

Barriers to and facilitators of using cognitive aids in perioperative emergencies: An integrative review

Supplement: Literature matrix

Search strategy

Databases used: EBSCO databases (CINAHL Complete, Health Source: Nursing/Academic Edition, MEDLINE, MEDLINE Complete), Pubmed, Scopus.

Search terms, keywords and phrases: “cognitive aids” AND “perioperative” (127), “cognitive aids” AND “operating room” (29), “cognitive aids” AND surgery (28), “cognitive aids” AND anaesthesia (131), “cognitive aids” AND nurs* (52), “cognitive aid” AND “perioperative” (22) “emergency manual” AND perioperative (10)

Author (year)	Title (intent) Study design (level of evidence)	Population/sample	Key findings	Conclusions, implications and recommendations	Limitations of the study
Alidina et al. ¹ (2018)	Factors associated with the use of cognitive aids (CAs) in operating room crises: A cross-sectional study of US hospitals and ambulatory surgical centres (To examine organisational context and implementation process factors influencing the use of CAs for operating room crises.) Cross-sectional study (Level IV) The relationship between main outcome and covariates was analysed. The main outcome was reporting more successful versus less successful implementation; the covariates were facility quality improvement experience, implementation processes, diverse uses for CAs.	368 surveys (1796 survey responses were collected from individuals who downloaded CAs, of which 1428 were excluded leaving 368 surveys as the final dataset.) Survey responses were excluded if they were incomplete, respondent's workplace had used CAs for less than six months, respondents had not used the downloaded CA, deployment of the CA was still in process, respondents indicated uncertainty about CA use, respondents were outside the United States of America.	Barriers (mentioned by a higher percentage of respondents from facilities with less successful CA implementation): • lack of institutional commitment to improving patient safety ($p=0.0026$) • lack of leadership support ($p<0.0001$) • absence of an implementation champion ($p<0.0001$) • provider resistance to using CAs ($p=0.0155$). Facilitators (mentioned by a higher percentage of respondents from facilities with more successful CA implementation): • institutional commitment to improving patient safety ($p=0.0007$) • leadership support ($p<0.0001$) • time to train staff ($p=0.0332$).	Building strong organisational support and following a well-planned multi-step implementation process will likely increase the use of operating room CAs. Recommendations: • perform quality improvement initiatives to create a 'quality culture' • build leadership support • make time available for training • address reasons for resistance to enhance willingness to use CAs • follow a multi-step implementation process • use CAs in different contexts (e.g. simulations, preparation, debriefing, educational review) to encourage their use.	Research based on surveys can be influenced by many biases. The outcome measure is a perception rather than an actual measurement, and there may be same-source bias since dependent and independent variables came from a single respondent. The analysis is limited to reporting associations and not causality. There is a small possibility of more than one respondent from a single facility. The researchers were not able to adjust for clustering. The analysis is reflective of implementation experience surrounding two specific tools, the experience with other tools may be different. The survey was given at a single point in time, limiting the ability to better understand sustainability.

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Blanié et al. ² (2020)	Use of cognitive aids: Results from a national survey among anaesthesia providers in France and Canada (To assess the knowledge and use of cognitive aids (CAs) by anaesthesia providers in France and Canada.) Cross-sectional study (Level IV) Statistical analysis was not performed because of the low response rate.	912 (survey 1) from individuals in France 278 (survey 1) from individuals in Canada 28 (survey 2) from simulation centres in France (Survey 1 was emailed to French and Canadian anaesthesia providers in 2017 through their respective national societies. Survey 2 was emailed to French simulation centres.) 70% of the French respondents and 85% of the Canadian respondents were anaesthetists, mostly with more than five years of experience.	- Although 56% of French and 92% of Canadian respondents knew about CAs and 66% of French and 85% of Canadian respondents indicated CAs were available in their workplace, only 38% of French and 44% of Canadian respondents had actually used them. This confirms the well-known difficulties of implementing new strategies. - Only 25% (225/912) of French and 45% (126/278) of Canadian respondents had received formal training in how to use CAs. This is a very important finding as unfamiliarity with a CA has been shown to lead to suboptimal care. 82% of simulation centres used CAs in their high-fidelity simulation sessions in anaesthesia.	CAs were better known in Canada than France, but their actual use in real life was low in both countries. Simulation appears to play a potentially important role in training anaesthesia providers in the use of CAs.	The main limitation of this study is the low response rate (7% in France and 11% in Canada). There is also a possible selection bias as some respondents may have taken the time to complete the questionnaire because they knew and had some interest in using CAs.
Clebone et al. ³ (2019)	Matching design to use: a task analysis comparison of three cognitive aid designs used during simulated crisis management (To compare a linear cognitive aid (CA) with non-linear CAs designed according to cognitive science principles to optimise acquisition of specific information.) Randomised controlled trial (Level II) Participants were surveyed before and after the simulated scenarios. Eye-tracking was used to determine where participants were looking while accessing the CAs	23 participants Participants were recruited from the anaesthesia department of an academic tertiary care medical centre and from a national paediatric anaesthesia conference and comprised 17 anaesthesia faculty members, 3 senior residents or fellows, 3 nurse anaesthetists.	- The CAs with non-linear design facilitated faster information acquisition during a spectrum of critical event scenarios that required different types of information for successful patient management. - Eye-tracking data confirmed that participants seeking information spent more time searching the linear than the non-linear CAs.	Incorporating specific CA design features is feasible and may facilitate efficient acquisition of crucial information during patient crisis management.	Findings from this study may not be generalisable to other anaesthesia providers. Potential confounding variables were not accounted for. Participants were assigned tasks that could bias performance in favour of the experimental aid designs. Limitations in eye-tracking technology, variability in how the tracking device was worn and incomplete eye-tracking information for more than 50% of participants may have influenced the data.
Clebone et al. ⁴ (2020a)	The effect of cognitive aid design on the perceived usability of critical event cognitive aids (To compare the perceived usability of a linear cognitive aid (CA) with non-linear CAs designed to optimise discrete information transfer.) Mixed methods (Level IV) Participants used CAs during low fidelity simulation scenarios. A quantitative assessment of perceived usability was performed and structured knowledge elicitation interviews conducted.	23 participants Participants were recruited from the anaesthesia department of an academic tertiary care medical centre and from a national paediatric anaesthesia conference and comprised 17 anaesthesia faculty members, 3 senior residents or fellows, 3 nurse anaesthetists.	- The non-linear CAs were perceived as more usable than the linear CA across a range of hypothesised situations. On a 0–100 scale the median (IQR) rating was 25 (18,23) for the linear aid and 89 (80,95) and 81 (65,90) for the two non-linear designs with a higher number indicating greater ease of use ($P < .01$ for each). - Narrative responses suggested specific features that improved usability, including simplicity, accessibility and content.	CAs designed for retrieval of discrete information are perceived as easier to use by anaesthesia clinicians involved in critical event management. Design of CAs may improve clinician responses to critical events and increase overall compliance with CA use. Further research in CA design is needed to optimise the utility and usability of these important tools.	Findings from this study may not be generalisable to other institutions or anaesthesia providers. Responses were not stratified by training level or role and experience may affect perception of CAs. The effect of CA design on clinical outcomes was not evaluated. Nevertheless, because clinician willingness to use CAs is a major barrier to their adoption, improving perceived ease of use and reducing cognitive workload is an important aspect of increasing implementation.

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Clebone et al. ⁵ (2020b)	The timing of cognitive aid access during simulated paediatric intra-operative critical events (To measure the time from critical event trigger to cognitive aid (CA) use, and the number and type of key behaviours performed by simulation participants prior to CA access.) Randomised controlled trial (Level II) Previously published simulation data was reanalysed to measure the time from event trigger to CA use, and the number and type of key behaviours performed by simulation participants prior to CA access.	65 trials (Simulated paediatric intra-operative events divided into six types: arrhythmia, venous air embolus, hypoxemia, malignant hyperthermia, hypotension and supraventricular tachycardia. Participants were 89 anaesthesia residents and student nurse anaesthetists.)	- The average time from event trigger to first CA use was 258 seconds. - In 95% of trials (62/65) the CA was accessed after at least one key behaviour had already been performed. - The time from event trigger to CA use varied by type of scenario ($P = .03$, $df 5$, adjusted H 12.78), with the shortest time for 'supraventricular tachycardia' (90 [66,156] seconds (median [IQR]) and the longest time for 'hypoxemia' (354 [192,492] seconds).	In simulated critical events, anaesthesia residents and student nurse anaesthetists often consulted a CA only after first performing at least some key behaviours. Incorporating the possibility of delayed access into critical event CA design may facilitate the effectiveness of that aid. Because clinicians may access the CA after already initiating a response Designing CAs to accommodate access after a response to a critical event has been initiated may facilitate interest in and increase use of CAs by making them easier to use. The design of critical event CAs should consider the type of critical event being addressed, how familiar the practitioner already is with that event, and whether the CA is likely to be used for decision support, key pieces of information or both.	Findings from this study may not be widely generalisable because: - it was a retrospective analysis of data from simulated critical events involving certain scenarios - participants represented a limited number of roles, all were residents in training or student nurse anaesthetists - participants were emailed the CAs several days before the trials which is unlikely to occur in real-world conditions.
Gallegos et al. ⁶ (2022)	Malignant hyperthermia preparedness training: Using cognitive aids and emergency checklists in the perioperative setting (To prepare perioperative staff to respond to a malignant hyperthermia crisis effectively with the assistance of a cognitive aid (CA) and assess participant willingness to use it.) Quasi-experimental study (Level IV) Participants received in-service education about the CA, participated in a simulation exercise and completed pre- and post-implementation surveys.	13 perioperative staff members at a military ambulatory surgical centre participated in the training. (Participants included 5 registered nurses, 2 registered nurse anaesthetists, 5 operating room technicians, 1 participant who did not state their job title. Participant years of practice varied from less than four years to more than 20 years.) 9 participants completed the post-implementation survey.	- Staff positive perception of and willingness to use the CA improved after implementation of an education session and simulation exercise using the CA. - Participants felt the training was beneficial in treating a patient with malignant hyperthermia and in the use of CAs in general. - Many clinicians were distrustful of or biased against the use of CAs if they had not been previously trained to use them.	Introduction of the CA to multidisciplinary perioperative staff with an in-service and simulated malignant hyperthermia scenario improved staff perception of CA use during emergencies. Use of CA checklists during simulated perioperative emergencies was shown to reduce missed critical treatment steps.	
Gleich et al. ⁷ (2019)	Emergency manual implementation in a large academic anaesthesia practice: Strategy and improvement in performance on critical steps (To implement a cognitive aid and subsequently evaluate team member performance on critical steps.) Quasi-experimental study (Level IV) Phases of emergency manual (EM) implementation were observed and utilisation of the EM was tested using a standardised verbal simulation of three crisis events both pre-implementation and six months post-implementation.	Pre-implementation phase: 59 participants Post-implementation phase: 60 participants (Participants were equal proportions of anaesthesiology attending physicians, resident physicians, nurse anaesthetists and student nurse anaesthetists.)	- Significantly improved performance (adherence to critical steps) on three verbal-simulated crisis events were recorded when subjects used the EM after implementation. - The time and cost needed to custom design a new EM was prohibitive. - Familiarity and accessibility are crucial when introducing a new EM. - Despite a wide range of verbal and e-mail communication to the department staff, a minority of practitioners (42%) used the EM during our verbal simulation study of intra-operative crisis events six months after implementation.	Implementation of an EM in a large academic anaesthesia practice is not without challenges. While full integration of the EM was not achieved, we demonstrated improved performance on simulated crisis events. Future efforts will be directed toward increasing familiarity and use to achieve more culture change and, ultimately, full integration. Recommendations: - use an existing EM and modify it to meet local institution needs - include surgical staff in implementation of and training in an EM.	Findings from this study may not be widely generalisable because: - only staff from the anaesthesiology department - were included - the sample size was small - there was no control group - intergroup analysis was not performed - there may have been confounding factors from participant characteristics, such as intellectual ability and experience level, and the study duration, such as factors that changed with time over the six months of the study.

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King et al. ⁸ (2018)	Using eye tracking technology to compare the effectiveness of malignant hyperthermia cognitive aid design (To compare the accessibility of five malignant hyperthermia cognitive aids (CAs).) Observational study (Level IV) Eye-tracking was used to measure time taken to answer three questions and time to first gaze fixation.	12 attending anaesthesiologists (a convenience sample from a single university-affiliated Veterans Affairs hospital)	- Participants demonstrated the shortest cumulative time to answer when viewing the Society for Pediatric Anesthesia (SPA) CA compared to the four others. - Potentially advantageous design features of the SPA CA include linear layout on a single page and simple typescript with minimal use of single colour blocking.	Eye tracking technology may provide useful data in the design of future CAs. This represents a new application within the field of medicine and warrants further research.	The sample size was small and based at a single institution to allow easy access to the study site for all participants. Generalisability is limited to the set of CAs and topic studied. Metrics related to CA performance using eye tracking in this experimental setting may not translate to performance in other real-life settings such as clinical simulation or actual clinical care. The differences in eye tracking metrics between CAs can be measured in seconds, and we do not yet know if these differences are clinically relevant.
Knudsen et al. ⁹ (2022)	Swedish registered nurse anaesthetists' understanding of difficult airway algorithms (To explore Swedish registered nurse anaesthetists' different ways of understanding difficult airway algorithms.) Qualitative study, phenomenographic approach (Level IV) Individual interviews were conducted and the data analysed.	18 nurse anaesthetists working at three hospitals in Sweden	- Nurse anaesthetists have different ways of understanding difficult airway algorithms. - Some participants viewed algorithms as a tool for anaesthesiologists that is not communicated to or available for them. - Most participants viewed airway algorithms as an important supportive shared plan to improve teamwork. - Many participants considered it important for nurse anaesthetists to communicate airway procedures and difficult airway algorithms to enforce compliance. - Many participants reported that having a shared algorithm allowed them to feel prepared when they were alone and airway problems arose.	Airway algorithms for management of difficult airways were understood in three different ways: - Algorithms constitute a plan not communicated at the clinic. - Algorithms constitute a shared plan to improve teamwork. - Algorithms constitute a plan for how to think and work systematically. Airway management algorithms should: - be discussed more openly at the workplace - easy to remember - practiced repeatedly in simulation scenarios - not be adhered to too strictly but adapted in response to the situation.	Small sample size. Limited generalisability. Length of time (five years) between data collection and results may be a limitation but, based on their clinical experience, the authors believe the findings are still valid.
Kolawole et al. ¹⁰ (2019)	Use of simulation to improve management of perioperative anaphylaxis: A narrative review (To address the deficiencies in management of perioperative anaphylaxis by appraising the training and assessment of individuals and teams, and the potential to enhance clinical processes.) Narrative review (Level I) The PICO (population/problem, intervention, comparators, outcome) framework was used to formulate the search strategy applied to MEDLINE and Embase databases.	41 relevant papers	- Simulation has played a key role in presenting and developing cognitive aids (CAs). - The design of CAs has recently undergone some examination using simulation, with more simple, linear designs being preferred over complex branched algorithms. - One of the main problems of CAs is having them immediately available and remembering to use them. Simulation training may also play a key role in educating anaesthetists on when and how to use CAs.	Perioperative anaphylaxis is used widely as a scenario in simulation training and as part of competency assessment. Although studies linking training, assessment and system performance to improved management of anaphylaxis or patient outcomes were not identified, this review found evidence that <i>in situ</i> simulation and the use of CAs lead to improved teamwork and task performance. It is recommended that research priorities shift towards <i>in situ</i> simulation to improve team and system performance.	The review focusses on published literature on simulation and anaphylaxis, there may be relevant literature published on simulation and other perioperative crises.

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McIntosh et al. ¹¹ (2018)	Using simulation to iteratively test and re-design a cognitive aid for use in the management of severe local anaesthetic toxicity (To conduct formative usability testing of three existing cognitive aids (CAs) in order to develop, via a user-centred design approach, a new CA.) Randomised controlled trial (Level II) Participants were interviewed after using one of three CAs in a simulation. Interview information was used to develop a fourth CA which was subjected to further testing and re-design by the fourth group.	20 anaesthetists 20 anaesthetic nurses (Participants were paired into anaesthetist–anaesthetic assistant dyads and then randomised into four groups that used one of four CAs.)	- Many features of the existing CAs appeared useful in a non-emergency situation but those same features were detrimental in a simulated crisis. - The three tested existing CAs appeared easy to understand in a non-emergency situation but they were reported to be not useful in a simulated crisis and, in many instances, were discarded immediately. - The new aid was reported to be easy to use without prior familiarity or training. However, this does not negate the need for education – the literature suggests that familiarity and/or ongoing education on specific aids may make them more likely to be used appropriately in crises. - Features of the new, preferred aid that were identified during testing, such as use of colour, providing a single stream of information and limiting the information to that required during the crisis, are consistent with recommendations made by human factors engineering experts.	Utilisation of formative usability testing and simulation-based, user-centred design resulted in a visually very different CA and reinforces the importance of designing aids in the context in which they are to be used. Simplified tools may be more appropriate for use in emergencies but more detailed guidelines may be necessary for training, education and development of local standard operating procedures. Iterative simulation-based testing and re-design is likely to be of assistance when developing aids for other crises, and to eliminate design failure as a confounder when investigating the relationship between use of CAs and performance.	Study participants included junior trainee and senior consultant anaesthetists. However, given the purpose of the CA is to support clinicians of all levels of experience it was important the aid was tested by a range of potential users. Quantitative supporting validity evidence was not collected; the primary focus of the study was on the design of the aid.
Merrell et al. ¹² (2018)	Use of an emergency manual during an intra-operative cardiac arrest by an interprofessional team: A positive-exemplar case study of a new patient safety tool (To identify and synthesise the impacts of emergency manual (EM) use on clinical team functioning, delivery of patient care and planned future use during applicable crises.) Positive-exemplar case study (Level IV) All six clinicians present during the crisis were interviewed, interview transcripts were iteratively coded and thematic analysis was performed.	6 interviewees (The six clinicians present during the crisis – anaesthetist, surgeon, surgical resident, surgical technician, circulating nurse, nurse anaesthetist.)	- The EM provided clear guidance, reduced individual stress and intrateam tension, improved communication and enabled effective clinical team functioning. - The EM fostered a calm work environment, helped focus attention on the patient and supported efficient and effective delivery of key patient care management actions. - All six participants expressed their positive intentions to use the EM during applicable crises in the future. - All team members commented on the successful use of a reader role, which facilitated effective team EM use and efficient delivery of patient care.	Our results suggest the potential clinical utility of EMs in the operating room (and likely beyond) and identify issues for future research in clinical settings. Recommendation: Optimise local implementation of an EM by: - ensuring the EM meets local needs (create a new EM or modify an existing tool) - familiarising staff with the EM (including training) - enabling effective use of the EM (including clinical accessibility and reader role) - integrating the EM into local culture.	Interviews were conducted four to five months after the crisis. However, participant accounts were vivid and consistent with each other suggesting that veracity had survived. Eyewitness accounts are not always accurate. To mitigate this a low-stakes context for the interviews was created, biased framing was avoided and neutral language was used throughout the interviews. Participants may have exhibited recall bias and social desirability bias. These were mitigated during the interview process. As this is one in-depth case study, the specific impact of the EM remains unknown relative to other factors affecting team performance. However, the individual members of the team do not regularly practice together, and multiple participants remarked on the calmness and ease of teamwork. It is important to note that the participants themselves believed that the EM was useful and made a difference to their patient care.

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Siddiqui et al. ¹³ (2019)	Impact of critical event checklists on anaesthetist performance in simulated operating theatre emergencies (To determine the uptake of Society for Pediatric Anesthesia (SPA) critical events checklists (CECs) in a simulated operating theatre emergency and the performance enhancement conferred by using the SPA CEC.) Randomised 2x2 factorial study (Level II) Participants were randomly assigned to four groups to participate in orientation and simulated emergencies. Videos of simulations were rated by trained expert raters.	25 senior anaesthesia trainees 78 simulation encounters (Participants were senior anaesthesia trainees at a single university-affiliated tertiary level paediatric hospital.)	- The overall uptake of the SPA CECs in the simulated critical events was 17.9%. - The uptake of the SPA CECs was not significantly different whether participants received an e-module or a didactic orientation to the SPA CEC (16% vs. 20%, respectively, $p = 0.690$). - The proportion of encounters where the SPA CEC was used did not differ significantly whether the SPA CEC was available (in clear view) or not (20% vs. 16%, respectively, $p = 0.690$). - There was significantly greater uptake of the SPA CEC in scenarios that required a diagnosis-based SPA CEC (45%) than ones which required the use of a generic event (altered-physiology) SPA CEC (2%). - Clinical performance was enhanced by the use of a CEC, with a mean difference in global rating scale of 0.57 (out of six).	Uptake of CAs is poor despite formalised orientation. Certain types of CAs are used more frequently than others. When individuals did use the SPA CEC, they performed better in simulated events than participants that did not use the SPA CEC. Recommendation: Further research needs to be conducted surrounding novel means of orientation and education surrounding CAs as they have important implications for patient safety and medical education.	SPA CECs are meant for whole-team use, rather than just the anaesthetist. The intent of the current study was to examine uptake of SPA CECs and their impact during uniprofessional simulation training. The impact of the independent variables was not analysed at a later stage; therefore, the study cannot detect, for example, whether the modes of orientation had a delayed impact on uptake of CAs.
Zasso et al. ¹⁴ (2021)	Effects of prior exposure to a visual airway cognitive aid on decision-making in a simulated airway emergency: A randomised controlled study (To investigate the effects of a visual airway cognitive aid (CA) on decision-making in a simulated airway emergency scenario.) Randomised controlled trial (Level II) Participants were randomly assigned to two groups to participate in orientation and simulated emergencies. Main outcome measures were decision-making time to perform a front-of-neck access (FONA), airway checklist actions, teamwork performances and a post-scenario questionnaire.	40 teams of three individuals (Teams comprised an anaesthesia resident, a nurse and a respiratory therapist. Teams were randomly assigned to an intervention group ($n=20$) and a control group ($n=20$). Demographics for age and years of clinical practice were similar between intervention and control groups.)	- Decision-making time to perform a FONA was significantly faster in the intervention than control group (mean $\pm$ SD, 80.9 ± 54.5 vs. 122.2 ± 55.7 s, difference (95% CI) -41.2 (-76.5 to -6.0), $P = 0.023$). - The intervention group reported using the CA during the simulated scenario more than the control group (63.0 vs. 28.1%, $P < 0.001$). A higher proportion of the intervention group perceived the CA as important than in the control group (73.3 vs. 50.0%, $P < 0.01$). - A high proportion of the participants in both groups indicated they would use the CA in the future if it was available in a clinical airway emergency (93.3 vs. 96.7%, $P = 0.67$).	Prior exposure to and teaching of a visual airway CA improved decision-making time to perform a FONA during a simulated airway emergency. Furthermore, increased use of the aid did not appear to have negative effects on the total time of scenario completion and the checklist task scores. These findings may have important clinical implications for the role of a visual airway CA in airway emergencies, particularly with decision-making. Familiarisation and availability of a CA in airway management might be an important tool in the clinical setting.	The study was conducted in a laboratory setting rather than the clinical environment. As with all simulation, performances may suffer from the Hawthorne effect. The use of junior anaesthesia trainees may hinder generalisability to practising physicians who are experts in airway management. The time of simulation scenario assessment varying from 1 to 4 weeks after the teaching session may have introduced a confounding factor. The sequence of the post-scenario debriefs and completion of the questionnaire was variable among the teams; teams which were debriefed first may have been influenced when completing the questionnaire. Teamwork performances were similar between the intervention and control groups; however, the reported interrater coefficient between the raters was low (ICC 0.4), possibly because team performances are more complex to assess than individual performance.

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