Evolution, development, and simulation-based testing of 'Check CRISIS' – A unique cognitive tool in perioperative crisis management

INTRODUCTION

Peri-operative crisis management is challenging due to its dynamicity, uncertainty, and the associated intense time pressure.[1] In most circumstances, crisis is approached with an individual approach based on knowledge, and more commonly clinical intuition acquired through experience during the course of residency and anaesthesia practice. This may sometimes be unstructured, in the moment of stress and lead to ineffective crisis management. Anaesthesiologist would tackle the situation based on his ability to handle various human factors, such as: (i) facing new situation; (ii) inadequate planning for unanticipated problems; (iii) a single person juggling multiple tasks or multiple people attempting to execute a task unsystematically; (iv) handling a stressful situation with a fatigued mind; (v) unfamiliar personnel and environment; (vi) emotional strain caused by the awareness that he himself has triggered the adverse event; (vii) inability to remain calm; (vii) avoid committing knowledge-based mistakes; and (viii) avoid deliberately doing wrong things when there is no choice or non-caring attitude towards consequences.[2] These factors have the potential to trigger or deteriorate the situation. Some human factors (e.g., information processing, decision-making, avoiding fixation errors, communication, task execution, team management) are amenable to the application of a cognitive tool.[3]

Runciman[4] developed a cognitive tool called 'COVER-ABCD A SWIFT CHECK' helped many anaesthesiologists worldwide in better perioperative monitoring and handling the crisis effectively. This algorithm did not include the non-technical skills and also necessitated the development of sub-algorithms to manage the crisis effectively.[5,6]

Hence, we designed an easy-to-remember 'Check CRISIS' tool, incorporating the non-technical and technical skills of anaesthesia practice based on the survey conducted and collective practical experiences of all anaesthesiologists in our tertiary care centre. This less time-consuming approach would keep the patient safe while using an anaesthesiologist's natural response parameters in handling airway, breathing and circulation to analyse and manage the crises deftly. The 'Investigate' component of the tool can also be used for routine intraoperative monitoring. This cognitive tool, apart from being handy during crisis, if drilled into the anaesthesiology trainees' thought process during simulation-based training or theatre-based teaching, would help in handling the crisis effortlessly in stressful situations.

The distinct advantages of this tool are: (i) follows the natural decision-making process employed by anaesthesiologists utilising specialised senses; (ii) keeps the patient safe irrespective of the crisis cause, thereby allowing time to identify the genesis of the event; (iii) emphasises anaesthesia non-technical skills; (iv) background information of the preceding event to correct the cause; and (v) sequential analysis negates the anaesthesiologist's fixation error.

Through this manuscript, we intend to substantiate the utility of this tool in everyday anaesthesia practice. The manuscript discusses in detail the development and relevance of this tool under three main sections namely: (i) evolution of the cognitive tool; (ii) explanation of the design of this tool; and (iii) routine structured intraoperative patient monitoring.

EVOLUTION OF THE COGNITIVE TOOL

The approach was designed and refined based on three steps.

Assessment of need, challenges, and desirable components of a structured crisis management tool

We conducted an online survey using Google forms on the awareness and requirement of crisis management tool among 150 practicing anaesthesiologists in the city of Pondicherry (India). The response rate was 50%. All the anaesthesiologists (100%) who participated in the survey accepted the fact that they had faced crisis during their anaesthesia practice, but 77% were unaware of any existing crisis management tool. Seventy-three per cent of the participants agreed that crisis was dynamic and 63% felt

that crisis situation was stressful. Desirable features of a crisis management tool identified by 80% the participants were: It must be easy to recollect, comprehensive, follows a natural sequence of their response in management by integrating clinical assessment and monitoring parameters. All the participants expressed the need for a simpler approach.

Designing each component of the cognitive tool using inputs from survey and debriefing of critical events occurring in everyday clinical practice

During the extensive debriefing sessions on critical events happening in our department as part of everyday practice, the natural sequence of most anaesthesiologists during a crisis was reported to be the utilisation of their specialised senses (look, listen, feel) for subjective monitoring to enhance their situational awareness. Therefore, we integrated the 'Check senses' part of the approach (Table 1).

It was also recognised that most anaesthesiologists had fixation errors based on their previous experiences leading to misdiagnosis. This led to the inclusion of structured 'Investigate' component (Table 2). Scenarios where the A, B, C, D, E components failed to arrive at a diagnosis were discussed again and changed accordingly. It was observed that most conditions had some background for the event, which clearly revealed the reason amongst the various possibilities of the crisis. This led us to incorporate 'Setting' (Table 1) in the approach.

It was also identified that irrespective of the crisis, the patient should be kept safe till the definitive cause is identified and the treatment is instituted. This engendered the 'Cease the stimulus and Re-Allocate the roles to manage A, B, C, D, E' component. Crisis arising due to machine malfunction was eliminated by ventilating with a self-inflating bag (Table 1).

Incorporating all these components resulted in the formulation of a cognitive tool called 'Check CRISIS' approach (Tables 1 and 2), which can be applied in any crisis situation to arrive at a probable diagnosis while simultaneously managing it. 'Check CRISIS' is an easily remembered word as (i) 'Check' means both arresting and looking for the presence of a crisis while (ii) CRISIS is what we are managing.

Simulation-based testing of the algorithm on post-graduates to assess the adequacy of the tool

Twenty-four post-graduate students at our department (8 first year, second and final year each) were exposed to a simulated scenario of intraoperative pneumothorax (intraoperative hypotension, hypoxia, and raised airway pressure). Each of the 24 participants was assigned as a team leader while faculty members acted as other team members to modulate the scenario and react as per the team leader's instructions. One instructor evaluated the participant based on the checklist consisting of desirable actions to be taken in that particular crisis situation (Table 3).

At the end of each session, the team leaders were individually debriefed using the checklist and video recording of the scenario. It was observed that they managed the case based on their medical knowledge and clinical experience. All of 1st year (100%) and 60% 2nd-year students failed to identify the reason for the crisis while 80% of the final year post-graduates could diagnose and manage the case satisfactorily. Average time taken from start of crisis to vocalise the diagnosis was 15 min. It was observed that among the 1st year post-graduates there was no situational awareness and 17% of them practiced delegation of roles. Among 2nd years, 62% utilised clinical senses to become aware of the situation and only 25% of them delegated roles to team members. However, 90% of final year post-graduates utilised situation awareness based on clinical findings and 95% of them practiced delegation of roles to team members. Non-technical skills were evidently lacking which led to a lot of chaos and mismanagement.

This guided us to incorporate and emphasise on delegation of roles in an asset manner to ensure task completion by each team member in an organised way. Subsequently, all the post-graduates were educated on this cognitive tool during the routine teaching sessions every day for 1 week in the operating room. One week later another simulated scenario of anaphylaxis (intraoperative hypotension, hypoxia, and raised airway pressure) was conducted on a similar pattern as before and the students were asked to respond to it. It was observed that 50% of 1st year, 90% of 2nd year, and 100% of the final year post-graduates could come to a diagnosis effectively and confidently while keeping the patient safe by early administration of oxygen and vasopressors. The average time taken by them to reach the diagnosis was 8 min which was substantially shorter than the previous scenario. This may be attributed to the fact that while all 1st and 2nd year post-graduates and 20% of the final year post-graduates could identify the crisis during the 'Analysis' stage of the tool, but 80% of the final years identified it during the 'Background' stage itself.

Table 1: Check crisis tool

Component and purpose	Perform the applicable steps relevant to crisis
Check confirm the crisis and its severity with the aid of senses for (situational awareness)	Apply your senses to assess current situation Touch Check pulse volume/rhythm and skin temperature Vision Check or do laryngoscopy to rule out airway device kink/obstruction/disconnection/displacement/foreign body (throat pack)/blocked HME filter and Breathing circuit integrity Breathing pattern Surgical field color and bleeding Auditory Auscultate the chest Hear audible leak/sounds around the airway device Hear to patient's complaints Vocalise For help
Cease (Task management prioritising)	Cease the stimulus Cease the surgical insult and prevent the progress of the developed complication Cease anaesthesia procedure/intravenous or inhalational anaesthetics administration or altered patient positioning
Re.allocate (to keep the patient safe, thereby allowing time to analyse the cause) (team dynamics) (task management.prioritising)	Re-allocate roles to available team members to manage Roles are allocated for the applicable coordinated activities among team members for efficient team dynamics Airway and breathing Airway device not *in situ*: To administer 100% oxygen by mask/use airway adjuncts and intubate if necessary Airway device in situ: To administer 100% oxygen and observe reservoir bag movement and compliance/disconnect HME filter/suction if ETT obstruction is suspected Circulation To secure additional intravenous access to administer fluid/blood To do chest compression Drugs To administer vasopressors/atropine Equipment and extra issues To assist in OT table tilt/defibrillation/runner to get blood/airway equipment/patient positioning etc. Re-allocate your thoughts Articulate your thoughts to ensure all team members are on same page of thought process
Interrupt (eliminating the machine when in doubt) (task management)	Interrupt anaesthesia machine and ventilate with self-inflating bag, if malfunction is suspected Common causes of machine malfunction are Failure of Power supply Oxygen supply Ventilator Anaesthetic agent delivery Stuck unidirectional valve Leak
Setting / background / preceding the event (task management)	Correlate with Any event/anaesthesia or surgical insult preceding crisis Patient comorbid condition Review Any wrong drug/dose/route
Investigate A, B, C, D, E (Table 2) - sequential crisis analysis (decision making-options and balancing risks)	Sequentially analyse ABCD Sequentially analyse airway, breathing, circulation, drugs, degree of temperature, decubitus, correlating with patient's clinical signs and electronically monitored parameters (Table 2) Evaluate further Evaluate further by analysing coagulation, acid base, electrolyte, blood sugar status and do ultrasound/echo if necessary
Steer (direct treatment towards definitive cause)	Start appropriate treatment

HME=Heat moisture exchange; ETT=Endotracheal tube; OT=Operation theatre

Table 2: "Investigate" (A-E) component of crisis tool/perioperative monitoring tool

Ascertain the adequacy of A, B, C, D by correlating patient state or drugs administered second and what to monitor keeping patient comorbidities in mind		
Component	**Patient state/drugs administered**	**What to monitor**
Airway and breathing (oxygenation and ventilation)	Patent airway Fresh gas flow settings Lung mechanics	Patient: Visual inspection of airway kink/obstruction/disconnection/displacement, respiratory pattern and rate and surgical field color Machine: Bellows movement/reservoir bag movement and compliance, expiratory tidal volume, airway pressure Monitor: HR, BP, FIO_2, EtO_2, SpO_2, capnography, respiratory plethysmograph
Circulation	Pre-load, after load, contractility	Trends in (ECG, BP, HR, $EtCO_2$, CVP and cardiac output monitoring) Input (fluid and blood) Output (urine and blood)
Drugs administered (depth of anaesthesia/analgesia/neuromuscular blockade/miscellaneous purposes) degree of temperature (thermoregulation) Decubitus (skin perfusion and nerve integrity)	Vaporiser dial settings/TCI settings Analgesics Neuromuscular blocking agents Miscellaneous drugs Warmer and operating room cold environment Patient positioning	End tidal agent concentration/MAC/effector site concentration/plasma concentration/BIS/entropy Analgesia nociceptive index Neuromuscular monitor Vital signs (i) Trend in skin/nasopharyngeal/mid oesophagus/rectal temperature (ii) Vital signs and touch perception visual inspection of pressure points, limb and neck position
If the reason for crisis could not be evaluated, do the diagnostics		
Evaluate diagnosticsfor the"cause"	Coagulation status Acid-base status Ultrasound/echocardiography Sugar Electrolytes	

$EtCO_2$=End-tidal carbon dioxide; FIO_2=Fraction of inspired oxygen; BP=Blood pressure; HR=Heart rate; SpO_2=Oxygen saturation measured by pulse oximetry; ECG=Electrocardiogram; CVP=Central venous pressure; TCI=Transport-based correction instruction; BIS=Bispectral index; MAC=Minimum alveolar concentration

During the debriefing sessions, students expressed that they could handle the crisis in a systematic manner with the use of this tool. They also affirmed that utilising the non-technical skills kept them much calm and organised throughout the scenario.

DESIGN OF THE COGNITIVE TOOL

This cognitive tool is designed to help both inexperienced and experienced anaesthesiologists by incorporating steps of (i) check to confirm the crisis and its severity with the aid of senses; (ii) cease the surgical and anaesthesia procedure stimulus; (iii) re-allocate the roles to keep the patient safe; (iv) interrupt the anaesthesia machine; (v) setting for the preceding event in mind; (vi) investigate sequentially to identify the definite cause; and (vii) steer the treatment.

Relevance of each component of approach

Check to confirm the crisis and its severity with the aid of senses

An anaesthesiologist becomes aware of crisis in the operating room from the values and alarms displayed on the monitor along with the patient's clinical signs. However, even the most sophisticated electronic monitors in the world are prone to errors. Hence, the anaesthesiologist should utilise his specialised senses (look, listen, feel) to cross-check the electronic monitor values to ascertain the crisis and its severity. Even during everyday practice, a vigilant anaesthesiologist routinely gathers subjective and objective information from monitors and senses to correct the anesthetised patient's deviations from normalcy.[7] Specialised senses provide cues about pulse volume and rhythm, skin temperature, breathing pattern, surgical site colour, bleeding and patient communication. This is called situational awareness. Therefore, situational awareness is gathering information using displayed data, direct observation, and communication with other team members. This helps to have knowledge about the overall situation that extends beyond the immediate problem. The ability to develop this awareness accurately, completely, and quickly increases with the anaesthesiologist's expertise. This non-technical skill also practiced in the aviation industry, involves the interpretation of several fast-changing subtle cues.[8] Sarter and Woods[9] defined this concept as 'effective attention filtering in changing data-rich environments'. Necessary skills needed for this process are acquired through experience and simulation-based training.[10]

Table 3: Evaluation checklist for critical scenario simulation

Variable	Response
Utilises clinical senses to understand the crisis and its ascertain its severity (situation awareness - gathering information and anticipates)	□Yes □No
Follows team dynamics by delegating roles based on capabilities to available team members, verbalising thought process to team members (team working-co-ordination and exchange of information)	□Yes □No
Takes steps to keep the patient safe, e.g., 100% oxygen, vasopressor (task management-prioritising)	□Yes □No
Discusses background of the situation and tries to correct reversible causes such as stopping administration of medication/surgical stimulus/ position change/pneumoperitoneum.	□Yes □No
Comes to an acceptable diagnosis by taking following steps (decision making-options and balancing risks)	
A Visual inspection of airway kink/obstruction/ disconnection/displacement, respiratory pattern and rate and surgical field color Checks oxygen flow settings, bellows movement/ reservoir bag movement and compliance, expiratory tidal volume, airway pressure Checks FIO_2, EtO_2, SPo_2, capnography and ascertains tight bag/raised airway pressure	□Yes □No
B Correlate the trends in (ECG, BP, HR, $EtCO_2$, CVP and cardiac output monitoring) with factors affecting pre-load, after load, contractility (e.g.: drugs administered/increase airway/intrathoracic pressure)	□Yes □No
C Assesses the adequacy of anaesthesia	□Yes □No
D Expresses possible need for thoracic ultrasound and acid base status evaluation	□Yes □No
Time taken to ascertain diagnosis (min)	□Yes □No
Manages situation in a calm and systematic manner (task management-planning and utilising resources)	□Yes □No
Re-evaluates situation frequently and consciously avoids fixation error (decision making–options and re-evaluating)	□Yes □No
Follows algorithm till end	□Yes □No
With the "check crisis" approach At what stage of algorithm was the crisis identified? (Check crisis)_____:	

$EtCO_2$=End-tidal carbon dioxide; BP=Blood pressure; HR=Heart rate; ECG=Electrocardiogram; CVP=Central venous pressure; SpO^2=Oxygen saturation

Cesate the stimulus and Re-allocate the roles to manage A, B, C, D, E based on crisis and help available. Articulate your thoughts since our helpers are not mind readers

Irrespective of the cause for crisis, the patient needs to be kept safe until the genesis of event is analysed. This can be accomplished in two steps: (i) anaesthesiologist ceases any procedure or anaesthesia drug administration and communicates with the surgeon to cease surgical stimulus and prevent the progress of insult further; and (ii) re-allocate the roles utilising the team dynamics to manage the patient's airway breathing and circulation. This necessitates non-technical skills for teamwork. The team skills relate to leadership, delegation of roles based on capabilities, effective communication, task coordination, supporting other team members, negotiating and resolving conflicts.[11] This can be done by effectively allocating the roles and following the principles of team dynamics. An easy approach in role delegation would be to follow A, B, C, D, E distribution. The team leader manages Airway and Breathing and supervises the management plan. One person manages the Circulation and also secures additional intravenous access, handles fluid and blood management, another person for administering Drugs. Another person handles Equipment and extra things such as airway gadgets, patient positioning, suction, operating table tilt, defibrillator and also acts as a runner to get blood in case of haemorrhage.

Inadequacy in non-technical skills can enhance the chances of error, raising the possibility of an adverse event. The application of good non-technical skills[12] is essential for efficient crisis management. Non-technical skills are defined as 'the cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task performance.[13] This includes four categories namely: Situation awareness (gather and recognise information, anticipation), decision making, task management (planning, prioritising, identifying and utilising the resources), teamwork (co-ordinating activities with team members, exchanging information, using authority and assertiveness, assessing capabilities and supporting others).

During the crisis, there is a tendency to get carried away in analysing and managing it without the optimisation of oxygenation and organ perfusion. However, managing ABC is the priority to sustain tissue oxygenation in all clinical emergencies during resuscitation.[14]

Interrupt the machine malfunction

If there is oxygen failure or difficulty in ventilation even after the above steps, anaesthesia machine cause is eliminated by ventilating the patient with self-inflating bag. This is because the anaesthesia machine malfunction predisposes critical events and subsequent patient injury. Anaesthesia machine malfunction can occur due to failure of (i) power supply; (ii) oxygen supply, (iii) ventilator; (iv) anaesthetic agent delivery; and (v) a stuck unidirectional valve.[15]

Setting

Most crisis have a preceding event. A drug administered or surgical step or some action of the anaesthesiologist or the patient's comorbid condition may have precipitated the crisis. The setting emphasised in this approach provides clues to the diagnosis. The background for the event

explains circumstances leading to the event.[16] Situational awareness helps to recognise the background during an adverse event at the earliest.[17]

Investigate and Steer the treatment

Fixation errors occur when the anaesthesiologist focuses solely on a single aspect of the problem while ignoring relevant findings by overlooking the bigger picture. These mistakes can significantly contribute to morbidity and mortality. These errors can be avoided by sequential investigation of the findings to identify the definitive diagnosis (Table 2). The uniqueness of this analysis component is that it is (1) easy to remember and familiar (ABCDE), (2) sequential, (3) prioritised, and (4) logical. The individual letter refers to one component avoiding confusion and can be applied to all crisis situations. The analysis is performed in the order of priority starting with Airway and followed by breathing, circulation, drugs administered, degree (temperature), decubitus, and evaluating further causes. This step also incorporates non-technical skills like decision making (identifying options and re-evaluating) and task management (planning, prioritising and utilising resources) for analysing to arrive at a diagnosis and to execute appropriate management.

ROUTINE STRUCTURED INTRAOPERATIVE PATIENT MONITORING

'An ounce of prevention is worth a pound of cure'. The age-old saying can be aptly applied to prevent a crisis. Traditional teaching in anaesthesia emphasises intraoperative vigilant monitoring. However, most residents monitor and manage patients noting the displayed values on the monitor. They do not correlate the displayed values with other factors affecting airway, breathing, and circulation. A structured monitored tool if applied to monitor the patient would aid the resident to understand the interplay of various factors under anaesthesia and assist him to identify the crisis at the earliest. To the best of our knowledge, such a tool is yet unavailable. The 'investigate' component of this approach, 'ABCDE', can be effectively used as a routine intraoperative monitoring tool and is in line with the American Society of Anaesthesiologists monitoring standards.[18] The sequence ABCDE is universally used in most algorithms for airway, breathing, circulation, disability and evaluate which makes it familiar and easily applicable. Moreover, it guides to follows the order of priority for organ systems during monitoring/managing crisis.

The structured and easily remembered cognitive tool 'Check CRISIS' approach incorporates the natural behaviour response of an anaesthesiologist in reacting to the crisis while also incorporating the non-technical skills. This tool can help an inexperienced anaesthesiologist to keep the patient safe until expert help arrives and also improves reacting ability of the experienced anaesthesiologist in a stressed and unfamiliar environment. A uniform structured approach also helps in keeping all the team members on the same page of thought process for a better outcome. We recommend regular use of this cognitive tool in day-to-day anaesthesia practice, theatre teaching and simulation-based training. However, future studies are required for exploring usefulness as well as limitations of this cognitive tool in various crisis scenarios of different subspecialties.

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Conflicts of interest

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