



## Research article

## Using critical care physicians to deliver anesthesia and boost surgical caseload in austere environments: the Critical Care General Anesthesia Syllabus (CC GAS)



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## ABSTRACT

**Background:** Despite an often severe lack of surgeons and surgical equipment, the rate-limiting step in surgical care for the nearly five billion people living in resource-limited areas is frequently the absence of safe anesthesia. During disaster relief and surgical missions, critical care physicians (CCPs), who are already competent in complex airway and ventilator management, can help address the need for skilled anesthetists in these settings.

**Methods:** We provided a descriptive analysis that CCPs were trained to provide safe general anesthesia, monitored anesthesia care (MAC), and spinal anesthesia using a specifically designed and simple syllabus.

**Results:** Six CCPs provided anesthesia under the supervision of a board-certified anesthesiologist for 58 (32%) cases of a total of 183 surgical cases performed by a surgical mission team at St. Luc Hospital in Port-au-Prince, Haiti in 2013, 2017, and 2018. There were no reported complications.

**Conclusions:** Given CCPs' competencies in complex airway and ventilator management, a CCP, with minimal training from a simple syllabus, may be able to act as an anesthesiologist-extender and safely administer anesthesia in the austere environment, increasing the number of surgical cases that can be performed. Further studies are necessary to confirm our observation.

## 1. Introduction

On January 12, 2010, a 7.0-magnitude earthquake struck Haiti, causing an estimated 222,570 deaths and an additional 300,000 injuries [1]. Prior to this earthquake and the subsequent cholera epidemic, Haiti's health care system was already suffering from a troubling shortage of medical facilities and specialists, including board-certified anesthesiologists [2, 3]. This deficit became especially apparent in the months following the disaster, as Haiti's remaining hospitals became inundated by patients with a variety of injuries requiring surgical management.

The scarcity of anesthesiologists and other specialized physicians is not limited to Haiti. Five billion people, primarily in low- and middle-income countries (LMICs), do not have consistent access to safe and affordable surgical and anesthetic care [2, 4]. In many cases, the impediment to surgical procedures is the lack of access to safe anesthesia [5]. For example, multiple studies from low- and middle-income countries showed anesthesia-mortality rate ranging from 1 death per 133 anesthetic cases in Togo [6], 1 in 482 in anesthetic cases in Zimbabwe [7], or 1 per 504 anesthetics in Malawi [8], while a report from the United Kingdom quoted the mortality from anesthesia was 1 death per 185000 anesthetic cases [9]. Most of these studies suggested that causes

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for the high mortality per anesthetic cases were attributed to the lack of medically qualified anesthetists, lack of appropriate training and supervision for non-anesthetists, lack of equipment and supplies [9]. The Lancet Commission on Global Surgery suggested that 143 million additional surgical procedures are needed each year to save lives [4], with many regions have up to 5000 unmet surgical cases per 100000 population per year [4]. More specifically, a survey from Uganda showed that only 23% of anesthetists had adequate facilities to deliver safe anesthesia to adult surgery, and only 13% could safely deliver anesthesia to children [10].

We propose that critical care physicians (CCPs) trained as anesthesiologist-extenders and acting under the supervision of an anesthesiologist can fill this void. CCPs possess complex airway management skills, including mask ventilation and endotracheal intubation. They are familiar with commonly used monitoring equipment as well as drugs employed in the operating room (OR), such as analgesics, sedative hypnotics, and paralytics. These skills make them suitable candidates for administering anesthetic care [11, 12]. Furthermore, CCPs are frequently responsible for directing fluid management and resuscitation, vasopressor use, and ventilator management, making them an asset in the preoperative and postoperative settings as their training core competencies dictated that they are proficient with caring for perioperative critically ill patients [11, 12] (Appendix 1). In addition to this skill set, addition of anesthesia training using the Critical Care General Anesthesia Syllabus (CC GAS) [13] and the focus on patient monitoring and safety, CCPs could function at a level similar to that of a certified registered nurse anesthetist (CRNA) in a resource-limited setting, under a board-certified anesthesiologist's direct supervision.

In this article, we report the effects of incorporating six CCPs as anesthesiologist-extenders into civilian surgical mission teams operating in Haiti. We also discuss the impact of this training on the increase in the number of surgeries that could be performed in this austere environment.

## 2. Methods

### 2.1. Training CCPs in anesthesia

We used the CC GAS curriculum to train six CCPs in the basics of the delivery of general anesthesia. The curriculum is based on the Emergency Medicine General Anesthesia Syllabus (EP GAS), which was developed for training emergency medicine physicians in the provision of general anesthesia in disaster and resource-limited settings [13, 14]. The supervising anesthesiologist provided instruction on managing difficult airways according to existing curricula in anesthesia certification training [15, 16]. A list of the core competencies required to train Critical Care physicians was provided in Appendix 1. Among this list, Core competencies included airway management, initiation and maintenance of, and withdrawal of mechanical ventilatory support. The core competencies for critical care physicians also mandated that critical care physicians are proficient in endotracheal intubation and lumbar puncture [11].

The Core competencies (Appendix 1) for critical care physicians mandated that CCPs are proficient in managing peri-operative critically ill patients and "operation of bedside hemodynamic monitoring systems" (Appendix 1). These core competencies prepare CCPs to provide monitored anesthesia care (MAC), in addition to conscious sedation. Monitored anesthesia care (MAC), according to the American Society of Anesthesiologists (ASA), is anesthesia service for diagnostic or therapeutic procedures under local anesthesia along with sedation and analgesia [17,18].

One of two methods was used to prepare the CCPs: training prior to arrival in Haiti or onsite training in Haiti. The first two ("index") CCPs were trained under the direct supervision of a board-certified anesthesiologist in the United States at two academic referral hospitals. They completed 103 surgical cases in September 2013 and February 2015 prior to working in Haiti. During their training, an anesthesiologist was present for the full duration of each surgical case, monitoring the

measurement and administration of all medications. Subsequently, one of the index CCPs and the principal anesthesiologist provided supervision and training of the remaining four CCPs in Haiti.

Preparation before each case included completing a detailed checklist of the equipment and medications required for general anesthesia. The anesthesia machine, suction apparatus, monitor, airway, intravenous lines, and medications were reviewed using the "MS MAID" mnemonic (Table 1). A standardized sequence for delivering medications for pre-induction, induction, maintenance, and emergence was used for all cases (Table 2). During each case, the "MS MAID" items were checked and performed every 5 min, with an emphasis on oxygenation, gas flow, suction function, vital signs, ventilator settings, airway patency, IV line patency, medications given, and those expected to be given during the remainder of the case. Patients were assigned randomly to the first available clinicians to start the case, whether it was the principal anesthesiologist or the critical care physicians because there were insufficient patients' records to assign the American Society of Anesthesiologists (ASA) scores.

For basic training of spinal anesthesia, the critical care physicians first observed the principal anesthesiologist perform the technique. The critical care physicians then performed the procedure under the supervision of the principal anesthesiologist. Critical care physicians are proficient with performing lumbar puncture, as it is a required procedure for their training core competencies, the supervision was an added level for patient safety. It was not necessary to train the CCPs in MAC sedation, because it is one of their regular certification competencies [11] (Appendix 1).

Our study was approved by the principal investigator's Institutional review board. When the study was presented to the Institution Review Board, it was accepted that medical standard of care was met by constant and continuous supervision of the Critical Care physicians by the board-certified anesthesiologist throughout the operative periods, in accordance with previous international medical and surgical relief publications [19, 20, 21]. Furthermore, the board-certified anesthesiologist was immediately available to the Critical Care Physicians in an adjacent room in Haiti [19, 20, 21] and patients were consented for the surgery and the non-anesthetic providers in their native language. The study was also approved by the Ethics Committee at the Haitian hospital. No statistical analyses were used in this descriptive study.

## 3. Results

The Haitian surgical mission team consisted of two urologists, two general surgeons, one anesthesiologist, and as many as six CCPs. This team provided surgical care to 183 patients during 3-week periods in 2013, 2014, and 2018.

At the Haitian hospital, the CCPs administered the three stages of anesthesia: induction, maintenance, and emergence. In addition, they took a primary role in managing the preoperative and postoperative care of all of the team's patients. To ensure that medical standard of care was maintained, the anesthesiologist was always present in an adjoining room and available for consultation.

The two index CCPs performed 103 cases during their training under the direct supervision of three clinically practicing, board-certified anesthesiologists who were recruited by the lead anesthesiologist. These board-certified anesthesiologists supervised the CCPs as they learned anesthesia procedures such as general anesthesia, monitored anesthesia care, spinal anesthesia. The training cases are summarized in Table 3.

In Haiti, 183 procedures were performed by the surgical mission team (Table 4). In 58 (32%) of them, anesthesia was delivered by the six CCPs acting as anesthesiologist-extenders. These cases, as well as those performed by the supervising anesthesiologist, are summarized in Table 4. The most common procedure was Holium laser enucleation of the prostate (HoLEP) (35%), followed by herniorrhaphy (28%) and hydrocelectomy (15%). Spinal anesthesia was used in approximately 23% of cases, 7% by the CCP and 16% by the anesthesiologist (Table 4). No adverse events occurred during these cases.

**Table 1.** “MS MAID” mnemonic for safe anesthesia care.

M – Machine check	Check on/off switch, oxygen (O <sub>2</sub> ) flow, nitrous oxide (NO <sub>2</sub> ) flow, sevoflurane and desflurane levels, filling of apparatus with anesthetic, pop-off valve pressure, and circuitry
S – Suction apparatus	Assemble suction apparatus, monitor suction
M – Monitor	Monitor blood pressure (BP), heart rate (HR), O <sub>2</sub> saturation, end-tidal CO <sub>2</sub> (ETCO <sub>2</sub> ), anesthetic inspiratory and expiratory concentrations, ventilator and monitor settings
A – Airway	Prepare/inspect endotracheal tube, stylet, laryngoscope blade and handle, bag valve mask, oral airway, O <sub>2</sub> tubing, and tape
I – Intravenous (IV) access	Check IV line placement and ensure adequate flow
D – Drugs	Prepare anesthetic drug regimen, check for all labeled syringes

**Table 2.** Standardized medication regimen for general anesthesia.

Pre-Induction and Induction	Anesthesia Induction	Maintenance and Emergence
1. Preoxygenation with 100% O <sub>2</sub>	1. Sevoflurane, 4% at 10 L/min O <sub>2</sub>	1. Sevoflurane, 4% at 0.6 L/min O <sub>2</sub> upon incision
2. Rocuronium, 5 mg (0.5 mL), glycopyrrolate 0.2 mg (1 mL)	2. Sevoflurane, 4% at 2 L/min O <sub>2</sub> (after taping ET tube in place and positioning the patient)	2. Nitrous oxide at 0.6 L/min O <sub>2</sub> upon incision
3. Fentanyl, 100 µg (2 mL)	3. Nitrous oxide at 2 L/min O <sub>2</sub> (after taping ET tube in place and positioning the patient)	3. Emergence begins at last suture with stopping anesthetic and administering 10 L/min O <sub>2</sub> to wash out anesthetic gas
4. Propofol, 150 mg (15 mL)		
5. Succinylcholine, 100 mg (5 mL), (rocuronium, 30 mg [3 mL] for long cases)		
6. Propofol, 50 mg (5 mL) (rescue), succinylcholine, 100 mg (5 mL) (rescue)		

O<sub>2</sub>, oxygen; mg, milligram; mL, milliliter; µg, microgram; L/min, liters per minute.

**Table 3.** Index CCP training cases (N = 103).

Orthopedic, N (%)	
ORIF	4 (4)
Hip and knee arthroplasty	11 (10)
Rotator cuff repair	4 (4)
Genitourinary, N (%)	
Prostatectomy	2 (2)
Cystostomy	1 (1)
Ureteral stent placement	1 (1)
Otolaryngology, N (%)	
T&A	12 (11)
Thyroidectomy	3 (3)
Parotid tumor resection	1 (1)
Head and neck cancer resection	4 (4)
Obstetrics and gynecology, N (%)	
TAH	4 (4)
Vaginal hysterectomy	3 (3)
Oophorectomy	4 (4)
General surgery, N (%)	
Appendectomy	3 (3)
Colectomy	7 (7)
Cholecystectomy	9 (9)
Herniorrhaphy	15 (14)
Vascular, N (%)	
Endarterectomy	4 (4)
Aortic stent placement	4 (4)
Cardiac, N (%)	
CABG	4 (4)
Neurosurgery, N (%)	
Evacuation burr hole	2 (2)
Craniotomy	1 (1)

ORIF, open reduction internal fixation; T&A, tonsillectomy and adenoidectomy; TAH, transabdominal hysterectomy; CABG, coronary artery bypass graft.

#### 4. Discussion

The limited number of anesthesiologists in the developing world restricts access to safe anesthesia [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]. After the 2010 earthquake and the ensuing cholera epidemic in Haiti, the lack of infrastructure and appropriate personnel was associated with the deaths of thousands of people [22]. In response to this crisis, the EP GAS and ORTHO GAS curricula were developed to give emergency physicians the skills to act as anesthetists, working under close observation by anesthesiologists in Haiti [13, 14]. Our study extended this work, demonstrating that critical care physicians can also deliver effectively anesthesia in the role of anesthesiologist-extendors: more caseloads and successful performance of surgery.

By including CCPs trained in the CC GAS curriculum, surgical mission teams were able to increase the volume of their practice from 125, if done with anesthesiologist alone, to 183 cases, an increase of 32% during their limited time in Haiti. In 58 of the 183 procedures performed, anesthesia was administered by a CCP under the observation of an anesthesiologist. These 58 cases likely would have been postponed, in some instances indefinitely, due to the lack of trained anesthetists. Although our sample size was small and not be enough to statistically report complications and adverse events, all the case loads during the mission was outpatient cases, which were associated with lower rates of adverse events [23], thus reducing the probability of adverse events. Furthermore, critical care physicians are trained and specialized in the care of the peri-operative critically ill patients, as required by the training core competencies of critical care medicine (Appendix 1). As a result, critical care physicians are trained to manage patients if adverse events were to occur. Although further studies are necessary to confirm or refute our observation, our study may be supported by a previous study about the outcome of nurse anesthetists. Dulisse et al showed that nurse anesthetists working without the supervision of an anesthesiologist had similar mortality and adverse events as anesthesiologists' cases [24]. Additionally, when nurse anesthetists work as a team with anesthesiologists, the odds for complications was 10% lower to cases when anesthesiologists were working alone. Therefore, critical care physicians can increase surgical availability in resource-limited settings, without sacrificing safety, although further studies are still needed.

**Table 4.** Surgical cases performed by a board-certified anesthesiologist and critical care physicians (N = 183).

Procedure	Critical Care Physicians N = 58 (32%)			Anesthesiologist N = 125 (68%)			Total N (%)
	General Anesthesia N (%)	Spinal Anesthesia N (%)	MAC N (%)	General Anesthesia N (%)	Spinal Anesthesia N (%)	MAC N (%)	
Hemiorrhaphy	19 (10)*	6 (3)	0	15 (8)	12 (6)	0	52 (28)
HoLEP	12 (6)	0	0	52 (28)	0	0	64 (35)
Circumcision	5 (3)	1 (0.5)	0	0	9 (5)	0	15 (8)
Hydrocelectomy	4 (2)	2 (1)	0	13 (7)	9 (5)	0	28 (15)
Laparotomy	1 (0.5)	0	0	1 (0.5)	0	0	2 (1)
Appendectomy	1 (0.5)	0	0	0	0	0	1 (0.5)
Mass excision	0	0	3 (2)	0	0	0	3 (2)
Laser lithotripsy	0	0	0	3 (2)	0	0	3 (2)
Scrotal exploration & drainage	1 (0.5)	0	0	2 (1)	0	1 (0.5)	4 (2)
Orchiectomy	0	2 (1)	0	0	0	0	2 (1)
Orchiopexy	0	0	0	1 (0.5)	0	0	1 (0.5)
Cystotomy	0	0	0	2 (1)	0	0	2 (1)
Cystoscopy	0	1 (1)	0	1 (0.5)	0	0	2 (1)
Large keloid removal - ear	0	0	0	2 (1)	0	0	2 (1)
Lipomectomy	0	0	0	0	0	1 (0.5)	1 (0.5)
Mandibular cyst excision	0	0	0	1 (0.5)	0	0	1 (0.5)
Total, N (%)	43 (23)	12 (7)	3 (2)	93 (51)	30 (16)	2 (1)	183 (100)

\*One hemiorrhaphy began with spinal anesthesia, but the CCP needed to convert to general anesthesia.

The surgical mission group performed 23% of the procedures after inducing spinal anesthesia, which has been shown to be more cost-effective than general anesthesia for hysterectomy [25]. Spinal anesthesia for surgical operations below the umbilicus can be managed effectively by CCPs. After bupivacaine, with or without fentanyl, is introduced into the intrathecal space via lumbar puncture, patients are moderately sedated while undergoing surgery. Both lumbar puncture and moderate sedation are within the scope of practice and skill set of CCPs. Their presence allows the supervising anesthesiologist to pay more attention to patients undergoing general anesthesia.

While inducing spinal anesthesia in Haiti, we noticed that it took as long as 30 min for it to take effect. Therefore, we improvised our work flow to allow spinal anesthesia to take full effect while minimizing delays in OR turnover. We brought patients scheduled for spinal anesthesia to an area near the OR and began induction of spinal anesthesia 30 min prior to the end of the ongoing case. Then, as soon as the OR was ready, the patient was also ready for the CCP to administer conscious sedation so that the procedure could begin. The elongated induction time could have been a local effect, so we encourage further studies to confirm our observation.

#### 4.1. Limitations

Due to the lack of standardized medical records at the Haitian hospital, patients' demographic data were frequently missing in our study populations. We were not able to compare the patient populations cared for by CCPs with those seen by the anesthesiologist. Furthermore, we did not study the effect of CCP as anesthesiologist-extender on OR work flow. Furthermore, our sample size was small to provide any meaningful statistical analyses.

#### 5. Conclusion

This prospective pilot study demonstrated that CCPs can effectively provide anesthesia under the supervision of a board-certified anesthesiologist to fill the void caused by a lack of trained anesthesiologists in resource-limited settings. Further study is needed to determine the scope of CCPs' role in anesthesia in these settings. Following the CC GAS curriculum, a critical care physician can be taught the basics of general

anesthesia, and spinal anesthesia, increasing the number of procedures that can be performed in resource-limited settings by surgical mission teams. Further studies, especially to quantify the safety profile, are needed to confirm our observation.

#### Declarations

##### Author contribution statement

R. Skupski, A. Toth, D. Zimmer, M. Walsh, M. Mccurdy and J. Lantry: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Q. Tran, N. Mark, L. Losonczy, M. Augustin, L. Colas, B. Patel and R. Tracy: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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##### Competing interest statement

The authors declare no conflict of interest.

##### Additional information

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