

Title: THE RESPONSE OF ANESTHESIA TRAINEES TO SIMULATED CRITICAL INCIDENTS

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INTRODUCTION: Critical incidents during anesthesia¹ are those incidents which if not detected and corrected will lead to a negative outcome for the patient. Cooper, *et al.* stated that "...risk management depends almost solely on the anesthetist's ability to react instinctively and flawlessly every time a problem arises."¹ Because serious problems are uncommon we studied the response of 23 anesthesia trainees to the same predetermined minor and critical incidents in a comprehensive anesthesia simulation environment.²

METHODS: Use of human subjects was approved by the Institutional Review Board and informed consent was obtained from 23 subjects: 4 medical students (MS), 10 first year anesthesia residents (R1), 9 second year anesthesia residents (R2). Simulations took place in a vacant operating room. The simulator system² provides inputs to most commonly used monitors during anesthesia (ECG, non-invasive and intravascular blood pressure, central venous and pulmonary artery pressures, temperature, mass spectrometry, pulse oximetry, circuit spirometry). A mannequin allows endotracheal intubation and has lungs which can be occluded preferentially. Standard intravenous tubing allows administration of drugs from syringes. The simulator responds to the subject's actions as determined by a pre-defined script which lists planned problems and the results of administering various drugs. The same test scenario lasting approximately 60 minutes was presented to all subjects who were given a brief written description of the patient's history, physical examination, and laboratory data.

Subjects then administered anesthesia for the designated case (mastoid surgery with the OR table turned 180 degrees), during which several planned incidents occurred (Tables 1-4). Manifestations of these events were made to worsen until the subject compensated for or corrected the underlying abnormality (by pre-defined criteria). In order to observe the response to an intraoperative cardiac arrest, the final incident in all cases (regardless of the prior responses) was a lethal ventricular arrhythmia. Deviations from the 1983 or 1986 ACLS protocols during the cardiac arrest were scored as: MINOR (e.g. different shock energies; lidocaine prior to epinephrine) and MAJOR (e.g. anesthetic gases left on; epinephrine never administered)

The subjects were instructed to "think aloud" and the simulations were videotaped. The tapes were transcribed by the authors and the responses to incidents were tabulated.

RESULTS: The 23 subjects experienced 135 planned incidents (3 incidents were cancelled for technical reasons). 93 unplanned problems occurred, 7 due to equipment failure and 86 due to human error. The percentage of successful recognition of the need for long breathing hoses (with the table turned) is shown in Table 1. The success rates and times (sec., mean \pm SD) for detection (observing any manifestation of the incident) and for beginning definitive correction of 4 of the planned incidents are shown in Tables 2&3. Compliance with ACLS protocols is shown in Table 4.

DISCUSSION: The responses, while generally successful, were not flawless. A large number of unplanned problems were caused by the subject's errors. There was a non-significant trend to faster and more successful responses in the R2 group. Errors made by the outliers may give as much information as the mean behavior of the groups.

Although these subjects, especially the MS and R1 groups, had a minimum of anesthesia experience, the R2 group had completed more than 50% of its ABA training requirement. It is not yet known whether more experienced subjects will respond faster and with fewer errors.

Classic examples of human error in anesthesia have focused on faulty vigilance and on errors at the sensory/motor level. While we observed several sensory/motor errors (e.g. 2 errors in switching the ventilator and the ventilator/bag valve, and 1 case of a "look-alike" ampule swap) vigilance was never lacking. This study supports our contention³ that vigilant detection of a problem is not alone sufficient to correct the problem. Errors in anesthesiologist also responses stemmed from defects in rule-based problem solving (e.g. If S_pO_2 decreases assume cautery artefact or faulty probe) or from faults in stored didactic knowledge (e.g. omission of "endobronchial intubation" in the list of causes of hypoxemia; errors in remembering ACLS protocol).

Further definition of the different levels of human error in anesthesia may lead to improvements in training, equipment, or practice protocols which will reduce the risk or impact of anesthetic mishaps (Supported by an Anesthesia Patient Safety Foundation grant)

Table 1: Early Recognition of Need for Extension Hoses

	MS	R1	R2
	25%	50%	50%

Table 2: First Detection of Critical Incidents

INCIDENT	MS		R1		R2	
	%	Time	%	Time	%	Time
1)Endobronchial Intubation	75	(169 \pm 60)	100	(137 \pm 180)	100	(72 \pm 90)
2)Kinked IV	75	(309 \pm 375)	90	(222 \pm 247)	89	(114 \pm 73)
3)Atrial Fibrillation	50	(70 \pm 55)	80	(106 \pm 152)	83	(39 \pm 26)
4)Circuit Disconnect	100	(19 \pm 6)	100	(25 \pm 23)	100	(17 \pm 4)

Table 3: Definitive Diagnosis and Correction of Incidents

INCIDENT	MS		R1		R2	
	%	Time	%	Time	%	Time
1)Endobronchial Intubation	50	(546 \pm 215)	100	(622 \pm 376)	89	(382 \pm 176)
2)Kinked IV	75	(353 \pm 362)	70	(320 \pm 271)	89	(166 \pm 85)
3)Atrial Fibrillation	25	(77 \pm 0)	40	(344 \pm 122)	55	(213 \pm 90)
4)Circuit Disconnect	75	(49 \pm 17)	100	(72 \pm 46)	100	(32 \pm 9)

Table 4: Compliance with ACLS protocol

	MS	R1	R2
Perfect	0%	20%	11%
Minor Deviation	0%	20%	33%
Major Deviation	100%	60%	56%

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