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Brief Report

Procedure-Focused Escape Room: A Pilot Study on Teaching High-Stakes Technical Skills in Anesthesia Residents

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Introduction

High-stakes yet clinically infrequent procedures are challenging to teaching medical education. Escape rooms offer an innovative solution that leverages game-based learning to enhance knowledge retention, engagement, and motivation.

Game-based learning, the application of game design elements to non-game areas, may enhance knowledge retention, engagement, and motivation compared with traditional didactics.[1] Benefits of game-based learning have been described in many disciplines and specialties; examples include improved detection of chest radiograph abnormalities and increased use of a surgical anastomosis simulator.[2,3] Escape rooms are team-based games in which participants collaborate to solve a series of puzzles and escape a locked space within the allotted time. Educational escape rooms are serious games that have been described for healthcare professionals across various stages of training and multiple content domains.[4-6] Compared with other simulation modalities, escape rooms offer advantages in critical thinking, teamwork, communication skills, cooperative problem-solving skills, peer-assisted learning, and enhanced motivation through competition and time pressure.[1,4,7] Most of the escape room literature focuses on cognitive puzzles, with fewer examples focusing on physical puzzles.[4,6] In this brief report, we describe an escape room to teach high-stakes advanced airway and vascular management techniques to anesthesia residents.

Materials and Methods

The escape room curriculum was designed and implemented over the 2022 calendar year as illustrated in Figure 1. Escape room sessions were held across 3 days in July, October, and November 2022, respectively, as detailed under "Implementation."

Setting and Participants

All clinical anesthesiology residents at Mayo Clinic in Rochester, Minnesota, were invited to participate.

Topic Selection and Skills Station Design

Six board-certified anesthesiologists generated an exhaustive list of skills using a combination of existing curricula, expert opinion, and personal experience. We narrowed this list based on educational importance and feasibility using a 2-round modified Delphi process. The 5 highest rated topics were fiberoptic intubation, rapid infuser setup, intraosseous line placement, flexible bronchoscopy, and supraglottic airway exchange. We designed skills stations and puzzles in collaboration with simulation center personnel.

Room and Equipment Selection

We identified a suitable space in the simulation center equipped with cameras and a 1-way window and designated an adjacent classroom for debriefing. We purchased a variety of locks, invisible ink pens, and UV flashlights for a total cost of $169.53 as detailed in Appendix A.[8] A bronchoscopy task trainer and intraosseous drill trainer were 3D-printed using publicly available templates with resin ($20) and Ultimaker Tough PLA ($4), respectively.[9,10] Other simulation and clinical equipment are detailed in Appendix A.

Facilitator Selection

We selected 3 individuals to facilitate: authors J.H. and N.T. and a respiratory therapist.

Facilitator Handout Design

We created a setup sheet with prebrief and debrief guides to standardize escape room setup and ensure a uniform experience for all residents.

Surveys

We assessed residents using a single group pretest-posttest study design. Surveys were administered immediately after the escape room, before any post–escape-room practice. We assessed prior experience with each procedure and measured pretest/posttest self-efficacy using a 5-point Likert scale. We compared the escape room format with a typical procedural skills workshop (defined as didactics followed by hands-on practice) using a 5-point Likert scale. We ended with open-ended comments.

Pilot Testing

We performed 2 pilot tests with 3 early career anesthesiologists and 4 senior resident volunteers. We identified optimal

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task trainers and airway device sizes for each station, adjusted the positioning of puzzle equipment to reduce extraneous cognitive load, and set an upper limit of 5 residents per session based on the number of stations.

Implementation

We conducted 12 sessions across 3 days in July, October, and November 2022, respectively. Each group of 2 to 5 residents completed a pretest survey and underwent a 3-minute prebrief conducted by author J.H. After finishing the escape room, residents completed posttest surveys, followed by a debrief with J.H. for the remainder of the designated hour in a separate classroom. During the debrief, N.T. and the respiratory therapist reset the escape room for the next group. Following the debrief, residents were provided unlimited time for independent practice.

Data Analysis

We analyzed pretest-posttest change in trainee self-efficacy using Wilcoxon signed rank tests and calculated descriptive statistics using BlueSky Statistics Version 10.3.1, R package version 8.81. We analyzed open-ended comments with thematic analysis.

Ethical Approval

This project was approved by the Mayo Clinic Education Research Committee (ID# 22-009) and exempted by the Mayo Clinic Institutional Review Board (ID# 21-013362).

Results

Fifty-five anesthesiology residents were eligible to participate. Forty-three of 55 (78%) anesthesiology residents participated in the escape room; the remaining residents were unavailable on all 3 of the designated escape room dates because of absences or rotation schedule conflicts. Data from the first 12 residents (mostly second-year clinical anesthesia residents [CA2s]) were omitted from analysis because of changes to the survey instruments. Thirty-one residents completed pretest and posttest surveys, including 16 (52%) first-year (CA1), 4 (13%) CA2, and 11 (35%) third year clinical anesthesia residents (CA3). Residents reported limited prior procedural experience (Table 1). All groups successfully solved all 5 stations and escaped the room. The mean time to escape was 33.5 minutes (SD 9.6 minutes). Residents' prior experience and change in self-efficacy for each of the 5 procedures are shown in Table 1 ($P < .001$ for each procedure for the cumulative study population). Twenty-six of 27 (96%) residents found the escape room format more enjoyable than a typical procedural skills workshop. Twenty-two residents provided open-ended comments. Thematic analysis revealed 3 key themes: (1) enjoyment, (2) knowledge acquisition, and (3) desire for similar sessions in the future. Seventeen of 22 (77%) residents commented that the escape room format was fun and enjoyable.

Discussion

In this pilot study, we confirmed that all 5 high-stakes procedures were clinically infrequent, and self-efficacy significantly improved after a single 30-minute escape room session. Most residents preferred the escape room format over a traditional workshop. We found significant increases in self-efficacy among CA1 and CA3 residents for all procedures, with the exception of bronchoscopy for CA3 residents. This was likely because out of the 5 procedures in this escape room, bronchoscopy was the procedure with which CA3 residents reported the most prior exposure and highest pretest self-efficacy. CA2 residents were underrepresented in our results for logistical reasons and the CA2 subgroup was underpowered to detect changes in self-efficacy. Most CA2 residents were excluded from analysis because we revised the survey instruments after many of the CA2 residents had already participated in the escape room in July.

Integration With Prior Work

Although the medical education literature includes many examples of escape room implementation, most focus on cognitive puzzles.[4,5] We elaborate on the existing literature by highlighting unique aspects and challenges associated with developing and implementing complex physical puzzles as compared with cognitive puzzles.

1. Set Participant Caps Intentionally

While cognitive-focused puzzles permit multiple individuals to contribute simultaneously, procedure-based puzzles limit the number of active participants. For example, rapid infuser setup allows a larger number of participants to contribute simultaneously, whereas placing an intraosseous line does not.

2. Optimize Resource Usage

To reset the room efficiently, provide duplicate task trainers outside the escape room. The escape room can be facilitated by a single expert with assistants to improve room turnover efficiency. Running multiple escape rooms on a single day improves efficiency because of the fixed time costs of setup and teardown.

3. Maximize Reproducibility

Complex physical puzzles are vulnerable to technical problems, which break immersion and derail the experience. In addition to thorough pilot testing, it is important to prepare detailed contingency plans in case of equipment malfunction or if the participants stray too far off track. Setup sheets should be detailed enough that anyone can set up the room identically and independently.

Limitations

Limitations include the single specialty and single institution nature of this study. We have abstracted principles and lessons generalizable to other medical specialties. Several of the procedures in this escape room are applicable to other specialties, including Emergency Medicine and Critical Care. It is paramount to account for local institutional resources and constraints during the design process, including simulation space and equipment. Another limitation is the small number of CA2 residents included in this study. Survey results largely came from CA1 and CA3 residents, and CA2 residents' change in self-efficacy should be intermediate between CA1 and CA3 residents. Another limitation is the single group pretest-posttest study design and lack of objective comparisons with non–escape room simulation. In addition, escape rooms are better at reinforcing and refining knowledge compared with teaching new skills. Pre-course material may help to address this limitation.

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Conclusions

In this pilot study, we designed and implemented a procedure-focused escape room to teach 5 advanced airway and vascular management techniques to anesthesiology residents. We found that participating in a single 30-minute escape room session significantly increased resident self-efficacy and that residents strongly preferred the escape room format over a traditional skills workshop. Residents found the escape room format fun and enjoyable and desired similar sessions in the future.

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Abstract

Background: High-stakes yet clinically infrequent procedures are challenging to teach. Escape rooms may offer an innovative solution through game-based learning. There is limited guidance on how to design an escape room focused on physical puzzles. We designed and implemented a procedure-focused escape room to teach high-stakes procedures to anesthesiology residents.

Methods: We selected 5 procedural skills relevant to anesthesiology residents through a modified Delphi technique: fiberoptic intubation, rapid infuser setup, intraosseous line placement, flexible bronchoscopy, and supraglottic airway exchange. We designed associated skills stations and linked them in sequence using an elaborate series of puzzles, locks, keys, and codes. The total cost of puzzle equipment was $169.53. After pilot testing, we implemented the escape room from July to November 2022. We assessed residents using a single group pretest-posttest study design.

Results: Forty-three of 55 (78%) eligible anesthesiology residents participated in the escape room. Thirty-one residents completed the surveys. Resident self-efficacy significantly improved for each of the 5 procedures. Twenty-six of 27 (96%) residents preferred the escape room over a typical procedural skills workshop.

Conclusions: This pilot study demonstrated the feasibility of a procedure-focused escape room for teaching high-stakes technical skills. We identified 3 lessons in procedure-focused escape room design: set participant caps intentionally, optimize resource usage, and maximize reproducibility. Participating in a single escape room session significantly increased resident self-efficacy. Residents strongly preferred the escape room format over a traditional procedural skills workshop.

Keywords: Escape room, game-based learning, simulation-based medical education, gamification

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Figure

Figure 1. *Timeline of project. Escape rooms were implemented in 12 sessions divided across 3 separate days in July, October, and November 2022.*

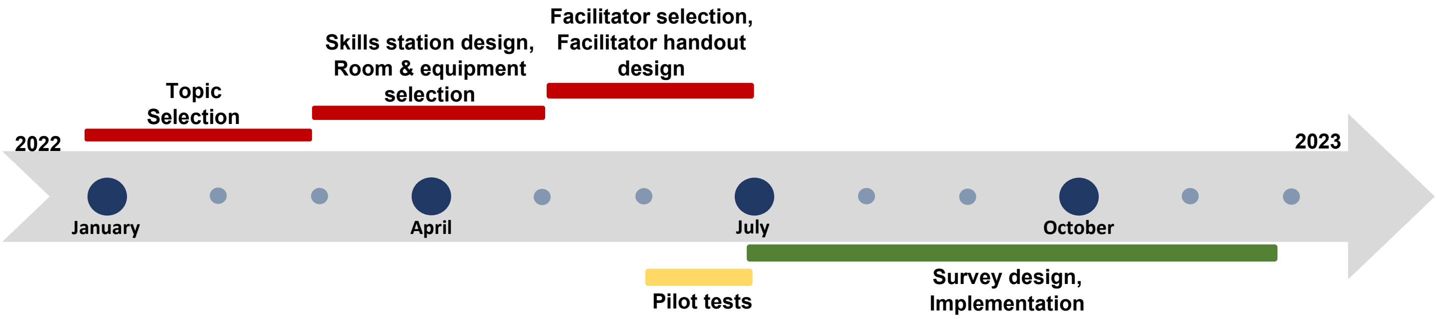

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Table

Table 1. *Residents' Prior Experience and Pretest-Posttest Change in Self-Efficacy.*

Name of procedure	Previously Observed	Previously Performed	How confident are you that you could perform this procedure successfully in clinical practice with supervision? (Left bar = Pre; Right bar = Post)					
	Median (IQR)	Median (IQR)	Not at all confident	Slightly confident	Moderately confident	Quite confident	Extremely confident	p-value
First Year Clinical Anesthesiology (CA1, n = 16)								
Fiberoptic intubation	0.5 (0-1.25)	0 (0-1.25)	7 / 0	5 / 4	4 / 11	0 / 1	0 / 0	0.0015
Bronchoscopy	3 (0.75-10)	2 (0-2)	7 / 0	7 / 5	1 / 9	1 / 1	0 / 1	0.0005
Supraglottic airway exchange	0 (0-0)	0 (0-0)	9 / 1	6 / 6	1 / 8	0 / 1	0 / 0	0.0031
Rapid infuser setup	0 (0-0)	0 (0-0)	12 / 0	4 / 5	0 / 9	0 / 2	0 / 0	0.0004
Intraosseous line placement	0 (0-1.5)	0 (0-0.5)	7 / 1	4 / 3	2 / 7	2 / 3	1 / 2	0.0055
Second Year Clinical Anesthesiology (CA2, n = 4)								
Fiberoptic intubation	2.5 (1.5-3.25)	3 (1.5-4.25)	0 / 0	2 / 1	2 / 1	0 / 2	0 / 0	0.3447
Bronchoscopy	3.5 (2.75-6.75)	10 (7.75-13.75)	0 / 0	1 / 0	0 / 1	3 / 3	0 / 0	1.0000
Supraglottic airway exchange	0 (0-0.25)	0 (0-0)	1 / 0	3 / 1	0 / 1	0 / 2	0 / 0	0.0947
Rapid infuser setup	1 (1-2.25)	0.5 (0-1.75)	1 / 0	2 / 0	0 / 2	0 / 2	1 / 0	0.3447
Intraosseous line placement	1 (0-2.25)	0 (0-0)	0 / 0	3 / 1	1 / 1	0 / 2	0 / 0	0.1736
Third Year Clinical Anesthesiology (CA3, n = 11)								
Fiberoptic intubation	5 (3-6)	7.5 (4.25-10)	2 / 0	1 / 1	4 / 1	3 / 8	1 / 1	0.0310
Bronchoscopy	10 (5-15)	15 (6.5-20)	0 / 0	2 / 1	3 / 2	5 / 8	1 / 0	0.4237
Supraglottic airway exchange	0 (0-1)	0.5 (0.5-1)	1 / 0	7 / 1	1 / 5	1 / 5	0 / 0	0.0060
Rapid infuser setup	2 (0.5-2)	2 (1-2.5)	1 / 0	3 / 0	5 / 2	1 / 6	0 / 3	0.0132
Intraosseous line placement	1 (0.5-2.5)	0 (0-1)	1 / 0	6 / 1	3 / 3	1 / 4	0 / 3	0.0085

Abbreviation: IQR = interquartile range.

Totals may vary due to unanswered questions on the pretest and posttest surveys.

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Appendix

Appendix A. Equipment List and Selected Photos

1. Puzzle Equipment

Item	Name on Amazon.com	Cost	No.	Cost
Invisible Ink Markers - red/blue/yellow (pack of 3)	DirectGlow Set of 3 Invisible UV Blacklight Ink Marker Blue Red Yellow with UV Lights	$8.95	1	$8.95
Directional Combination Padlock	Master Lock Directional Combination Lock, Set Your Own Directional Lock, Combination Lock for Gym and School Lockers, 1500iD	$9.99	2	$19.98
Small Lockbox	Jssmst Locking Small Steel Cash Box without Money Tray, Lock Box, Black Small	$9.99	2	$19.98
Medium Lockbox	Jssmst Locking Medium Steel Cash Box with Money Tray, Lock Box, Black	$13.50	2	$27.00
UV Flashlight (pack of 5)	Findway 5 UV Ultraviolet Blacklight 9 LED Flashlight Torch Light Outdoors, Pet Urine Detector for Dog Urine, Pet Stains and Bed Bug Detector, Dog Urine Remover	$23.99	1	$23.99
Word Combination Padlock horizontal	Master Lock Word Combination Lock, Set Your Own Word Lock, Combination Lock for Gym and School Lockers, Colors May Vary, 1534D	$9.98	1	$9.98
Word Combination Padlock vertical	Master Lock Word Combination Lock, Set Your Own Word Lock, Combination Lock for Gym and School Lockers, Colors May Vary, 1535DWD	$9.68	1	$9.68
Vintage lock and key	GTHER Decorative Vintage Lock and Key, Antique Chinese Padlock Lock Magpie Flower Old Lock for Small Wooden Box Furniture Cabinets Chest	$11.99	1	$11.99
Bronze locks and keys (pack of 2)	SDTC Tech 2 pcs Mini Antique Padlock Retro Vintage Style Bear Head Shape Bronze Locks and Keys	$6.99	1	$6.99
Word Combination Padlock round	Master Lock Padlock, Standard Dial Lock, 1-7/8 in. Wide, Colors may vary	$10.02	1	$10.02
Burlap bags 3 × 4 inch (pack of 20)	20 Pcs 3 × 4 Inch Linen Burlap Bags with Drawstring Reusable Jewelry Pouches Craft Gift Bags for Christmas	$6.99	1	$6.99
Security cables (pack of 2)	100 CM/3.3 ft 3 mm Outdoor Travel Security Cable Lock, Braided Steel-Coated Safety Cable Luggage Lock, Safety Cable Wire Rope Double Loop Lightweight GOMRQING (2 Pack)	$6.99	2	$13.98
		Grand Total		$169.53

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2. Simulation Equipment

- Vice grips to position the bronchoscopy task trainer at an inclined angle: $25-60.
  - Adhesive tape can be used as a cheaper substitute.
- Laerdal® Airway Management Trainer airway mannequin
- TruCorp AirSim Advance X intubation mannequin
- Ambu® aScope™ Broncho bronchoscope (slim)
- Ambu® aView™ 2 Advance display screen
- Teleflex® LMA® Unique (size 3)
- Cook® Aintree Intubation Catheter
- Cook® Airway Exchange Catheter
- Belmont® Rapid Infuser RI-2 and associated tubing
- IV extension tubing
- 1-liter suction cannister
- Arrow® EZ-IO® power driver with associated needles and IV tubing
- 1-liter normal saline bags
- 10-cc and 20-cc syringes
- Endotracheal tubes (size 6.0)
- Self-inflating anesthesia bag
- For debriefing purposes, we created a low-fidelity model for intraosseous drill practice consisting of 3-inch PVC pipe ($4/ft) filled with insulating foam spray ($5/can) and covered with a piece of flesh-colored silicone.

3. Selected Photos of Puzzles and Stations

Figure A1. *Various puzzles and locks.*

Several 3D-printed task trainers are visible on the left side of the photo. A variety of small and medium-sized lockboxes are arranged along the top of the photo. A laminated diagram of bronchial anatomy is sitting in the middle lockbox with a UV flashlight highlighting the invisible ink on the diagram. The invisible ink instructs learners to examine the 3 locations in a specific order to obtain the clue; see Figure A3 for additional information. A variety of locks and combination locks are shown across the remainder of the image.

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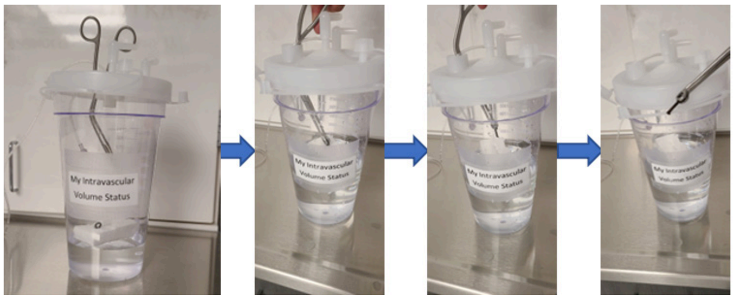
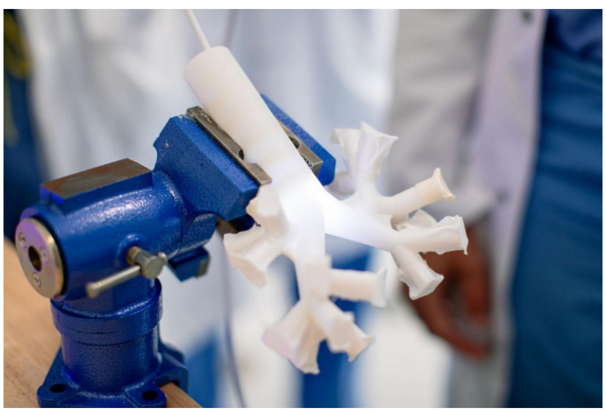
Figure A2. *Rapid infuser puzzle.*



(A) A key is stabbed into a Styrofoam block floating within this suction cannister. (B+C+D) Once 500 mL of fluid is administered using the rapid infuser, the water level rises, lifting the Styrofoam block and allowing the key to be retrieved using the forceps.

Figure A3. *Bronchoscopy: invisible ink puzzle and 3D printed task trainer.*



Individual letters are taped to the end of each bronchus facing internally. Residents must navigate to the specified lobes to spell out the combination to a lock (listed as Word Combination Padlock round in the Puzzle Equipment table).

Figure A4. *Intraosseous line puzzle.*

A piece of paper with a riddle is wrapped around the plunger of a 20-cc syringe. The syringe is loaded into the 3D-printed task trainer that obscures the paper. Once the intraosseous line is placed, flushing the line displaces the syringe plunger outward, revealing the riddle paper, which can then be manually retrieved.