Austin Journal of Anesthesia and Analgesia

Austin Publishing Group

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Full Text Article

Editorial

Challenges in Learning and Assessing Anesthesia Cognitive & Non-technical Skills

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Received: February 24, 2014; Accepted: April 04, 2014; Published: April 10, 2014

Editorial

The definition of performance in anesthesia varies dramatically– from vague (vigilance, data interpretation, plan formulation, and implementation) [1] to very technical, organized, and detailed (gathering information for preoperative evaluation, equipment pre-use preparation, intra-operative checks, postoperative management, airway assessment) [2,3]. Some investigators evaluate performance in anesthesia by separating basic knowledge (gathering information) or the technical (initiating and working with protocols, reviewing checklists) from the cognitive and behavioral or affective (decision-making and team interaction) aspects [4,5]. This separation is based on strong analogies to performance during management of critical events in aviation, another complex and dynamic domain [5]. Most educators in anesthesia today believe it is important to measure two separate aspects of skilled performance in managing crisis situations: implementing appropriate technical actions (technical performance) and manifesting appropriate crisis solving and management of anesthesia non-technical behaviors.

The definition of anesthesia non-technical skills (ANTS) [6-10], includes: (a) task management (planning, prioritizing, keeping standards, using resources); (b) team work (coordinating, exchanging information, using authority, assessing capabilities, supporting); (c) situation awareness (interpreting information, recognizing, anticipating; (d) decision making (identifying & selecting options, re-evaluating). Conversely, technical skills refers to everything that is not ANTS: basic &technical knowledge (gathering information, preparation of drugs and equipment, initiating and working with protocols and checklists) [11,3,12-14] and psychomotor skills (perception, guided response) [15]. The ANTS concept was developed and evaluated in a project between the University of Aberdeen Industrial Psychology Research Center and the Scottish Clinical Simulation Center. A team of anesthetists and psychologists was assembled and designed the anesthetists' non-technical skills system using methods of task analysis similar to the one used for pilots [7,16]. The ANTS include the main nontechnical skills (cognitive and affective) associated with good anesthetic practice [11,3,17].

Models that integrates lower level knowledge and skills-based learning with a higher level of attitude, skills, behavior and culture of patient safety – were developed for the simulated [13,18] and non-simulated [19] environment. One of the early models integrates four progressive capabilities: understanding (knows), application (knows how), integration (shows how) and practice (does) [19]. Knowledge is at the base of this framework and action/doing is at the top. Basic anesthesia knowledge is also a predictive academic variable for anesthesia resident clinical higher-level performance and is measured by using different tests during the first year of training [11].

Cognitive learning and memory (motivation, decision-making) is based in the basal ganglia contrasting with the known role of the medial temporal lobe in declarative memory [20]. Nontechnical skills can be divided into two subgroups: (1) cognitive or mental skills (decision-making, planning, strategy, risk assessment, situation awareness); and (2) social or interpersonal affective skills (teamwork, communication, leadership). Both are necessary for safe and effective

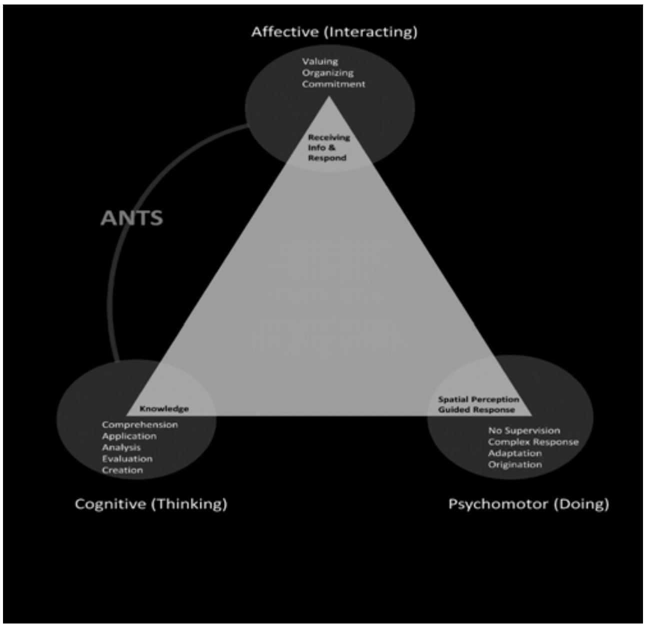

Figure 1: The 3 legs in the skills triangle (with the Cognitive, Affective and Psychomotor skills being the 3 legs), presented in **Figure** created and modified from references [15,18,22].
Affective(Interacting) Skills (a) Receiving Information (b) Responding (c) Valuing (d) Organizing (e) Commitment (see the Affective circle)
Cognitive(Thinking) Skills: (a) Basic Knowledge (b)Comprehension (c) Application (d) Analysis (e) Evaluation (f) Creation (see Cognitive circle).
Psychomotor(Doing) Skills:(a) Technical Information (Perception; Guided Response) (b) Independence (c) Complexity (d) Adaptation (e) Origination (see the Psychomotor circle).
ANTS: Combination of Anesthesia-Non-Technical-Skills (Affective and Cognitive Skills).
Basic & Technical knowledge: receiving information and responding (**lower skill level**=shaded areas) in each circle, are enclosed within the triangle.

Citation: Sidi A. Challenges in Learning and Assessing Anesthesia Cognitive & Non-technical Skills. Austin J Anesthesia and Analgesia. 2014;2(4): 1023.

performance in the operating room [21], and represent 2 of 3 legs in the skills triangle (with the psychomotor skills being the third leg), presented in Figure [15,18,22].

Competency assessment of nontechnical (i.e. cognitive and affective) and technical (i.e. psychomotor) skills [15,22], extremely hard be accomplished using only traditional examinations [11,23-25]. Most clinical competence assessments use either performance-based methods (e.g., objective structured clinical examinations aka OSCEs) or tests that assess the "technical rationality" part of clinical reasoning (e.g., multiple-choice questions). These fail to capture the uncertainty of some clinical scenarios that will be encountered. Problem-solving in the operating room requires a mixture of knowledge and experience [24].

Current evaluation methods (including simulation-based) typically measure basic knowledge and performance, rather than competency, in the complex tasks of acute care [2]. This is why it is important to develop more efficacious methods to measure acute care clinical performance. Simulation could be used to measure advanced cognitive diagnostic and therapeutic management skills and the ability to integrate knowledge, clinical judgment, communication, and teamwork into the simulated practice setting.

Learning theories in medical education offer insights into memory formation, motor skills acquisition, diagnostic decision-making, and instructional design [26]. In spite of a "non-consistent" approach to applying learning theories [27,28]. The Accreditation Council for Graduate Medical Education (ACGME) has instituted an initiative that requires training programs to assess each resident's competence in several domains of medical practice (ACGME Outcomes Project, 2006). [29]. The ACGME toolbox for evaluation lists simulation training as the most effective evaluation strategy for medical procedures [30]. The upcoming ACGME "Developmental Milestones" for internal medicine residency may play an even more prominent role in assessing clinical skills & reasoning and consultative care than in the Outcomes project [31].

Nontechnical skills should be specifically taught and evaluated in all anesthesia training programs [32-34]. Understanding and correcting cognitive errors cannot be overemphasized. Cognitive errors are thought-process errors which lead to incorrect diagnoses and/or treatments. The psychology of decision-making has received little formal attention in the anesthesiology literature. Recently, a cognitive error catalogue specific to anesthesiology practice was created [35]. This catalogue with the original ranking was matched with the cognitive errors found in the Operating-Room, Trauma and Resuscitation Scenarios–in another anesthesia teaching program [18] (Table). The most common cognitive errors in all three tested domains were ranked within top "cognitive-errors" [18,35]. The most common higher-order errors in the *OR* scenarios as well as all 3 domains were anchoring, availability bias, premature closure, and confirmation bias [18]. Some items that were scored as critical by the authors when the cognitive- error anesthesiology 'top 10' was created but were observed relatively infrequently in these 2 comparative studies [18,35]. A goal for each anesthesiology training program should be to explore, define, and pinpoint its own cognitive learning errors and then plan an education strategy designed to decrease these errors.

If we view optimal performance as a combined ANTS integrated with technical skills, we should then expect anesthesiology residents to perform on the same high level for both technical and nontechnical skills. In order to achieve that level, learning objectives and curriculum/teaching should be adjusted to address the deficiencies identified in these learning skills. To reach this objective, educational training in cognitive errors, meta-cognition, and de-biasing strategies is needed [35]. However, there are still many questions regarding which errors are most important to address and which "adjustment" learning strategies are the most appropriate and effective in anesthesiology. Further research in this area is needed to reduce decision-making errors and improve patient safety [35]. Unfortunately, education research is not rocket science, which is built on a structured linear system with a straightforward set of factors which can be inserted into a well-articulated formula to predict a clearly defined outcome. Rather, if we must make analogies to the physical sciences, we might do better to look to quantum mechanics, or the "chaos" theory [36]. Such analogies might lead us away from the search for proof of simple generalized solutions to the observed problems/errors.

A typical process of building "adjustment" learning strategies might follow this strategy: identify a content area that needs to be taught; develop a teaching module to match the content and

Table 1: Cognitive Errors found in the Operating-Room (O.R.), Trauma and Resuscitation Scenarios according to reference [18], compared with the errors catalogue ranking according to Reference [35].

Catalogue Ranking Importance[35]	Error Frequency Ranking in OR Trauma Resusitation [18]	Cognitive Error Type	Cognitive Error Definition
1	1	Anchoring	Focusing on one issue at the expense of understanding the whole situation
2	2	Availability bias	Choosing a diagnosis because it is in the forefront of your mind due to an emotionally charged memory of a bad experience
3	3	Premature closure	Accepting a diagnosis prematurely, failure to consider reasonable differential of possibilities
5	4	Confirmation bias	Seeking or acknowledging only information that confirms the desired or suspected diagnosis
7	5	Commission bias	Tendency toward action rather than inaction. Performing un-indicated maneuvers, deviating from protocol. May be due to overconfidence, desperation, or pressure from others
8	6	Overconfidence bias	Inappropriate boldness, not recognizing the need for help, tendency to believe we are infallible
10	7	Sunk costs	Unwillingness to let go of a failing diagnosis or decision, especially if much time/resources have already been allocated. Ego may play a role
12	8	Zebra retreat	Rare diagnosis figures prominently among possibilities, but physician is hesitant to pursue it

implement the module; test to see if it works try to figure out what went wrong; tweak the design and delivery; test to see if it works now (if it does not, go back…) [36]. There are few suggestions in the literature for "adjustment" learning strategies in order to improve cognitive/higher-order learning or performance:

(1) Problem-Based Learning (PBL) is a well-known technique used in education for three decades [37]. This PBL approach can facilitate the students' processes of acquisition, organization, and retrieval of knowledge, and, to a certain degree, the transfer of knowledge and competencies across different problems [38].

(2) Focus groups [39] involve physicians with a variety of clinical experience in conducting and analyzing broad clinical headings while focusing on certain themes, such as transferring knowledge into practice, and decision-making and uncertainty.

(3) Cognitive Task Analysis (CTA) Simulation-based Modules [40] were developed using a framework of tasks, and the CTA theory as a guide [41] The underpinnings of this theory are based on the assumption that every performable task consists of a series of basic and irreducible cognitive and perceptual operations that enable the human mind [42].

(4) Conceptual frameworks [43] represent ways of thinking about a problem, or ways of representing how complex things work. Different frameworks will emphasize different variables and outcomes, and their inter-relationship.

(5) Cognitive simulators [44] use a generic framework for design, development, and evaluation of such simulators. This framework is generalizable, and can be applied to different task domains. It is independent of the types of sensors, simulation environment, and feedback mechanisms that simulators use.

(6) Script Concordance Test (SCT) [23], could be a new tool of clinical reasoning assessment, which may test the elaborated networks of knowledge that experienced surgeons/anesthesiologists acquire over the years. It allows for multiple different approaches to the same problem and could be developed.

Sharing scenarios can provide an objective comparative view of trainees in American and non-American residencies [45-47] and the potential for universal applicability of such scenarios, and learning from the mistakes detected [47]. When investigators used simulation-based assessment to highlight cognitive mistakes, these models also provided real-time feedback for the tested residents at the end of each scenario [18,47]. Exposing and revealing the mistakes found in the assessment during the debriefing stage can serve as an "adjustment" learning strategy. Defects or mistakes that are recurring themes should inform curriculum development [13].

When investigators based the assessment on testing for Minimal Requirement Task Performance (used in the OSCE [18,47-49]), it appears that even though a smaller number of the tasks/items were advanced/applied knowledge and skills, this type of task was more problematic for all residents [18,47], including the graduating residents [18,47-49]. These comparable results between studies demonstrate the "generalizability" or the feasibility of "sharing" formative or summative assessmentscenarios. This feasibility of sharing scenarios between different residency programs has been previously demonstrated [46,48]. Although simulation in anesthesia has become part of the teaching curricula [4,50,51]. Only 14% of simulation centers use simulation for evaluation of competence [52]. Reasons for this underutilization include lack of standardized, valid, and reliable tests [52]. Communication and collaboration among centers involved in simulation programs (including sharing of validated scenarios) is important to the future of this technology and approach [53].

Using simulation for assessment may have its limitations. We do not have a very good understanding of how cues in the simulated environment affect decision-making and problem-solving. Thus, what we are witnessing may in part be due to the limitations of using simulation for summative assessment. For example, residents often perform relatively well in resuscitation scenarios because the cues received in the simulated environment are often clear-cut (e.g., arrhythmia on monitor), and the treatment follows well known algorithmic approaches (e.g., ACLS). Scenarios that are less clear-cut e.g. evolving hypertension or hypotension may depend on multiple cues from various sources with varying degrees of fidelity.

In summary, cognitive and non-cognitive simulation based skills assessment that included the so called anaesthesia nontechnical skills (ANTS) can help to identify areas of strength and weakness that can be used guide the residency curriculum, especially with regard to deficiencies in tasks requiring higher-order processing. Any such deficiencies need to be addressed in any training program.

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Austin J Anesthesia and Analgesia - Volume 2 Issue 4 - 2014
ISSN : 2381-893X | www.austinpublishinggroup.com

Citation: Sidi A. Challenges in Learning and Assessing Anesthesia Cognitive & Non-technical Skills. Austin J Anesthesia and Analgesia. 2014;2(4): 1023.