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Pediatric Surgery Simulation-Based Training for the General Surgery Resident

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ABSTRACT

Background: Surgical simulation-based training (SBT) can increase resident confidence and improve performance. SBT in pediatric surgery is in its infancy and often geared toward training pediatric surgery fellows. Since case volume for various pediatric surgery–specific procedures can be low based on the rarity of the pathology involved and the level of care provided by the institution, our aim was to create a pediatric surgery simulation-based curriculum for general surgery residents to address this need.
Materials and methods: We performed an institutional needs assessment consisting of 4 pediatric surgeons' and 28 general surgery residents' confidence in resident ability to independently perform pediatric surgery–specific tasks and procedures using a Likert-scaled survey. These included the placement of a silastic silo for gastroschisis, a percutaneous drain for perforated necrotizing enterocolitis, and completion of a laparoscopic pyloromyotomy for pyloric stenosis. Models simulating these pathologies and curriculum for performing each procedure were generated.
Results: We successfully created a model and SBT curriculum to teach general surgery residents how to place a silastic silo for patients with gastroschisis, a percutaneous drain for patients with perforated necrotizing enterocolitis, and how to complete a laparoscopic pyloromyotomy for patients with pyloric stenosis. These were deemed high fidelity models based on a survey of our pediatric surgeons.
Conclusions: We created a pediatric surgery SBT curriculum for general surgery residents, which can be used to supplement learning of various high-acuity, low-occurrence procedures. Assessment of residents and validation of scores is underway.

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Introduction

Simulation-based training (SBT) is an essential tool in surgical education. As surgical training has evolved, there is growing concern by residents and faculty that graduating residents are not prepared to practice autonomously.[1-3] Changes to hospital policy and surgeon expectations are the main contributing factors. There is greater emphasis on patient outcomes and safety, case efficiency, and increased attending surgeon involvement in the operating room than ever before.[4,5] Residents are limited to an 80-h work week while demand for subspecialization has increased.[2] SBT has become a popular platform to teach surgical residents and fill this gap, improving resident confidence and performance.[6-10]

While many surgical SBT models exist in the adult literature, SBT in pediatric surgery is still in its infancy. Currently, there are less than 50 published pediatric surgery simulation models and only a few pediatric surgery curricula.[11-15] However, the majority are geared toward pediatric surgery fellows with none specifically for general surgery residents. Case volume for various pediatric surgery–specific procedures can be low based on the rarity of the pathology involved and the level of care provided by the institution. Therefore, general surgery resident experience and attending confidence in residents' ability to complete these procedures are often low.

Integration of a pediatric surgery SBT curriculum into general surgery residency training has the potential to teach residents to become confident and proficient in high-acuity, low-volume pediatric procedures. For example, the placement of a silastic silo for gastroschisis, the placement of a percutaneous peritoneal drain for perforated necrotizing enterocolitis (NEC), and completion of a laparoscopic pyloromyotomy (LP) for pyloric stenosis are a few case scenarios in which resident experience is likely suboptimal. Knowing how to perform these procedures not only prepares residents for their pediatric surgery rotations but also is particularly useful to graduating general surgery residents who will practice in low-resource areas so that they can confidently treat or stabilize patients for transfer. Therefore, our goal was to create a pediatric surgery SBT curriculum comprised of these procedures specifically for general surgery residents.

Material and methods

Needs assessment

An institutional needs assessment was conducted via a Likert-scaled survey of 4 pediatric surgeons and 28 general surgery residents. We assessed attendings' confidence in allowing residents to independently perform a silastic silo placement for patients with gastroschisis, percutaneous peritoneal drain placement for patients with perforated NEC, and LP for patients with pyloric stenosis. This was scored from 1, "I have no confidence a resident could complete this procedure" to 4, "I feel the resident could independently complete this procedure." We also assessed residents' confidence in performing and experience completing the aforementioned procedures. This was scored from 1 to 5, with 1, "I have no confidence independently performing the procedure," 3, "I have moderate confidence, but would require assistance," and 5, "I feel like I can do the procedure independently." Based on this assessment, we designed a proficiency and confidence-based pediatric surgery curriculum specifically for general surgery residents. Approval for creation and implementation of this curriculum as well as waiver of informed consent for resident participation was obtained from the institutional review board of Rush University Medical Center.

Model creation

Models for gastroschisis, perforated NEC, and pyloric stenosis were created in collaboration with the Rush Center for Clinical Skills and Simulation. The model for gastroschisis was constructed using a commercially available toy doll. A large diameter hole was created to simulate the abdominal wall defect. Synthetic intestine was made using EcoFlex 00-30 silicone rubber and Silicone Thinner. We coated a simple shoe lace in layers until the size of the synthetic intestine was 3/4-inch thick. For each model fabricated, we closely followed the Smooth-On EcoFlex instructions available in their user manual and online instructional videos.[16] Silastic silicone silos were provided (Bentec Medical, Inc, Woodland, USA). We used expired silastic silos donated by Rush University Medical Center. Saline and kidney basin, umbilical tape, drapes, and minor surgery tray (consisting of a hemostat, forceps, needle driver, scissors), were provided (although not all are required for the procedure). The total cost to create this model was 450 dollars, which includes the purchase of a new silastic silo, and 45 dollars without.

The model for perforated NEC was constructed using a commercially available toy doll. Three anterior holes 1-2 cm in size were created to provide possible locations for drain placement. Synthetic skin was created using EcoFlex 00-30 silicone rubber and Silicone Thinner in two 1/16-inch thick layers, with a thin fabric mesh in between to simulate the abdominal wall (1/8-inch thick). This was wrapped around the doll and secured. Two inflated Oonies balloons were used and placed intra-abdominally via a posterior opening in the doll to simulate the liver (placed in the right upper quadrant) and the bladder (placed in the pelvis). Residents were provided Betadine skin preparation swabs, sterile towels, predrawn up saline in a 5-mL syringe (to simulate local anesthetic), 22- and 25-gauge needles, a minor surgical tray (consisting of a hemostat, forceps, needle driver, scissors), ¼- and ½-penrose drains, 4-0 silk suture, gauze, and tape. The total cost to create this model was 100 dollars.

The model for pyloric stenosis was constructed using EcoFlex 00-30 silicone rubber and Silicone Thinner in a 1/8-inch layer, to replicate the stomach. 2.4 cm diameter raw sausage, cored out to a 3-mm layer with inflated balloon within the core of the sausage was used to simulate the pyloric stenosis. This was placed into an FLS box trainer and secured. Laparoscopic grasper, endoshears, Maryland grasper, and Bovie cautery were provided. The total cost of the model excluding the FLS box trainer and laparoscopic instruments was 290 dollars.

Curriculum design

Four pediatric surgeons determined the key steps for each procedure and collaborated with the Rush Center for Clinical Skills and Simulation to design a pediatric surgical skills curriculum. For each SBT model, we created a web-based cognitive component, a scripted case scenario to be used during the simulation session, a global assessment rating tool, to be used to assess resident proficiency, and a structured debriefing session. The web-based cognitive component consisted of one video, which outlines and demonstrates the steps for each procedure, a link to the Surgical Council on Resident Education (SCORE) curriculum for each pathology, which is an outlined didactic overview of the topic by learning objectives (which typically include anatomy, physiology, epidemiology, diagnosis, management, operative treatment, and follow-up), and a link to the associated textbook chapter in Pediatric Surgery Not a Textbook (NaT).[17-25] The scripted case scenarios were synthesized by our team of four pediatric surgeons. The global assessment rating tool was based on the modified objective structured assessment of technical skills (OSATS).[26]

Fig. 1 – Inanimate model for gastroschisis.

Results

Our needs assessment demonstrated that attending surgeons did not have confidence in residents' ability to independently complete a silastic silo placement for gastroschisis 1.5/4; a percutaneous peritoneal drain placement for perforated NEC, 1.5/4; or an LP for pyloric stenosis 1.5/4. The consensus reason was that residents lacked experience and exposure to these low-volume procedures and since they are being performed on high-risk pediatric patients, they did not feel comfortable allowing residents to perform them without prior training. Our needs assessment also demonstrated that residents did not have confidence in their ability to perform the aforementioned procedures and had minimal exposure to these procedures, as given in Table 1.

Models for gastroschisis, perforated NEC, and pyloric stenosis were successfully created, as shown in Figures 1-3. Each of these models had high fidelity according to the consensus of our attending pediatric surgeons, as summarized in Table 2. All attending surgeons agreed that each model was accurate with respect to the pathology simulated and good for teaching both junior and senior residents. Following our initial testing on the gastroschisis, NEC and pyloric stenosis models, residents uniformly believe these models simulate each pathology well and has prepared them to perform the procedure, Table 3.

This curriculum has been integrated into our larger general surgery simulation curriculum. Third- and fourth-year general surgery residents have a dedicated 2-h pediatric surgical simulation session twice a year, 3 mo apart (September and December for third-year residents, October and January for fourth-year residents).

Discussion

We designed and created the first pediatric surgery SBT curriculum in the United States specifically tailored to the needs of general surgery residents. Our curriculum not only fills a gap in surgical training but also is cheap and easy to fabricate. Over the last 20 y, surgical training has significantly evolved. The traditional approach has been challenged by increasing financial restraints, regulation, concern for patient safety, the need for efficiency, the requirement of attending surgeons in the OR, the implementation of an 80-h work week, and a push for further subspecialization, among others.[2,4,5]

Table 1 – Residents' experience and confidence in ability to perform various pediatric surgery procedures.

Procedure	Average case experience completing at least one		Average confidence level in performing the procedure	
	PGY 1, 2 3 ($n = 19$)	PGY 4, 5 ($n = 9$)	PGY 1, 2 3 ($n = 19$)	PGY 4, 5 ($n = 9$)
Silastic silo placement for gastroschisis	0.053	0.222	1.22	2.22
Percutaneous peritoneal drain placement for perforated NEC	0.053	0.222	1.28	1.89
LP for pyloric stenosis	0	0.444	1.00	2.33

Confidence based on Likert-scaled survey, 1) I have no confidence independently performing the procedure, 3) I have moderate confidence but would require assistance, 5) I feel like I can do the procedure independently.

Fig. 2 – Inanimate model for perforated NEC.

Consequently, on graduation, residents feel less prepared to operate autonomously and program directors and attending surgeons feel residents may be inadequately trained.[1,4,27,28] As a result, SBT has emerged as a mechanism to help bridge the training gap.[6-10]

We believe that SBT is particularly useful for general surgery residents in preparation for and during their pediatric surgery rotations and for those who plan on serving low-resource populations post-graduation. Currently, as demonstrated by our needs assessment, pediatric surgery attendings and general surgery residents lack confidence in residents' ability to complete pediatric surgery procedures. General surgery residents rotating on pediatric surgery services are particularly vulnerable to insufficient preparation and inadequate case exposure.[15] Since the ACGME requires general surgery residents to complete at least 20 pediatric surgery cases, many residencies require rotations on pediatric surgery services.[29] However, the number of total rotations throughout the residency is often low (once as an intern, and once as a fourth-year resident at our institution) and caseload diverse.[11,12] At institutions without pediatric surgery fellows,

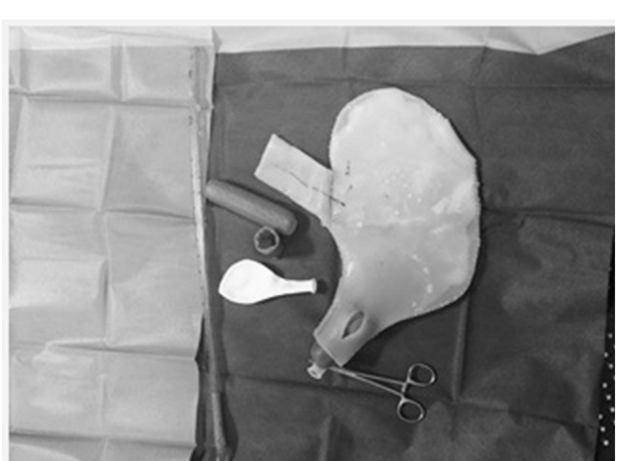

Fig. 3 – Inanimate model for pyloric stenosis.

Table 2 – Fidelity assessment by four attending pediatric surgeons using a Likert-scaled survey.

Model and fidelity assessment	Score
Gastroschisis model	
The model accurately simulates a patient with gastroschisis.	4.5
The model accurately simulates the placement of a silastic silo.	5.0
The model accurately simulates the steps of the procedure.	5.0
The model is a good support for teaching junior residents.	5.0
The model is a good support for teaching senior residents.	5.0
Perforated NEC model	
The model accurately simulates a patient with perforated NEC.	5.0
The model accurately simulates the placement of a percutaneous peritoneal drain.	5.0
The model accurately simulates the steps of the procedure.	5.0
The model is a good support for teaching junior residents.	5.0
The model is a good support for teaching senior residents.	5.0
Pyloric stenosis model	
The model accurately simulates a patient with pyloric stenosis.	4.0
The model accurately simulates a LP.	5.0
The model accurately simulates the steps of the procedure.	5.0
The model is a good support for teaching junior residents.	5.0
The model is a good support for teaching senior residents.	5.0

Likert scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree.

Table 3 – Resident satisfaction scores after initial testing on each model.

Model and fidelity assessment	Score
Gastroschisis Model (n = 7)	
This model simulated a gastroschisis defect and placement of a silastic silo well	4.1
This model prepared me well for clinical practice	4.1
Perforated NEC model (n = 5)	
This model simulated perforated NEC and drain placement well	4.0
This model prepared me well for clinical practice	4.2
Pyloric stenosis model (n = 15)	
This model simulated pyloric stenosis and LP well	4.0
This model prepared me well for clinical practice	4.2

Likert scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree.

general surgery residents may also lead the pediatric surgical service. In these instances, they may be required to complete various procedures outside the realm of adult general surgery training or case type required by the ACGME. It is not surprising that with few pediatric surgery rotations, low case exposure, high diversity of case load, and expanding responsibility, general surgery residents feel ill-prepared to rotate on pediatric surgery services. We saw this as an excellent opportunity to introduce SBT to help residents prepare for their pediatric surgery rotation and improve confidence and proficiency in various pediatric-specific procedures. It will also provide training for graduating residents that plan to practice in low-resource areas, so they can provide life-saving surgery or temporizing care so patients can be transferred to higher-level pediatric centers.

Like with many surgical fields, SBT in pediatric surgery has been successful in improving surgeon performance.[6] It is particularly useful in this specialty because there is a wide variability in techniques, rare indications for surgery, smaller workspaces, and thus potentially longer learning curve.[11,12,15] However, in multiple current literature reviews evaluating the impact of SBT in pediatric surgery, fewer than 50 models currently exist. There are less than five curricula.[11,12] No model or curriculum has been created specifically for general surgery residents. Therefore, we sought to create this pediatric surgery SBT curriculum for our general surgery residents to fill our identified need.

We designed our curriculum using Kern's six-step approach in combination with the consensus framework set forth by Zevin *et al*.[30,31] This included a predevelopment assessment, identification of goals and specific measurable objectives, and writing the curriculum to measure both cognitive and technical aspects of each procedure. This was done by deconstructing each procedure into critical steps from which we created our OSATS. In our curriculum, we ultimately chose to include the following procedures based on need, cost, ease of implementation, and usefulness for residents rotating on the pediatric surgery service or who plan on practicing in low-resource locations: silastic silo placement for gastroschisis, percutaneous peritoneal drain placement for perforated NEC and LP for pyloric stenosis. Although rare for the surgical resident to experience, they are relatively common procedures in pediatric surgery. The first two are important skills general surgery residents should be able to perform while on call covering pediatric surgery or while on service. Graduating general surgery residents may also encounter these pathologies if practicing in low-resource locations and should be able to temporize patients for transfer. LP is not only an index pediatric surgery case, but laparoscopic skills learned using this model could be transferable to adult general surgery procedures.

Now that the models have been created, we are in the process of implementing the curriculum. The pediatric SBT includes the third and fourth clinical years and consists of two sessions. During the first session, which is underway, residents complete the online component and each simulation module. During the second session, 3 mo later, we will assess retention of residents' skills. The third clinical year was selected since it is the first year residents take senior call and the year prior to rotating on the pediatric surgery service as chief resident. The fourth clinical year was chosen since it is the year general surgery residents are chief of the pediatric surgery service. Models are available in the simulation laboratory 24 h a day, 7 d a week for residents to practice. To fulfill the framework of Zevin *et al*. and Kern, we plan to validate scores, assess retention of knowledge, and continue to evaluate the curriculum for improvement with the goal of improving resident proficiency in each skill and both residents' and attendings' confidence in residents' ability to perform each procedure.

This curriculum has some limitations. Although these models replicate the procedure well, they are still not as lifelike and realistic as an infant with each of these pathologies. Moreover, there are many pediatric procedures for which we have not created models. Although this curriculum is inexpensive, creating models for each possible procedure encountered is time and labor-intensive. That being said, we are in the process of expanding this curriculum by adding pediatric appendicitis, inguinal hernia, and central line placement models. Our goal is to offer this curriculum to other residencies to obviate the need for them to develop their own.

Conclusion

We successfully created a pediatric surgery SBT curriculum specifically for general surgery residents to help prepare them for not only their pediatric surgery rotations, but so they have the ability to treat and temporize patients for transfer if practicing in low-resource areas after graduation. Residents are currently enrolled in this curriculum, and future validation of resident scores during simulation performance is still needed.

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Author contributions: NJS, SWS, SP, CR, MBM, and ANS collaborated to design the curriculum. NJS, ANS, SWS, and CR were responsible for data collection and analysis/interpretation. The Rush University Medical Center, Center for Clinical Skills and Simulation fabricated the models. This manuscript was written by NJS, TL, ALW, SWS, and ANS. SP, CR, and MBM were responsible for critical revision as well as the final approval.

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