rather serve to decrease reliance on memory alone during mentally stressful situations [12]. Deviations from practice guidelines are common in times of mental stress, which places patients at risk of adverse events [12,14,15].

Historically, CAs are effective in high-risk technical professions, such as the aviation industry [12,16,17]. Recently, CAs have become common in healthcare. A systematic review by Saxena et al. (2019) found that the use of CAs in crisis simulation studies consistently resulted in improved provider performance. Several randomized control trials (RCTs) comparing the use of CAs to reliance on memory alone support the use of CAs to improve guideline adherence in crisis simulations [14,18-22]. The use of CAs has also demonstrated improved team dynamics such as communication, leadership, situational awareness, and decision making [12,19,23,24].

The goal of this quality improvement (QI) project was to support staff knowledge of the critical performance elements (CPE) or key steps required during emergencies and to help facilitate a coordinated response in the setting of an outpatient periodontics clinic. The specific aims were to describe existing processes for managing periprocedural emergencies and improving staff self-efficacy, knowledge, and performance during simulated periprocedural emergencies through the creation and implementation of contextualized emergency management cognitive aids for anaphylaxis, airway obstruction, sublingual hemorrhage, and cardiac arrest.

METHODS

This QI project was implemented at an outpatient periodontics clinic in South Eastern United States. The project was determined to be exempt, category 2, through an external IRB review (protocol number 00106561). A needs assessment identified the available resources and existing emergency management techniques. This clinic staff was made up of periodontists, dental assistants (DAs), and certified registered nurse anesthetists (CRNAs) depending on the case requirements. Non-sedation cases were performed by the periodontist and DA alone, while cases requiring intravenous (IV) sedation included a CRNA. While no formal protocol or plan was in place for emergency management, the facility was equipped with the American Society of Anesthesiologist standard monitors, emergency medications, emergency airway equipment, and an automated external defibrillator (AED).

A single group pre-post-test repeated measures design was used to assess the knowledge of emergency management interventions, self-efficacy with roles and assigned tasks during an emergency, and emergency simulation performance. The measures were collected across five-time points to establish baseline performance, immediate improvement after training, and retention over three months: phase 1 pre and post, phase 2 pre and post, and phase 3 final. This time interval was selected because of project time constraints and to reduce the likelihood of staff attrition during data collection.

Prior to implementation, key stakeholders, including a periodontist and a CRNA from the clinic, provided input for the development of contextualized CAs for anaphylaxis, sublingual hemorrhage, airway obstruction, and cardiac arrest. These CAs were evaluated for design and usability with the Cognitive Aids in Medicine Tool, as presented by Evans et al. (2015) with permission from the author [25]. The CAs featured typewritten scripts in a linear format. For each emergency, the CA was limited to a single page for brevity and ease of interpretation. While the CAs featured a consistent design theme, the contrast between the CAs was established using a unique monochromic color scheme for each individual CA. Signs or risk factors, triggers, and interventions or action items were numbered and arranged in order of treatment priority.

To isolate and evaluate the effectiveness of the CAs, training was first provided without CAs during phase 1. The training sessions were 1-hour long and took place in the clinic procedural rooms during a clinical day. The initial training session covered salient information on managing the four emergencies. The initial training included visual aids and opportunities for hands-on practice with emergency materials and task trainers. Three months later, during phase 2, a CA training session covered the same emergency scenarios that were initially introduced, focusing on using contextualized CAs. Finally, knowledge and skill retention was assessed in phase 3, an additional three months after the CAs were introduced.

All participants were issued a unique and anonymous 5-digit pin connecting the pre-and post-implementation assessments, surveys, and simulation recordings. A demographic survey was completed by the participants in Phase 1 prior to the initial training session. This survey identified participants' years of experience in their current role, gender, familiarity with simulation and the use of cognitive aids, and the type and frequency of emergencies they had experienced.

The knowledge assessment was a 10-item, true/false, multiple-choice test reflecting the content of the CAs. The test was constructed utilizing principles outlined by Coughlin and Featherstone (2017) such that each question reflected the facility's resources and equipment while emphasizing the learning objectives for each emergency [26]. The assessment included salient items, such as the definitive treatment for anaphylaxis and the main treatment goals for managing sublingual hemorrhage. This knowledge assessment was completed before and after each training session and with the phase 3 final evaluation. The outcome was measured by the change in the total correct scores between the pre-training and post-training assessments.

The self-efficacy survey was developed from the General Self-Efficacy Scale by Schwarzer and Jerusalem (1995) [27]. This 7-item survey was formatted as a 5-point Likert scale, as validated by Maurer and Andrews (2000), where 1=strongly agree and 5=strongly disagree [28]. Following the recommendations of Bandra (2006), psychometric measures included confidence in general role performance and specific tasks [29]. Specifically, self-efficacy survey items allowed participants to rate their confidence level within their role during an emergency and confidence level with specific tasks, such as the administration of a facility-specific epinephrine auto-injector and the use of a bag-valve-mask device. The outcome for each survey item was measured as the total score out of five possible points.

Emergency simulations were used to assess staff performance. The simulations involved the clinic's existing care teams composed of a periodontist and two dental assistants with an anesthetist stand-in present for simulations involving sedation. There were five care teams, two of which had the same periodontist to accommodate the total number of dental assistants.

The simulations included anaphylaxis, sublingual hemorrhage, and airway obstruction, leading to cardiac arrest. Prior to implementation, simulation scenarios were developed from evidence-based management strategies identified through a literature review. Recommendations from the periodontists and anesthesia providers were also incorporated to ensure contextual relevance. The contextualized CAs were converted into a checklist to evaluate simulation performance. The simulations utilized

Table 1. Type of emergency encountered, frequency, and percentage of total respondents (N = 14)

Type of emergency	Frequency	Percentage %
Airway obstruction	8	57.1
Sublingual hemorrhage	3	21.4
Syncope	2	14.3
Hypoglycemia	4	28.6
Foreign body obstruction	1	7.1
Palatal bleeding	1	7.1

Table 2. Knowledge assessment and self-efficacy scores median (interquartile range)

	Phase 1		Phase 2		Phase 3
	Pre	Post	Pre	Post	Final
Variable	Median (interquartile range)				
Knowledge assessment*	7.0 (2)	9.0 (2)	9.0 (1)	10.0 (1)	10.0 (0)
Self-efficacy scores**	3.9 (0.6)	5.0 (1.1)	4.3 (1.0)	4.4 (0.9)	4.9 (0.9)

Note *Maximum score 10.0, **Maximum score 5.0.

a variety of task trainers, including a CPR and intubating manikin, AED trainer, epinephrine auto-injection trainer, and emergency airway management equipment. A simulated patient monitor for basic medical simulation was utilized to provide real-time vital sign monitoring changes in response to simulated interventions. For example, just prior to the anaphylaxis simulation, the care group was provided with a scenario stem that explained the immediate situation as they entered the scene. The participants then began interacting with the simulated patient (manikin). The simulation evaluator served as the voice of the manikin and provided assessment information as needed, such as an expression of shortness of breath or facial flushing. The patient's vital signs and assessment information changed in alignment with the patient's condition as it worsened or improved according to the care team interventions performed. To accommodate session time limitations, the project team prompted the care team as needed when the tasks or decisions were delayed. The number of prompts required during each simulation was recorded. The simulation ended after all interventions were performed or prompted. The simulation performance was evaluated based on the percentage of checklist items performed correctly. Simulations were also timed with time to completion of the simulations in seconds recorded as an outcome.

RESULTS

Statistical evaluation was performed using IBM SPSS version 26.0. Descriptive statistics were used to describe the sample characteristics collected through an anonymous survey. A total of 14 respondents participated, including four periodontists and ten DAs (N = 14). As a result of attrition during the phase 3 final data collection period, an alternate DA participated in a care team simulation and completed the knowledge and self-efficacy assessment. Years of experience in the current role ranged from 1 to 35 years, with an average of 16.8 ± 13.7 years. Only 14.3% (n = 2) had previous experience with simulation training. Most respondents responded they had "never" referenced a cognitive aid (n = 10, 71.4%) while 4 reported "rarely" to have referenced a cognitive aid (28.6%). The participants' experiences with procedural emergencies are summarized in Table 1.

Knowledge assessment scores, self-efficacy, and simulation scores were collected at five-time points: phase 1 pre and post, phase 2 pre and post, and phase 3 final.

Knowledge assessments were evaluated using nonparametric statistics because of the small sample size and non-normal distribution. The median and interquartile

Table 3. Time to Completion in seconds

Variable	Phase 1		Phase 2		Phase 3
	Pre	Post	Pre	Post	Final
	Mean ± SD				
Anaphylaxis	2.40 ± .52	1.29 ± .41	2.06 ± .89	.93 ± .21	.86 ± .47
Airway obstruction	3.14 ± 1.15	1.40 ± .03	1.98 ± .54	1.45 ± .33	1.45 ± .11
Sublingual hemorrhage	3.09 ± .99	1.35 ± .19	2.89 ± 1.10	2.13 ± .48	1.70 ± .54

SD, standard deviation.

Table 4. Simulation Scores

Variable	Phase 1		Phase 2		Phase 3
	Pre	Post	Pre	Post	Final
	Mean ± SD				
Anaphylaxis	7.0 ± .14	8.6 ± .89	8.8 ± .45	8.8 ± .45	9.0 ± 0.0
Airway obstruction	9.4 ± .89	11.5 ± 1.0	10.4 ± .55	11.6 ± .89	11.6 ± .55
Sublingual hemorrhage	6.4 ± .55	6.75 ± .50	7.0 ± 0.0	7.0 ± 0.0	7.0 ± 0.0

Note* Highest possible scores: anaphylaxis, 9; airway obstruction, 12; sublingual hemorrhage, 7
SD, standard deviation.

ranges are recorded in Table 2. The median scores were further evaluated using Friedman's test to identify significant differences ($P \leq 0.05$). This was followed by a pairwise Wilcoxon test to compare the time points. Significant differences were found between phase 1 pre- and post-scores (− 3.028, P = 0.002) and phase 2 pre-and phase 3 final (− 2.310, P = 0.021).

Self-efficacy scores recorded on a 5-point Likert scale were evaluated using nonparametric statistics because of the small sample size and non-normal distribution. Median self-efficacy scores with interquartile ranges are shown in Table 2. Friedman's test was used to determine the overall significance of the scores ($P \leq 0.05$). This was followed by a pairwise Wilcoxon test to compare the time points. A significant difference was found between phase 1 pre and post (−3.304, P = 0.001); phase 1 post and phase 2 pre (−2.952, P = 0.003); phase 2 pre and post (−2.047, P = 0.041); and phase 2 pre-and phase 3 final (−2.486, P = 0.013).

Three simulation scenarios were completed by five care groups. The time to complete the simulation and team scores were analyzed using descriptive statistics (mean ± SD). Table 3 displays the results for the time to completion at each of the five-time points. Prompting occurrence was high with initial simulations ranging from 1 to 6 prompts depending on the simulation and care group. Prompting occurrences decreased sharply in the subsequent phases and ranged from 0 to 1 in phase 3 final. Table 4 displays the results of the simulation scores (mean ± SD).

Simulation completion times and scores were also evaluated using Wilcoxon signed-rank tests to compare both phase 1 pre-and phase 2 pre with phase 3 final. Table 5 displays the average differences in the times and scores (Z value, $P \leq 0.05$).

DISCUSSION

The participants revealed that airway obstruction was the most common periprocedural emergency (57.1%). Airway obstruction occurs more frequently in the setting of sedation, which causes relaxation of pharyngeal tissues [30]. In fact, respiratory claims for anesthesia provided outside of the operating room are over two times greater than those in the operating room [31]. Furthermore, in the periodontology setting, there is also an increased risk that secretions or irrigation could fall into the airway and illicit a laryngospasm [31,32]. If not appropriately managed or recognized, mild airway obstruction can

Table 5. Wilcoxon signed rank test results for simulation scores and completion times

Simulation scores		
	Phase 1 pre and phase 3 final	Phase 2 pre and phase 3 final
Variable	Z-value (P value)	
Anaphylaxis	−1.890 (0.059)	−1.000 (0.317)
Sublingual hemorrhage	−1.732 (0.083)	0.000 (1.000)
Airway obstruction	−2.121 (0.034)	−1.857 (0.063)
Simulation completion times		
	Phase 1 pre and phase 3 final	Phase 2 pre and phase 3 final
Variable	Z-value (P value)	
Anaphylaxis	−2.023 (0.043)	−2.023 (0.043)
Sublingual hemorrhage	−2.023 (0.043)	−2.023 (0.043)
Airway obstruction	−1.826 (0.068)	−0.730 (0.465)

quickly progress to severe airway obstruction requiring invasive management [1,33]. As noted by Kim et al., the utilization of procedural sedation significantly increases the risk of airway obstruction and requires provider competency in airway management and resuscitation (2016) [1].

The CPEs for airway obstruction include gentle suctioning to avoid causing laryngospasm, repositioning, providing supplemental oxygen, inserting airway devices, and rescue breathing with a bag-valve-mask device [32,34]. The simulation scenario highlights common signs of airway obstruction, including rapid oxygen desaturation and symptoms, including laryngospasm. After the CPE for airway obstruction was attempted, the scenario quickly progressed to cardiac arrest.

Cardiac arrest is a rare occurrence in the periodontal setting, comprising < 0.1% of dental emergencies [5]. None of the participants reported having responded to cardiac arrest in an outpatient clinic setting. Although cardiopulmonary resuscitation training is required every 2 years, performance in simulated cardiac arrests can begin to decline in as little as 6 months after training [35]. The rarity of these serious events, combined with infrequent training requirements, highlights the importance of regular practice in this setting. The CPE for cardiac arrest includes the initiation of basic life support with an AED and expedient transfer of care to emergency medical services.

Sublingual hemorrhage was the third most common emergency reported by the participants (21.4%). Sublingual hemorrhage can occur if the lingual cortex is perforated and is most common in mandibular implants [8]. Variability in arterial blood supply to the lingual cortex increases the risk of inadvertent puncture [36,37]. When this occurs, blood can collect in the sublingual tissue and can quickly lead to severe airway obstruction. A systematic review by Balaguer-Martí et al. (2015) found that 41% of dental implant-related hemorrhage cases required emergency endotracheal intubation and 47% required tracheostomy either emergently or for ongoing management [7]. The main goals of managing severe sublingual hemorrhage include ligation of the artery, quick airway securing, and transportation to the hospital ([8,36]). The potential morbidity and mortality associated with sublingual hemorrhage highlight the importance of expedient recognition and coordinated response in any setting, particularly in outpatient clinic settings.

None of the participants reported experiencing anaphylaxis in their practice environment. Similarly, anaphylaxis accounts for only approximately 1% of reported dental emergencies [4]. Anaphylaxis results from an inappropriate and excessive immune response where massive amounts of histamine and other inflammatory mediators are released, resulting in characteristic respiratory, cardiac, and cutaneous signs and symptoms [38,39]. Potential triggering agents in the periodontics setting include latex, antibiotics, and local anesthetics. In the case of anaphylaxis, the definitive treatment is IV or intramuscular (IM) epinephrine, which stabilizes mast cells and antagonizes the systemic effects of histamine [39]. Other secondary CPEs for anaphylaxis monitoring include positioning the patient flat, administering supplemental oxygen and intravenous fluids, and transferring the patient to emergency medical services.

The largest increase in median self-efficacy and knowledge scores occurred in phase 1 pre-and post-assessments (Table 2). As noted by Goldhaber-Fiebert and Macrae (2018), CAs cannot replace clinical knowledge, skills, and team communication [12]. With this initial training session, it was particularly important to establish both the geographic location of emergency supplies and common language among the existing care teams. The introduction of a CA without this initial training would reduce the ultimate utility of the CAs. When comparing retention after a training session prior to and after CA introduction at phase 2 pre and phase 3 final, significant improvements were found in both knowledge assessment (−2.310, $P = 0.021$) and self-efficacy (−2.486, $P = 0.013$) scores. This improvement is attributable to multiple factors, including training sessions and repeated simulations, in addition to the introduction of the CAs.

Comparing all time points for simulation completion times, both anaphylaxis and sublingual hemorrhage improved significantly (Table 5). Participants reported the most prior experience with airway obstruction (Table 1). Their baseline experience level may have contributed to the lack of statistically significant improvements in airway obstruction simulation times. When time points for simulation scores were compared, only the airway obstruction simulation demonstrated statistically significant improvement from phase 1 to phase 3. The lack of statistical significance with other scenarios and time points is attributable to the small sample size since there were only five care teams. Further, prompting during early simulations likely inflated the initial scores and times. Mean simulation scores and times, however, improved steadily or reached maximum scores during progression through the phases (Tables 3 and 4).

Due to the nature of the single-group repeated measures design, other factors may have contributed to the improvement in addition to the CA implementation. Twelve participants (85.7%) reported no previous experience with a simulation. Throughout the implementation, each participant completed five simulations for each emergency scenario. Increasing familiarity with the simulation likely contributed to improvements in performance. Roy et al. (2018) found that among dental students, repeated emergency simulation training improved the final simulation performance when compared to groups who only had primarily didactic training [40].

This QI project had several limitations. As a QI project with a small number of participants, these results are not generalizable to other settings and groups. A repeated member in two of the care teams and the attrition of one staff member during the implementation period may have altered care team performance. Furthermore, due to the use of a single-group repeated measures design, the project team was unable to control for confounding variables.

While participants likely benefited from the concise framework of the CAs, intra-simulation use of the CAs was not recorded as a metric. As noted by Goldhaber-Fiebert and Macrae (2018), CAs are often used as a reference after the initial emergency response steps are taken [12]. Accordingly, examining the effects of CA utilization during simulation may be more relevant when a long time has elapsed since the training. The rarity and high-stress nature of periprocedural emergencies in this setting highlight the value of a reference for these clinicians. Project time intervals were selected to accommodate the availability of the project and care teams. It is possible that altering the interval between phases may result in different outcomes. Future projects or studies should examine retention and performance over time to determine the optimal interval for retraining with CAs.

Future research should further explore the effects of implementing contextualized CAs in larger sample sizes with control groups and establish a means of validation. Cognitive aids in medicine was created and preliminarily validated by Evans et al. (2015) and served as a valuable objective measure to evaluate the CAs used in this project [24]. Further research in this area of contextualized CA development may aid clinic-based practices to substantiate and standardize their procedures for emergency management. Additionally, the concept of CAs developed for a specific setting allows CAs to be updated and reprinted in response to resource and policy changes. The creation and implementation of contextualized CAs for other emergencies should also be explored. Hypoglycemia and syncope are among the most common emergencies in dental practice as reported by participants and in the literature [4,40].

In conclusion, training sessions before and after CA introduction were effective in improving knowledge, self-efficacy, and simulation performance. While this improvement cannot be definitively attributed to the implementation of the CA alone, the overall goals of this QI project were achieved. CA can be an invaluable and a dynamic resource and should be further explored and developed in outpatient clinics settings and beyond.

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ACKNOWLEDGMENTS: The project team would like to acknowledge the contributions, time, and talents of Duke University School of Nursing statistician, Julie Thompson Ph.D., and the participation and interest from all clinical staff of Periodontics of Greenville, without which the project would not have been possible.

DECLARATION OF INTERESTS: No declaration of interests and no conflicts of interest.

FUNDING: No financial assistance was received for this project.

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