3D PRINTED VASCULAR SIMULATION-BASED MODEL TO IMPROVE RESIDENT EXPOSURE AND TIME TO PERFORM COIL EMBOLIZATION IN A COMMUNITY TEACHING HOSPITAL

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•Thanks to the advancement in technology, there has been a decrease cost in e… rinters which has… ntially in the con…

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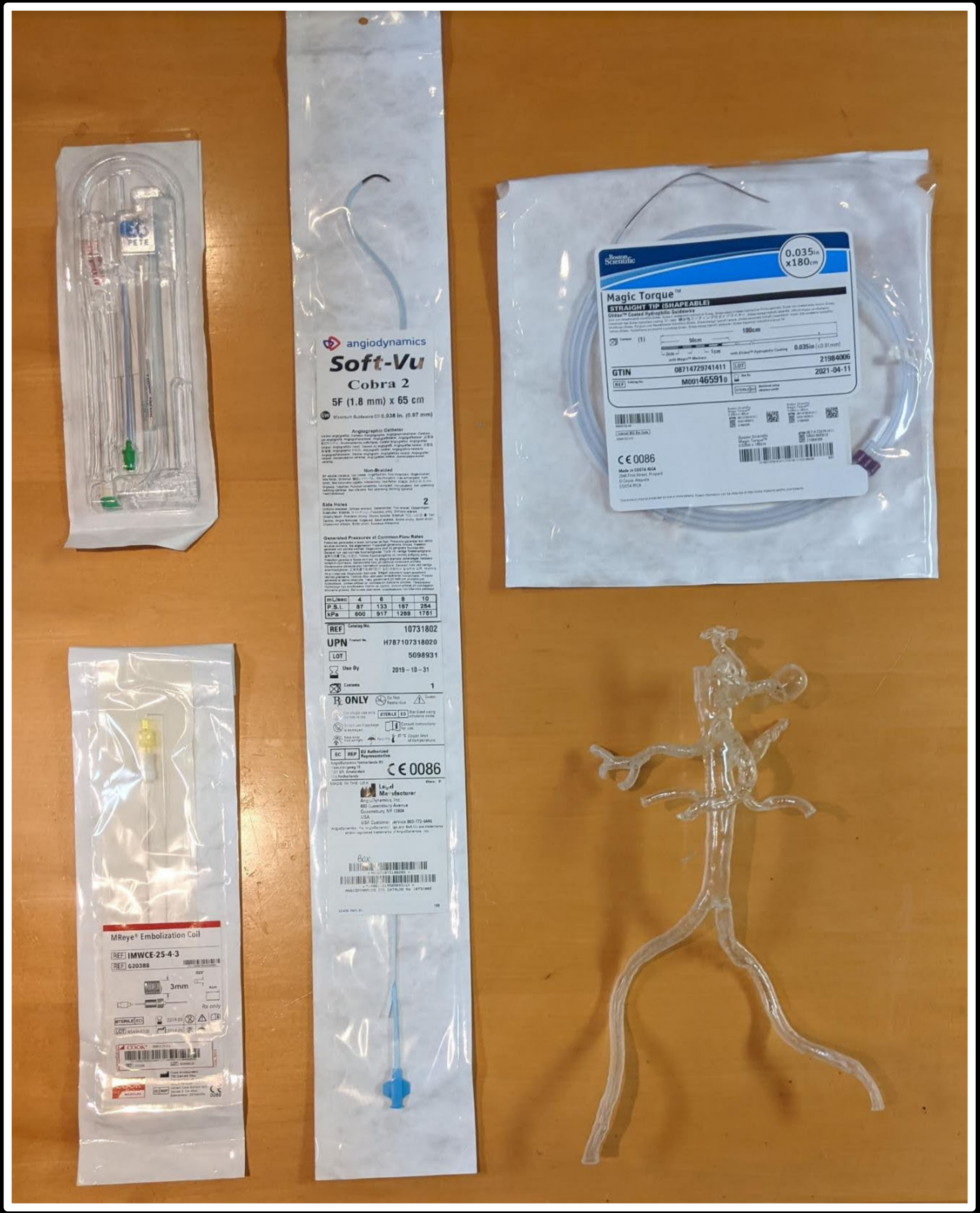
The purpose of this study is to assess if the procedure times of radiology residents from Mercy Catholic Medical Center in Darby Pennsylvania community teaching hospital can be improved in a simulation setting using a 3D-printed model of a splenic artery aneurysm.

- We used the fused deposition modeling 3D printing technology given its relatively cheaper and overall simpler methodology compared to stereolithography. The 3D printer used to produce our model was an Artillery Sidewinder X1. A non-flexible thermoplastic PVB filament of 1.75 mm diameter was utilized to create the model. Clear transparent color was chosen in aims to allow the proceduralist to have direct visualization of the embolization equipment in real-time.

- The model was printed in parts for each branch given its complex configuration in order to allow for shorter printing times. Supports were added when necessary, during slicing and were removed after printing by hand and by usage of a cautery. A combination of “spiralized” and “standard” modes were used with printing parameters including a 0.15 mm layer thickness.
- The separate parts were put together and fused using a cautery. Lastly a treatment with isopropyl alcohol bath was given to the model in order to create a relatively smooth and more transparent look.

- **Figure 1.** a) 3D reconstruction STL file of an abdominal aorta and its branches extending to the common femoral arteries. An aneurysm of the splenic artery was added upon image post-processing (arrow in a and b). 3D Printed model before isopropyl alcohol treatment in frontal b) and lateral c) views.



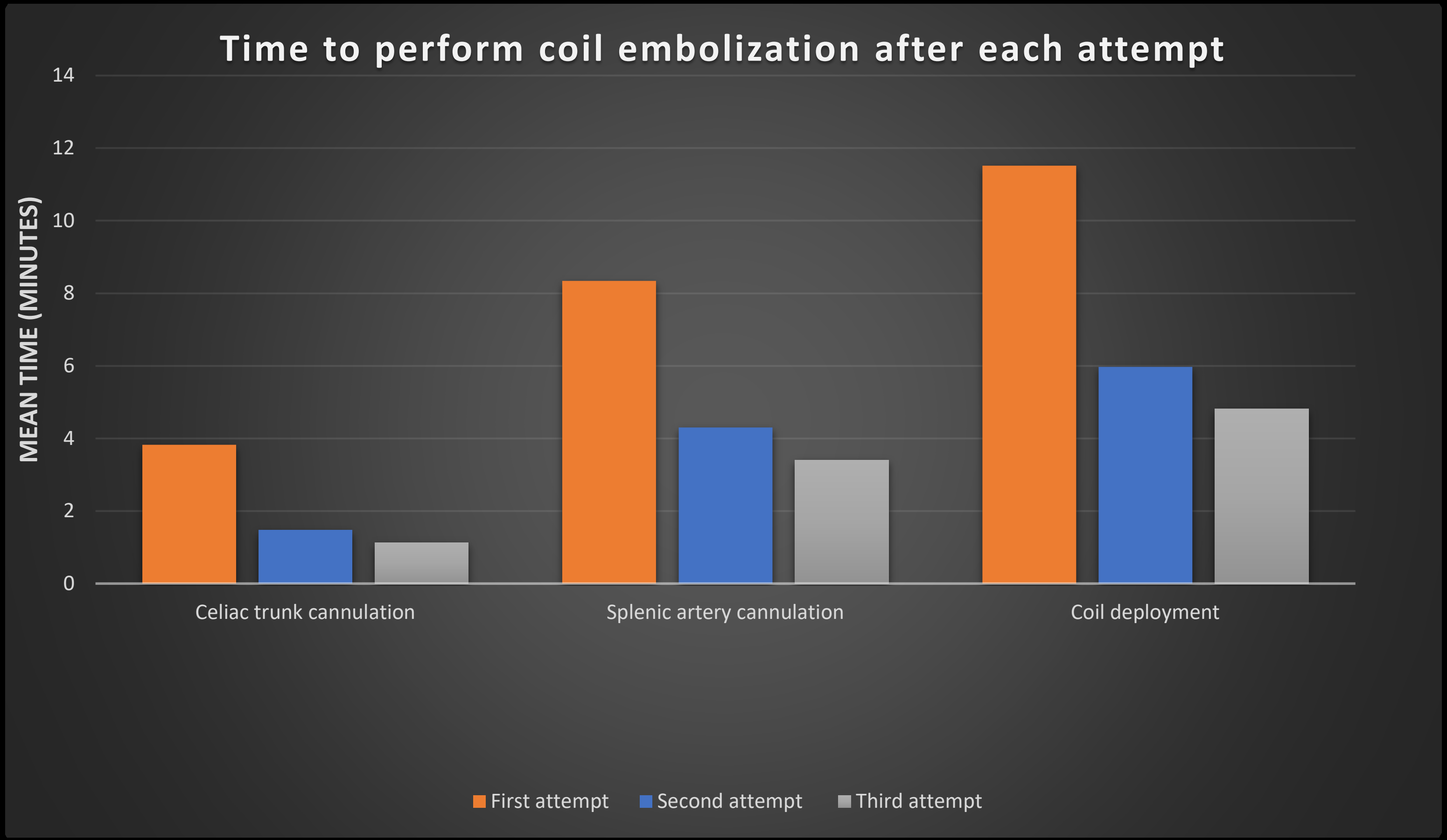
- Each radiology resident for a total of 10 residents was given an introducer sheath, a cobra catheter, a magic torque wire, a 10mL saline push, and a 3mm coil. The residents were given the task to use the model with the goal of deploying an embolization coil within the splenic aneurysm on 3 attempts. None of the residents had previously observed or assisted an embolization procedure in the past. The resident’s timings were recorded in minutes for each attempt including time to cannulate the celiac trunk, time to cannulate the splenic artery and time to successfully deploy a coil within the aneurysm. The time in minutes was converted to decimal points.

Data was presented using summary statistics of mean time to attain target cannulation for each of the attempts. Comparison of their mean times to success was performed using the paired t-test. Only two tail p-values were reported using a predetermined statistical significant level of $p<0.05$ for all our comparisons. All analysis was performed in STATA version 11.2 (StataCorp College Station, Texas).

	Mean ± SD (minutes)		
Observations	**First attempt**	**Second attempt**	**p-value**
All	7.90 ± 4.34	3.92 ± 3.34	**<0.001**
Celiac trunk	3.83 ± 1.98	1.48 ± 0.82	**0.06**
Splenic artery	8.34 ±3.31	4.30 ± 2.69	**0.06**
Coil deployment	11.52 ± 3.61	5.97 ± 4.30	**0.04**

	Mean ± SD (minutes)		
Observations	**First attempt**	**Third attempt**	**p-value**
All	7.90 ± 4.34	3.11 ± 3.07	**<0.001**
Celiac trunk	3.83 ± 1.98	1.13 ± 0.40	**0.02**
Splenic artery	8.34 ±3.31	3.41 ± 2.68	**0.01**
Coil deployment	11.52 ± 3.61	4.81 ± 4.02	**0.004**

Table 1. Comparison of mean times to success measured in minutes converted to decimal points including time to cannulate the celiac trunk, cannulation of the splenic artery and coil deployment at the splenic artery aneurysm at the first, second and third attempts.



Graph 1. Graphic representation of the mean time to successfully cannulate the celiac trunk, splenic artery, and deploy a coil within the splenic aneurysm after the first (orange), second (blue), and third (gray) attempts.

DISCUSSION

- It has recently been described that medical 3D printed models in interventional radiology are associated with an increased understanding of vascular procedures and better understanding of the anatomy by medical students. 8
- In orthopedic surgery, 3D-printing has been used for surgical planning leading to shortening procedure times and faster learning curves in surgical simulation. 9
- As mentioned before, residents at the community hospitals have less exposure to complex vascular procedures compared to at some of the larger academic centers. In our case none of the study participants have previously witnessed or assisted an embolization procedure in the past.
- 3D printed bio models could potentially be a great option to learn and practice invasive vascular procedures as they replicate the patient's anatomy and allow for a simulation setting in a safe environment. Experienced interventional radiologists can potentially teach complex vascular interventions to trainees without time constrains or radiation exposure and allow trainees to perform rehearsals on complex procedures such as embolization.

DISCUSSION

LIMITATIONS

The 3D model had clear transparent walls which allowed the proceduralist to have direct visual contact from every angle with the instruments utilized as opposed to real endovascular procedures utilizing fluoroscopic guidance which allow only for visualization at a mono-dimensional angle. The material used for our model is rigid and non-pliable contrasted to the vascular walls and tissue in real life which may affect the way catheters and wires are manipulated in real life. There are other considerations pertained to coil embolization that our study did not consider such as the initial arterial puncture in order to obtain arterial access. Further investigation can be performed in these aspects order to provide more insight.

CONCLUSION

1. REFERENCES
2. Mitsouras D, Liacouras P, Imanzadeh A, Giannopoulos AA, Cai T, Kumamaru KK, George E, Wake N, Caterson EJ, Pomahac B, Ho VB, Grant GT, Rybicki FJ. Medical 3D Printing for the Radiologist. Radiographics. 2015 Nov-Dec;35(7):1965-88. doi: 10.1148/rg.2015140320. PMID: 26562233; PMCID: PMC4671424.
3. Silvestro E, Betts KN, Francavilla ML, Andronikou S, Sze RW. Imaging Properties of Additive Manufactured (3D Printed) Materials for Potential Use for Phantom Models. J Digit Imaging. 2020 Apr;33(2):456-464. doi: 10.1007/s10278-019-00257-5. PMID: 31520278; PMCID: PMC7165207.
4. Msallem B, Sharma N, Cao S, Halbeisen FS, Zeilhofer HF, Thieringer FM. Evaluation of the Dimensional Accuracy of 3D-Printed Anatomical Mandibular Models Using FFF, SLA, SLS, MJ, and BJ Printing Technology. J Clin Med. 2020 Mar 17;9(3):817. doi: 10.3390/jcm9030817. PMID: 32192099; PMCID: PMC7141211.
5. Mitsouras D, Liacouras PC, Wake N, Rybicki FJ. RadioGraphics Update: Medical 3D Printing for the Radiologist. Radiographics. 2020 Jul-Aug;40(4):E21-E23. doi: 10.1148/rg.2020190217. PMID: 32609597.
6. Haleem A, Javaid M, Suman R, Singh RP. 3D Printing Applications for Radiology: An Overview. Indian J Radiol Imaging. 2021;31(1):10-17. doi:10.1055/s-0041-1729129.
7. Massat MB. Radiology Matters: 3D Printing Is Bridging the Gap Between Radiology and Surgery. Appl Radiol. 2020;49(2):38-41.
8. Silvina Zabala-Travers. Biomodeling and 3D printing: A novel radiology subspecialty, Annals of 3D Printed Medicine. Volume 4, 2021, 100038, ISSN 2666-9641.
9. Goudie C, Kinnin J, Bartellas M, Gullipalli R, Dubrowski A. The Use of 3D Printed Vasculature for Simulation-based Medical Education Within Interventional Radiology. Cureus. 2019;11(4):e4381. Published 2019 Apr 3. doi:10.7759/cureus.4381.
10. David H. Ballard, Patrick Mills, Richard Duszak, Jeffery A. Weisman, Frank J. Rybicki, Pamela K. Woodard, Medical 3D Printing Cost-Savings in Orthopedic and Maxillofacial Surgery: Cost Analysis of Operating Room Time Saved with 3D Printed Anatomic Models and Surgical Guides. Academic Radiology, Volume 27, Issue 8, 2020, Pages 1103-1113, ISSN 1076-6332.