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Original Research

An Advanced Boot Camp for Pediatric Anesthesiology Fellows

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Introduction

A boot camp is a brief, focused course designed to enhance learning, orientation, and preparation of the learners using multiple educational methods.[1] Medical schools, residencies, and fellowship programs have integrated the concept of boot camps as part of their curricula.[1-3] Most medical education boot camps employ a combination of low- and high-fidelity simulation scenarios, skill stations, and standardized patient encounters with an emphasis on repetition followed by structured, formative feedback. By providing a safe, nonjudgmental, and realistic learning environment where trainees can partake in the act of deliberate practice, this type of educational format can be useful for trainees who are learning new clinical roles.

In a previous report,[2] we described the development of an introductory boot camp for pediatric anesthesiology fellows that was intended to teach skills such as pediatric difficult airway techniques, ultrasound-guided placement of vascular access, and management of simulated pediatric perioperative critical events. Pediatric anesthesiology fellows were encouraged to develop strategies to apply their knowledge and review decision-making during the simulated critical events. Participants reported that the introductory boot camp improved their knowledge, self-confidence, technical skills, and clinical performance at the beginning of their fellowship training.[2]

However, the role of the pediatric anesthesiologist is complex and requires unique skills in diverse areas such as the perioperative arena and the emergency department, as well as in diverse situations such as cardiac arrest and difficult airway occurrences. Thus managing pediatric patients for general anesthesia or sedation necessitates not only acquisition of unique skills during fellowship training but also the acquisition of confidence in its execution. Additionally, transitioning from trainee to an independent practitioner is a crucial step in the development of a pediatric anesthesiologist. To address these unique challenges, we have developed a curriculum in the form of an advanced boot camp that targets the graduating pediatric anesthesiology fellows. Our methodology is based on prior studies[4,5] suggesting that the adult learner's perceptions of any educational offering are substantially linked to the impact of the offering on the learner. The aim of the present study is to formulate a curriculum for graduating pediatric anesthesiology fellows and assess their perceptions of methods used in the curriculum regarding the following: (1) application and improvement of knowledge, (2) enhancement of self-confidence, and (3) assistance with transition preparation from fellow to attending anesthesiologist. We hypothesize that graduating fellows will determine that our curriculum will assist in their transition to attending anesthesiologists.

Material and Methods

The study (IRB00133941) was qualified as exempt research under DHHS regulation by the Johns Hopkins Medicine Institutional Review Board.

Curriculum Design

The curriculum design was based on creating a constructivist learning environment, which emphasizes case-based learning with skill acquisition in a meaningful manner, thereby promoting *context and content dependent knowledge construction*.[6] The simulated patient care environment was deliberately constructed to represent complex real-life situations that a pediatric anesthesiologist may encounter. This format intention was to support collaborative building of knowledge among the participants during the management of the perioperative critical events and allowed for a thoughtful reflection after each experience.[7] We developed scenarios based on Kolb's theory of the importance of affectively, perceptually, and behaviorally oriented environments, which required the participants to draw from skills and knowledge gained during fellowship training.[8] Participants were given the opportunity to practice a variety of

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nontechnical skills such as critical decision making, crisis resource management, delivering bad news to a standardized parent, and providing feedback to trainees. Table 1 describes the details and objectives of the training stations used in the boot camp.

Course Design

Participants

All the participating institutions were informed about the boot camp 6 months in advance. Fellow participation for the boot camp was based on institutional preference (ie, mandatory vs voluntary). All the participants who attended the boot camp (22 in 2017 and 28 in 2018) were divided into teams of 4 or 5 participants each, with minimal redundancy from each institution. Each participant was encouraged to play the role of team leader in at least 1 scenario. Each team remained intact throughout the day (across all learning stations).

Stations and Scenario Selection

Simulation scenarios were based on the clinical conditions or events that would be experienced by a pediatric anesthesiologist such as neonatal emergencies, nonoperative room anesthesia such as interventional radiology suite or an airway emergency in an emergency department, cardiac patient for noncardiac surgery, and reviewing the principles of Pediatric Advanced Life Support (PALS). To address the expansion of the role of the pediatric anesthesiologist from perioperative arena to hospital code and difficult airway response teams, in 2018 we substituted PALS rapid cycle deliberate practice with debriefing with evaluation and management of a pediatric burn patient in an emergency department. The complexity of cases provided fellows the opportunity to demonstrate key strategies for managing pediatric emergencies while exploring knowledge and confidence at their current level of training. Fellows practiced leadership and teamwork strategies when working in unfamiliar environments and with unfamiliar personnel and dealing with real life issues, such as surgical pressure while maintaining patient safety. (A sample of a simulation scenario is available in the Supplemental Online Material 1).

Addressing perioperative complications presents a unique challenge to the newly graduate pediatric anesthesiologist. To teach this unique skill, we developed a second victim self-reflection module and a station to simulate the delivery of bad news to a standardized parent. To address professional development and self-improvement, a facilitated discussion on how to give feedback was developed. A regional anesthesia skill station with standardized patients was developed to refine ultrasound scanning skills and identify neurovascular structures for advanced regional blocks including quadratus lumborum block, anterior and subgluteal approaches to sciatic nerve, and paravertebral nerve blocks for the fellows.

Faculty

Pediatric anesthesiologists from participating academic institutions with a focus on fellow's education served as faculty for the boot camp. Each simulation station had faculty with experience in simulation-based education and facilitated debriefing. The faculty were assigned to different stations depending on their expertise and field of interests. For simulation-based scenarios, faculty played roles of an embedded participant such as operating room nurse, scrub technician, surgeon, or simulation facilitator depending on the needs of the station. Faculty with prior training in facilitated debriefing or those familiar with reflective and learner-centered debriefing led the debriefing as described in our prior publication.[2]

Facility and Supplies

All the activities for the boot camp occurred in the clinical work environment at the Johns Hopkins Hospital. For the nonoperative anesthesia scenario, we turned one of the operating rooms into a neurointerventional suite. We also converted a Pediatric Anesthesia Care Unit bay into a believable emergency room trauma room. Because we had used expired and not for patient use consumable items for teaching purposes, at the end of the boot camp we removed these items from patient care areas. A nominal fee was charged to the participating institutions for each fellow. The fee was used to cover administrative costs such as parking, food, standardized patients, and simulation technicians. No monetary compensation was provided to the faculty.

Assessment of the Boot Camp

At the conclusion of the boot camp, participants were asked to complete a survey. The participants' completion of the survey served as their consent to participate in the research study. The survey evaluated each station and the overall course in the following domains using a Likert Scale:

a. This activity was useful to enhance my knowledge
b. This activity helped to develop my self confidence
c. This activity was appropriately designed for the level of a graduating fellow
d. This activity provided tools for me to transition into my new role of an independent practitioner

Nominal Values were assigned to the Likert Scale as follows: *1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree,* and *5 = strongly agree*.

Descriptive statistics were used to characterize survey responses among participants. Medians, interquartile range, and minimum and maximum values were tabulated and reported for all items on the survey. Frequency counts and percentages were used for categorical variables. Data were analyzed using SPSS statistical software (version 20, IBM Corporation, Chicago, IL).

Results

Forty-nine out of 50 participants completed the survey. Two surveys were incomplete and were excluded from the analysis. Fellow perception of the advanced boot camp was positive (Tables 2 and 3). Fellows agreed that the curriculum provided an appropriate level of complexity for their level of training, enhanced their knowledge, and improved their self-confidence. Fellows' assessments also reported that the experience provided tools that help them transition into their new role as a pediatric anesthesiologist (median scores of 5 in all domains for the overall experience in 2017 and 2018; Tables 2 and 3).

High-fidelity simulation scenarios each

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had a median score of 5 in all the domains, with the exception of the vein of Galen malformation, congenital pulmonary airway malformation, and unrepaired tetralogy of Fallot for exploratory laparotomy scenarios, each of which had median score of 4 to 4.5 for effect on self-confidence, in one or both the years. In 2018, the vein of Galen scenario had a median score of 4 for the transition into a new role. In 2018, we replaced the PALS refresher station with a pediatric burn scenario that had similar median score of 5 in all domains. The disclosure of perioperative adverse event and second victim modules were well received and had median scores of 4 to 5 in all the domains in 2017 and 2018. The ultrasound-guided regional anesthesia skill station had median scores of 4 and 5 for all of the domains in 2017 and 2018, respectively, with the exception of knowledge where the median score was 4 in both the years. Interestingly, because of feedback regarding the need for more complexity in 2017, the regional anesthesia station was revised to include complex blocks described in the methods section. A reduction in the interquartile range from 3 to 5 in 2017 (Table 2) to 4 to 5 in 2018 along with median scores of 5 in 3 of 4 domains (Table 3) was demonstrated.

The qualitative feedback (written comments) for the second victim module included a request for more time for self-reflection. Additionally, participants believed that exposure to this topic should occur earlier during the pediatric anesthesia fellowship. One participant reported that the vein of Galen malformation scenario was a topic of which they had limited prior experience or knowledge. Several fellows also suggested that the total duration for each simulation session be reduced to either add more activities or shorten the length of the day. The other comments focused on improving the organization and administrative components of the day such as the distribution of assignments to the fellows and faculty, information about the facility (map), or details regarding where and when to arrive on the day of the boot camp.

Discussion

We have described a novel, advanced boot camp curriculum for pediatric anesthesiology fellows as a platform to practice and reflect on their knowledge and skills and to prepare them for the transition to becoming an independent practitioner. Participants reported that the experience was appropriately designed for pediatric anesthesiology fellows near the end of their training and provided them with tools and strategies for transition into the role of an attending pediatric anesthesiologist. Interestingly, revisions to the curriculum based on feedback from 2017 appeared to be well received by the fellows in 2018, which emphasizes the importance of learner feedback in curriculum development.

Advanced Boot Camps Address Unmet Educational Needs for Graduating Clinical Medicine Trainees

Most of the boot camps reported in the literature are used in orientation, occurring either at the onset of the new clinical role or prior to the start of internships or residencies.[1-3] Surveys from newly hired independent practitioners show that prior training and experiences give them medical knowledge and clinical skills. However, areas of deficiency identified by these newly independent medical doctors include conflict resolution, leadership, supervision, time management, and administrative and finance skills.[9-12] MacDonald et al[13] developed a national forum for senior psychiatry trainees to assist their transition to independence. This forum included training in nonclinical skills such as teaching and supervision, leadership and management, professional standards, health informatics, conducting scientific investigation and publication, handling complaints, and understanding structure and function of the health service system in New Zealand.[13] A journal club for peer mentorship program was described for recent general internal medicine fellowship graduates. Some of the areas of discussion for the internal medicine fellowship journal club included diagnostic challenges, how to address unexpected or adverse patient outcomes, ethical dilemmas, conflict resolution, negotiation, how to address regulatory or legal complaints, in addition to how to compose letters of reference or negative evaluations.[14] Similar to the psychiatry and internal medicine educational activities geared for transition to independence, our advanced boot camp was deliberately designed as a late fellowship experience to address some of the challenges associated with transition, such as how to provide feedback and how to address personal emotions and patient families following an adverse outcome. We used standardized patients to practice the delivery of bad news and integrated the concept of the second victim into this discussion. These tools provided opportunities for the fellows to practice speaking up in these situations as well as the opportunity to practice being a perioperative team leader.

Advanced Boot Camps Encourage Self-confidence in the Execution of Critical Tasks by Graduating Clinical Medical Trainees

Our participants report that the boot camp activity positively affected their self-confidence; however, this may be considered subjective. Being self-confident means to be secure in yourself and your abilities.[15] Self-confidence in execution of certain tasks depends on individual knowledge, training, and prior experience and has been addressed in prior training workshops and boot camps. A prior report[16] has described a 1-day workshop that was developed to improve confidence in therapists (physical and occupational) with limited experience in providing rehabilitation intervention therapies to burn patients. Similarly, an Emergency Preparedness Training has described improved participants' self-confidence in recognizing and responding to disaster.[17] Thus, these prior reports support our finding that our activity could positively impact the self-confidence of our advanced pediatric anesthesiology fellows.

Advanced Boot Camps Encourage Acquisition of Knowledge for Graduating Clinical Medicine Trainees

Our advanced pediatric anesthesiology fellow participants report acquisition of new knowledge following our boot camp activity. Knowledge acquisition during fellowship training is achieved during

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dedicated didactic sessions such as lectures, problem-based learning and discussions, journal clubs, departmental grand rounds, simulation experiences, self-directed and guided reading as well as clinical experience. Scott et al[17] have developed an Emergency Preparedness Training curriculum to improve knowledge acquisition in mass casualty events. Levine et al[18] have developed a 2-day multidisciplinary program to increase knowledge and awareness of issues related to geriatric medicine among chief residents of various specialties. Additionally, these multidisciplinary programs have fostered interprofessional collaboration among health care teams while taking care of complex elderly patients and refining teaching and leadership skills for the chief residents who serve as the role model for other trainees in the latter program.[18] Another project developed to train primary care physicians used an interprofessional team of experts to diagnose, treat, and manage both common, uncommon, and complex patient conditions using didactics, simulation, case-based discussion, and guided practice, with a goal of improving community health care outcomes.[19] Similar to these studies, we have developed simulation scenarios and educational modules based on encounters and challenges faced by pediatric anesthesiologists. As our faculty are from 9 different academic centers, we provide diverse valuable insight regarding variation in system-based practices among various academic institutions that promotes acquisition of new knowledge by our fellow participants.

The Advanced Pediatric Anesthesiology Boot Camp Addresses Accreditation Council for Graduate Medical Education Milestones in a Formative and Not Assessment Fashion

The Accreditation Council for Graduate Medical Education fellowship programs has incorporated milestones as part of fellow evaluation at the commencement and at the completion of training. The purpose of the advanced boot camp for pediatric anesthesiology fellows is to provide formative learning experiences using simulation in order to address the educational needs of graduating pediatric anesthesiology fellows. The use of simulation for assessment has been described in the literature[20-23] using a checklist for completion of key actions in a scenario or skill station and for assessment of global team performance. However, assessment of fellows' self-confidence and acquisition of new knowledge in our advanced boot camp activity was avoided because we wanted to maintain a nonjudgmental learning environment. Any perceived knowledge gap (the difference between expected performance and actual performance) was addressed during debriefing and was a part of the reflective learning by the participants. Thus, we have determined that assessments of fellow competencies during the advanced pediatric anesthesiology fellow boot camp are beyond the scope of this activity.

Limitations of Our Report

There are several limitations to our report. In our study over 10% of all pediatric anesthesiology fellows in the United States were represented. However, follow-up regarding educational outcomes may be limited because demographic and institutional data were not collected. We obtained feedback for our activity using a Likert scale, which is known to be subjective by nature, and no objective assessment tools were used to determine skills acquisition by the participants. We used self-report questionnaires to address self-confidence following participating in the educational activity. While self-report of self-confidence is important, it is unclear whether improved confidence will translate into enhanced competence, better clinical performance, reduction in clinical errors, or improved patient outcomes. Subsequent follow-up and ongoing self-assessment could be beneficial for studying improvement in these other areas. Our future directions will involve a 6-month follow-up with participants to assess their perceived value of this educational endeavor in their current clinical work environment.

Conclusions

The advanced boot camp for pediatric anesthesiology fellows was designed for fellows in the last quarter of their 1-year pediatric anesthesia fellowship. It provided the fellows an opportunity to reinforce crisis resource management skills, practice giving feedback, and discuss adverse clinical outcomes with a standardized patient. This educational activity was aimed at enhancing advanced trainee knowledge, self-confidence, and preparation for role transition into an independent practitioner. Our results suggest to us that this educational endeavor could be adopted as a key training component for graduating fellows. It is our opinion that these skills are applicable to all practicing anesthesiologists and this advanced format could be adapted to residency training.

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Abstract

Background: Managing pediatric crises necessitates the acquisition of unique skills and confidence in its execution. Our aim was to develop and assess a curriculum based on the constructivist learning environment to enhance learning, orientation, and preparation of graduating pediatric anesthesiology fellows.

Methods: Fifty pediatric anesthesiology fellows from 9 academic institutions in the United States were recruited for an advanced boot camp over a 2-year period. Training stations were developed using high-fidelity simulation, standardized patients, self-reflection modules, and facilitated discussions. The curriculum was evaluated using an anonymous survey that assessed knowledge, self-confidence, appropriateness of case-scenario complexity, and usefulness for transitioning into an independent practitioner on a Likert scale (*1 = strongly disagree* to *5 = strongly agree*). Data points were expressed as the median and interquartile range (IQR).

Results: Ninety-eight percent of the fellows completed a survey. Fellow perceptions of the advanced boot camp was positive. The median scores (IQR) for knowledge, self-confidence, appropriateness of case complexity, and usefulness for transition in 2017 were 5 (3,5), 4.5 (3,5), 5 (3,5), and 5 (3,5), respectively, and 5 (3,5), 4.5 (3,5), 5 (4,5), and 5 (3,5), respectively, in 2018. The IQR in the assessment for an appropriate level of complexity for their level of training, narrowed in 2018 (4,5), when compared with 2017 (3,5).

Conclusions: Fellow responses support the idea that the advanced boot camp provided tools and strategies for their transition. A narrowed IQR regarding the appropriate level of complexity of scenarios in 2018, when compared with 2017, might suggest an improvement in the curriculum.

Keywords: High-fidelity simulation, operating room, curriculum, anesthesiologist, pediatrics, training

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Tables

Table 1. *Description and Objectives for the Stations in the Advanced Boot Camp*

Station	Description	Objectives
Neonate for CPAM surgery	Neonate with CPAM for right lower lobe lobectomy develops intraoperative hypoxemia and cardiac arrest secondary to tension pneumothorax.	1. To recognize the perioperative risks and complications associated with management of CPAM. 2. To formulate a differential diagnosis for causes of hypoxia and sudden loss of end tidal CO_2 in patients undergoing CPAM repair. 3. To identify and manage tension pneumothorax, a critical perioperative complication that may occur in patients undergoing CPAM repair. 4. To practice critical communication strategies with surgeons and other members of the perioperative team during CPAM repair.
Patient with Down syndrome for a laparotomy	Induction techniques in a 12-month-old male with Down syndrome and unrepaired TOF presenting for exploratory laparotomy for bowel resection with tenuous IV access and management of intraoperative hypoxia (both with and without TOF spell).	1. To comprehend the anesthetic implications of caring for a patient with unrepaired TOF. 2. To formulate induction techniques for a patient with a full stomach and tenuous intravenous access. 3. To review and manage causes of intraoperative hypoxia (both with and without a tet spell). 4. To discuss postoperative analgesic options in a patient with congenital heart disease undergoing noncardiac surgery. 5. To practice communication strategies that may occur with an assertive and demanding surgeon and address social constructs associated with junior attending status.
Vein of Galen malformation	A 2-day-old female with a prenatal diagnosis of vein of Galen malformation for embolization in the Neuro-Interventional Radiology Suite and management of intraoperative pulmonary hypertensive crisis in a remote location.	1. To diagnose and manage an intraoperative pulmonary hypertension crisis. 2. To identify challenges with crisis management in remote location.
PALS	Use of rapid cycle deliberate practice with debriefing to improve quality CPR and timely delivery of shock in a shockable rhythm.	1. To review and reinforce timely initiation of CPR. 2. To list and demonstrate key determinants of high-quality CPR. 3. To identify and manage arrhythmias.

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Station	Description	Objectives
Pediatric burn	ER management of a 15-month-old with soot on her face and 15% body surface area burns to her lower extremities following a house fire.	1. To evaluate a child presenting with burns in the emergency department. 2. To identify risk factors associated with potential/impending airway compromise following smoke inhalation injury. 3. To identify and manage carbon monoxide and cyanide poisoning following a house fire injury. 4. To practice working as a team with ER-embedded participants. 5. To recognize common types of burn injuries in children and their clinical implications.
Disclosure of perioperative adverse event	Disclosure of known complication from a procedure and intraoperative adverse event.	1. To observe and practice the delivery of bad news with debriefing by faculty, peers, and SP. 2. To reflect on personal emotions during process. 3. To describe relevant literature on methods and delivery types for breaking bad news.
Second victim; self-reflection	Defining second victim, identify events that can lead to long-lasting emotional impact and identify support system options for self and colleagues during this stressful period.	1. To identify structural framework for self and collegial reflection following an adverse event. 2. To identify available sources for support during the stressful period within one's organization.
Ultrasound guided regional anesthesia	Physics of ultrasound, use of ultrasound to identify anatomy for basic and advanced regional techniques in children for a successful block and for prevention of iatrogenic harm.	1. To refine scanning techniques for identifying neurovascular structures for successful outcomes for regional anesthesia in children. 2. To demonstrate advanced regional techniques such as quadratus lumborum block, anterior and subgluteal approach to sciatic block, and paravertebral block.
Feedback (facilitated discussion)	Develop strategies for giving feedback via role play, using a cognitive aid as a guide, and reflecting on the feedback process.	1. To list elements of effective feedback as a teaching tool. 2. To develop an effective feedback technique using cognitive aid/scripted suggestions. 3. To practice giving feedback via both observing and debriefing via role play. 4. To identify benefits to both deliverer/receiver of feedback in a learning environment.

Abbreviations: CPAM, congenital pulmonary airway malformation; CPR, cardiopulmonary resuscitation; ER, emergency room; IV, intravenous; PALS, Pediatric Advanced Life Support; SP, standardized patient; TOF, tetralogy of Fallot.

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Table 2. *Participants' Perception of the Advanced Boot Camp 2017, median (interquartile range)*

	Knowledge	Self-Confidence	Level of Training	Transition to New Role
TOF for laparotomy	5 (5,5)	4 (4,5)	5 (4.25,5)	5 (4.25,5)
Neonatal CPAM	5 (4.25,5)	4.5 (4,5)	5 (5,5)	5 (4,5)
Vein of Galen malformation	5 (5,5)	5 (4,5)	5 (4.25,5)	5 (4,5)
PALS	5 (4.25,5)	5 (4.25,5)	5 (4.25,5)	5 (4,5)
Delivery of bad news	5 (4,5)	4.5 (4,5)	5 (4.25,5)	5 (4.25,5)
Second victim	4 (4,5)	4 (3,5)	5 (4,5)	4.5 (3.25,5)
Regional anesthesia	4 (3,5)	4 (3,5)	4 (3,5)	4 (3,5)
Feedback	4 (4,5)	4 (3.25,5)	4 (4,5)	4 (3.25,5)
Overall	5 (4,5)	5 (4,5)	5 (4,5)	5 (4,5)

Abbreviations: CPAM, congenital pulmonary airway malformation; PALS, Pediatric Advanced Life Support; TOF, tetralogy of Fallot.

Table 3. *Participants' Perception of Advanced Boot Camp 2018, median (interquartile range)*

	Knowledge	Self-Confidence	Level of Training	Transition to New Role
TOF for laparotomy	5 (4,5)	4 (4,5)	5 (5,5)	5 (4,5)
Neonatal CPAM	5 (4,5)	5 (4,5)	5 (5,5)	5 (5,5)
Vein of Galen malformation	5 (4,5)	4 (4,5)	5 (4,5)	4 (4,5)
Pediatric burn	5 (4,5)	5 (4,5)	5 (4,5)	5 (4,5)
Delivery of bad news	4 (4,5)	4 (4,5)	5 (4,5)	5 (4,5)
Second victim	4 (3,4)	4 (3,4)	4 (4,5)	4 (3,5)
Regional anesthesia	4 (5,5)	5 (4,5)	5 (5,5)	5 (5,5)
Overall	5 (4,5)	5 (4,5)	5 (4,5)	5 (4,5)

Abbreviations: CPAM, congenital pulmonary airway malformation; TOF, tetralogy of Fallot.

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Supplemental Online Material 1

Supplemental Online Material 1

Simulation Case Information[1]
Case Title: Cardiac for noncardiac surgery
Scenario Name: Unrepaired TOF for exploratory laparotomy
Patient Name: Richard Smith
Simulation Developers: Dr Shivani Patel, Dr Justin L. Lockman, and Dr Marco Corridore
Learning Group: Pediatric Anesthesiology Fellows

Curricular Information:
Learning Objectives:

1. To comprehend the anesthetic implications of caring for a patient with unrepaired TOF
2. To formulate induction techniques for a patient with a full stomach and tenuous intravenous access
3. To review and manage causes of intraoperative hypoxia (both with and without a TOF spell)
4. To discuss postoperative analgesic options in a patient with congenital heart disease undergoing non-cardiac surgery
5. To practice communication strategies that may occur with an assertive and demanding surgeon and address social constructs associated with junior attending status.

Accreditation Council for Graduate Medical Education Competencies:

1. Medical Knowledge
2. Patient Care
3. Interpersonal Communication

Guided Study Questions/Debrief Topics:

1. Induction techniques in a full stomach patient without IV access
2. Differential diagnosis and management of intraoperative hypoxemia (common things first)
3. Identification and management of intraoperative TOF spell
4. Postoperative analgesia options in patient with congenital heart disease presenting for noncardiac surgery
5. Review Crisis Resource Management principles focusing on communication: dealing with pressures of being a new attending

Simulation Preparation:
Monitors:

1. Non-invasive blood pressure cuff
2. 5-lead EKG
3. Capnography
4. Pulse oximeter
5. Temperature probe
6. Arterial line only if requested by the participant

Other Equipment:

1. Anesthesia machine
2. Endotracheal tubes cuffed (3.0, 3.5)
3. Laryngoscopes handle and blade (Miller 1, Mac 2)
4. Peripheral intravenous access
5. Suction
6. Stylet for endotracheal tube

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Supplemental Online Material 1 *continued*

Medications:

1. Atropine (0.4 mg/mL, 2.5 mL)
2. Succinylcholine (20 mg/mL, 5 mL)
3. Propofol (10 mg/mL, 2 × 10 mL)
4. Rocuronium (10 mg/mL, 5mL)
5. Ketamine (10 mg/mL, 10 mL)
6. Fentanyl (10 mcg/mL, 10 mL)
7. Midazolam (1 mg/mL, 2 mL)
8. Phenylephrine (100 mcg/mL, 10 mL)
9. Epinephrine (10 mcg/mL, 10 mL)
10. Epinephrine (100 mcg/mL, 10 mL)
11. Epinephrine (1 mcg/mL, 10 mL)
12. Sevoflurane (empty vaporizer)

Time Duration:

Set-up	15 minutes
Simulation	15 minutes
Debrief	30 minutes

Case Stem:

Case Stem (Learner):

A 12-month-old, male, with Down syndrome and unrepaired TOF presenting for exploratory laparotomy for small bowel obstruction. He is currently living with his adoptive family and has been in United States for 2 months. He has been having abdominal pain, nausea and vomiting for 2 days and has difficulty in tolerating anything by mouth.

Review of Systems:

CNS: normal
Cardiovascular: unrepaired TOF
Pulmonary: negative
Renal/hepatic: normal
Endocrine: normal
Hematology/coagulation studies: normal
GI: recent abdominal pain, nausea and vomiting in last 2 days, unable to tolerate anything by mouth

Current Medications and Allergies:

No known allergies
Propanolol twice daily

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Supplemental Online Material 1 *continued*

Physical Examination:
General: Down facies, ill appearing
Weight: 15 kg
Vital signs: Pulse 140/min, BP 80/60 mm Hg, SpO_2 90%, Temperature: 38.0, Respiratory rate 35
Airway: large tongue, unable to assess Mallampati score
Lungs: clear to auscultation bilaterally, no wheezing, slightly tachypneic
Heart: harsh systolic murmur left sternal border, capillary refill 2 seconds
Abdomen: distended, hypoactive bowel sounds, no hepatosplenomegaly

Laboratory, Radiology, and Other Relevant Studies:
Hemoglobin: 16
CXR: not done
EKG: not done
ECHO: large anterior malalignment VSD, valvar and subvalvular (infundibular) pulmonary stenosis, gradient across RVOT of 85 mm Hg, right ventricular hypertrophy, dilated pulmonary arteries, overriding aorta (<50% override) and small PFO with left to right shunting. Left aortic arch with normal branching. No patent ductus arteriosus.

Simulated Environment:
You are currently in the operating room with the nursing and surgical team. The anesthesia machine checked, prepped and ready to go. The airway equipment is set up with functioning and appropriate size endotracheal tubes, laryngoscope handles and blades, oral and laryngeal mask airway, and a suction. All the medications required for the case are on the top of anesthesia cart.

Briefing Information (for facilitator/coordinators eyes only):
Setting: The patient will arrive in the operating room.
Actors: One surgeon, one nurse (if more people are available then scrub technician)
Perform tasks as directed by the learner (role of anesthesia provider). Goal is to help the learners execute their plan.
When asked about intravenous access respond by saying the IV is infiltrated and not working. If they decide to place an IV prior to induction make it available easily. If they choose to perform a mask induction then we will simulate emesis by the patient.
After intubation, there will be hypoxemia with no breath sounds on the left (main stem intubation). Post-intubation the participants will listen for bilateral breath sounds. If they cannot appreciate absence of breath sounds on the left then announce the finding. Hypoxemia will not resolve until main stem intubation is corrected.
The surgeon is going to be very assertive, demanding and maintaining tunnel vision of getting small bowel obstruction repaired. Create a realistic environment, which reflects the pressures of being a new attending.
After correction of main stem intubation, the patient will have hypoxemia again due to a TOF spell and will require medical intervention.

Reference
1. Taekman JM. Template for simulation patient design. https://anesthesiology.duke.edu/wp-content/uploads/2018/12/Simulation-Scenario-Template.docx. Accessed August 3, 2020.

Abbreviations: BP, blood pressure; CNS, central nervous system; CXR, chest x-ray; ECHO, echocardiogram; EKG, electrocardiogram; GI, gastrointestinal; IV, intravenous; PFO, patient foramen ovale; RVOT, right ventricular outflow tract; TOF, tetralogy of Fallot; VSD, ventricular septal defect.

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Supplemental Online Material 1 *continued*

Scenario Description:

State	Patient Status	Student Learning Outcomes Or Actions Desired and Trigger To Move to Next State	
1. Baseline	Vitals: Gen: Awake, crying ECG: NSR HR: 150 BP: 80/60 RR: 35 SpO_2: 90 $ETCO_2$: – Temp: 38	Participant Response: Placement of IV: place IV for rapid sequence intubation Give fluid bolus, recognize patient is tachycardic and probably dehydrated Check for suction and airway equipment (sequence of events may change depending on when they decide to place the IV)	Operator: ▪ Nurse in room anounces IV is infiltrated at the start of case while monitors are being placed ▪ Easy IV availability when placed by the learners ▪ Decrease HR after fluid bolus to 120/min Teaching Points: ▪ Placement of NG tube (prior to induction or after) ▪ Importance of rapid sequence intubation for bowel obstruction ▪ Importance of fluid bolus prior to induction Trigger: Preoxygenation begins
2. Induction and intubation	ECG: ST HR: 130/min BP: 76/45 RR: controlled SpO_2: 90 $ETCO_2$: 50 Temp: 37.6	Participant Response: Induction: agent of their choice Intubation: easy airway	Operator: No significant changes Teaching Points: ▪ Inducing agents risk and benefits in light of unrepaired TOF ▪ Complications at induction Trigger: Intubation is completed, start listening for breath sounds
3. Hypoxemia due to main stem intubation	ECG: ST HR: 130/min BP: 76/45 RR: controlled SpO_2:73 $ETCO_2$: 50	Participant Response: Diagnose and manage intraoperative hypoxemia	Operator: ▪ Right main stem intubation, no breath sounds on the left ▪ No response to 100% oxygen, treatment of TOF spell, or any other interventions unless ETT is repositioned; followed by resolution SpO_2 90 (once diagnosed and treated)

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Supplemental Online Material 1 *continued*

	Temp: 37		Teaching Points: Regardless of case rule out common causes of hypoxia Trigger: Surgeon announces incision
4. Surgical incision and TOF spell	Vitals: ECG: ST HR: 180/min BP: 65/40 RR: controlled SpO_2: 73 $ETCO_2$: 28 Temp: 37.2	TOF spell Sudden decrease in SpO_2, hypotension, tachycardia Management of spell: ▪ 100% FiO_2 ▪ Manual ventilation and confirm tube position ▪ Fluid bolus to treat BP ▪ Consider fentanyl or morphine ▪ Phenylephrine ▪ Consider esmolol	Operator: ▪ TOF spell will occur 2 minutes after resolution of hypoxemia in stage 3 Teaching Points: ▪ Identification and management of TOF spell ▪ Reinforce principles of crisis resource management Trigger: Directed by facilitator
5. Resolution	Vitals: ECG: ST HR: 140 BP: 90/60 RR: controlled SpO_2: 90 $ETCO_2$: 40 Temp: 37.0	Surgery moves on and surgeon asks for an epidural placement for post-op pain control Participants should consider the pros and cons of the procedure and lead a discussion with the surgeon	Operator: ▪ Resolution/no changes

Abbreviations: BP, blood pressure; ECG, electrocardiogram; $ETCO_2$, end-tidal CO_2; ETT, endotracheal tube; FiO_2, fraction of inspired oxygen; HR, heart rate; IV, intravenous; NG, naso-gastric; NSR, normal sinus rhythm; RR, respiratory rate; SpO_2, oxygen saturation; ST, sinus tachycardia; TOF, tetralogy of Fallot.