Original Article

Endoscopy on a Human Cadaver: A Feasibility Study as a Training Tool

Avinash Bhat Balekuduru, Amit Kumar Dutta[1], Satyaprakash Bonthala Subbaraj

Department of Gastroenterology, MS Ramaiah Memorial Hospitals, Bengaluru, Karnataka, [1]Department of Gastroenterology, Christian Medical College and Hospitals, Vellore, Tamil Nadu, India

ABSTRACT

Background: Simulation device and porcine models are increasingly being used for training in gastrointestinal endoscopy. However reports on the use of human cadaver for training in diagnostic or therapeutic endoscopy are limited. **Method:** Human cadavers were preserved at our center in a customized non formalin based solution which retains organoleptic properties (preserves the colour, feel, inflation of gut). We studied the feasibility of using these cadavers for training in endoscopy. Endoscopy was performed using PENTAX/ EP 2940 with a light source processor PENTAX/EPM 3500. Participants performed endoscopy and submucosal injection on cadaver as well as simulator. Before and after simulator and cadaver training, attendees completed a questionnaire on intubation, manoeuvring esophagus, stomach and duodenum for diagnostic endoscopy and scope positioning, needle out, submucosal injection and elevation of mucosa and needle in. The steps of ESD- marking, precut and submucosal dissection were attempted on the stomach of human cadaver. **Results:** Ten participants with very little prior experience of endoscopy felt the cadaver based training more beneficial in obtaining the sub mucosal plane and positioning the needle for four quadrant injection as compared to the endoscopic simulator (ES). The attendees felt that while ES has the advantage of providing feedback for the procedure, training on cadaver gave more realistic tactile experience and feel of the elasticity of the gut wall. Overall, diagnostic endoscopy was comparable in both cadaver and simulator except for difficulty in intubation in the former due to supine cadaver position. The steps of ESD were done only in the cadaver with limited success. **Conclusion:** This study shows the feasibility of using human cadaver for simulation-based training programs in gastrointestinal encoscopy.

KEYWORDS: *Diagnostic endoscopy, human cadaver endoscopy, simulation models, therapeutic endoscopy*

INTRODUCTION

Computer-based simulation and animal-based models are increasingly being used for training in diagnostic as well as therapeutic endoscopy. It offers a number of advantages such as the opportunity to repeatedly practice the procedures and assessment of performance, reducing the harm caused to patients by novices performing procedures directly on them,[1-4] and an increase in performance efficiency by reducing the time needed to train in the clinical environment.[5]

Available endoscopy training tools

Endoscopic training devices can be divided into mechanical simulators, those involving animal tissue\ (living or cadaveric) and virtual reality tools. Mechanical simulators (Erlangen plastic mannequin, 1974) are limited by lack of variation.[6] Training models like EASIE (The Erlangen active simulator for interventional endoscopy, ECE-Training GmbH, Erlangen, Germany), use specially prepared cadaveric animal model which behave more like human but are limited by infrastructure

Access this article online

Quick Response Code:

Website: www.jdeonline.in

DOI: 10.4103/jde.JDE_13_18

Address for correspondence: Dr. Avinash Bhat Balekuduru, Department of Gastroenterology, MS Ramaiah Memorial Hospitals, Bengaluru - 560 054, Karnataka, India. E-mail: avinashbalekuduru@gmail.com

How to cite this article: Balekuduru AB, Dutta AK, Subbaraj SB. Endoscopy on a human cadaver: A feasibility study as a training tool. J Dig Endosc 2018;9:103-8.

and ethical concerns.[7,8] Others such as GI-BRONCH Mentor (Simbionix, Cleveland, Ohio) and the CAE AccuTouch (CAE Healthcare, Montreal, Quebec, Canada; previously marketed by Immersion Medical, San Jose, California) are virtual reality tools which have lot of advantages: little set up time, repeated use, and assessment of skills but still lack the feel and experience of performing endoscopy on a real patient.[9,10]

The relevance of these tools is more in a country like India where a large number of doctors perform endoscopy, and there is no mandatory competency certification.[11] Availability of these models may provide valuable training opportunities for our future endoscopists. Experience of endoscopy on a human cadaver may be closer to performing endoscopy on a real patient compared than experience with an animal model or simulator. It familiarizes with the normal human anatomy and the maneuvers required for negotiating the endoscope. In addition, it has advantages similar to a simulator. We performed a feasibility study on cadaver-based endoscopy and also compared the performance characteristics with an endoscopic medical simulator.

Methods

Cadaver environment

At our center, the cadavers are preserved in a customized nonformalin-based solution which retains organoleptic properties (preserve the color, feel, and inflation of intestine) of the cadaver for up to 2 years. We used these for this study. The endoscope and the accessories used were dedicated for use in cadaver laboratory.

Endoscopy on a simulator

Simulator (GI-BRONCH Mentor, Simbionix, Cleveland, Ohio) was used for diagnostic endoscopy which gives the sense and feel of the tissue with varying levels of sophistication. Simulator builds up hand-eye coordination, be reused multiple times, and gives feedback of the endoscopic visualization.[12]

Ten junior trainees in gastroenterology and surgery who were novices in endoscopy were the participants for this study between January 2017 and December 2017. None of the participants had prior exposure to training on human cadaver before the study commenced.

Training on human cadaver

Endoscopy was performed using forward-viewing single-channel gastroscope (PENTAX/EP 2940) using a light source processor PENTAX/EPM 3500 (Pentax U.K. Limited). The basic steps included were as follows: endoscopy tip deflection by knob movement, push in/pull back, right/left torque, air insufflation, and suction to achieve adequate examination of the upper gastrointestinal (GI) tract. These were done on both simulator and human cadaver model. The steps of (i) esophageal intubation, (ii) negotiating the pylorus, (iii) maneuvering into the second part of the duodenum, and (iv) retroflexion in the stomach for visualization of fundus were assessed with a questionnaire.

Endoscopic injection and submucosal dissection

Endoscopic injection (EI) was performed using Interject Boston Scientific 23G/240 cm needle for cadaver. The steps of EI scope positioning, needle sheath out, needle out, submucosal injection, mucosal elevation, needle in, and sheath in were compared between cadaver and simulator.

For endoscopic submucosal dissection (ESD), modular VIO generator (VIO 300D; Erbe Elektromedizin, Tübingen, Germany) was used as surgical system. For the hybrid-knife ESD, we used a water-jet hybrid knife (Erbe HybridKnife®, Erbe Elektromedizin, Tübingen, Germany). The VIO mode ENDO CUT Q effect 2-cut duration3-cut interval 1 was used for circumferential cutting and dissection. The steps of ESD training, marking the perimeter of a made lesion with cautery, lifting up by submucosal injection around the perimeter of the lesion, circumferential mucosal incision with electrocautery, and dissection in the submucosal plane using water jet and knife without hemostasis were done only in cadaver. The argon plasma coagulation (APC) mode FORCED APC 50 was used for marking of lesions. Dissection with electrocautery was alternated with submucosal fluid injection as many times as needed. The areas for resection were defined in an oval shape with a size of approximately 25 mm in length and 20 mm in width in the antrum and body of the stomach. The feasibility of ESD on human cadaver is tested.

The study was approved by the Institutional Ethical committee.

Results

Cadaver esophagoduodenoscopy

Two cadavers were used to assess the feasibility of performing endoscopy. One was a fresh cadaver <6 h old and another cadaver which was preserved for 3 months. The endoscopy was performed with cadaver in the supine position. The intubation was difficult in the fresh cadaver while it was not noted in the second [Figure 1]. Oesophageal lining was pink with surface ulcerations [Figure 2]. The stomach had liquid stasis with orange-brown mucosa and few hemorrhagic blebs [Figures 3 and 4]. The manoeuvres used for negotiating were similar and mild resistance was noted only in the fresh cadaver probably due

Figure 1: Endoscopic image of vocal cords

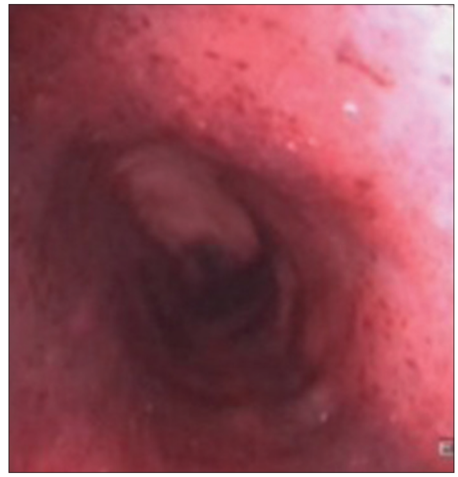

Figure 2: Endoscopic image of the esophagus and gastroesophageal junction

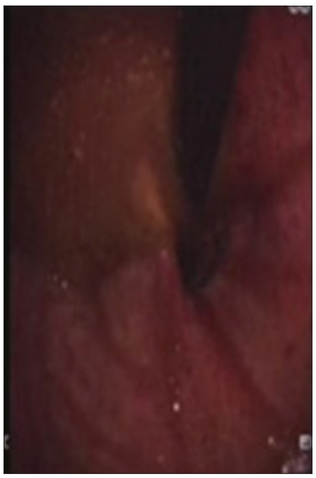

Figure 3: Endoscopic retroflexion image of the fundus with liquid stasis

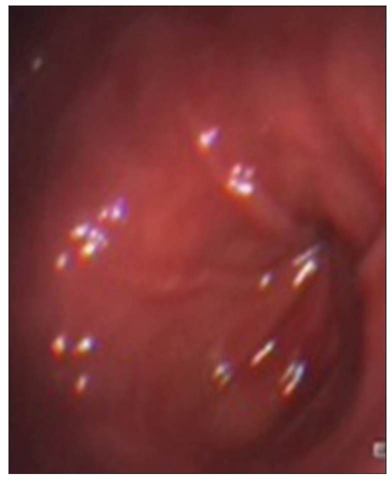

Figure 4: Endoscopic image of antrum and pylorus

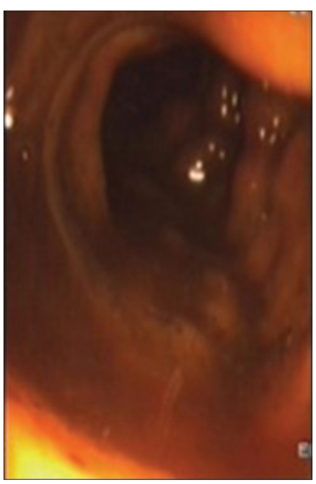

Figure 5: Endoscopic image of the first part of the duodenum

Figure 6: Endoscopic image of the second part of the duodenum

to rigor mortis. The first part of the duodenum was showing brownish orange mucosa [Figure 5]. The second part of the duodenum also had brownish orange mucosa with liquid stasis and surface ulcerations [Figure 6].

Cadaver endoscopy can be used for training trainees as any medical college can have access to cadavers. In fact, it is difficult to get an animal model with ethical clearance and assistance from veterinary hospital. The steps of the diagnostic endoscopy were shown on simulator.

Figure 7: The endoscopic training of trainees in the cadaver laboratory

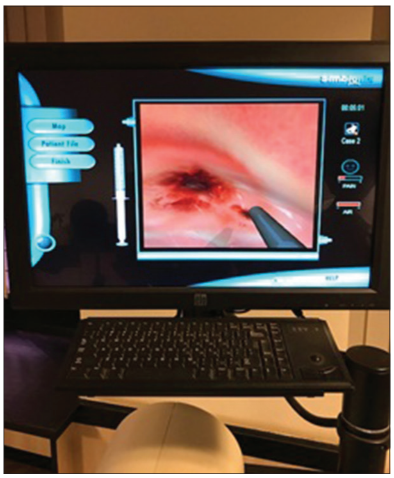

Figure 9: Bronchomentor monitor image of bleeding duodenal ulcer and tip of injector

The trainees were made to compare the simulator and the cadaver endoscopies by performing equal number of diagnostic endoscopies and score them 0–5 (0 is bad and 5 is excellent). The assessment of diagnostic endoscopy and the feasibility for EI/ESD were also compared as given in Table 1.

The limitations were nonavailability of distal cap and the diffusion of indigo carmine-dyed saline after submucosal injection in cadaver stomach. However, the plane of submucosa was identified. In two attempts, perforation of the stomach wall was noted. The cautery settings for the cadaver have to be standardized.

The use of distal cap as well as use of hydroxyethyl starch instead of saline might prove to be useful. We did not compare with the animal model that is being utilized in many centers for ESD training.

Discussion

Upper GI endoscopy is difficult to explain verbally and the skill assessment is very subjective. However, endoscopy is a relatively invasive procedure carried out

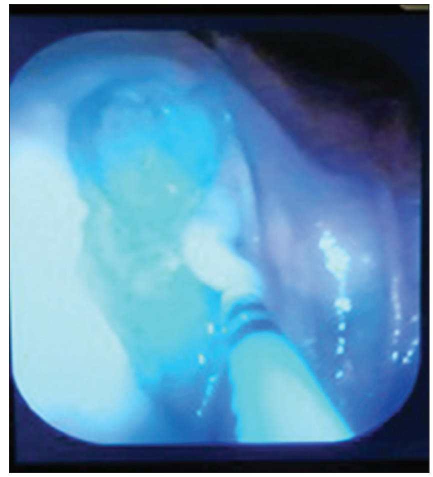

Figure 8: Endoscopic image of submucosal dissection using hybrid knife

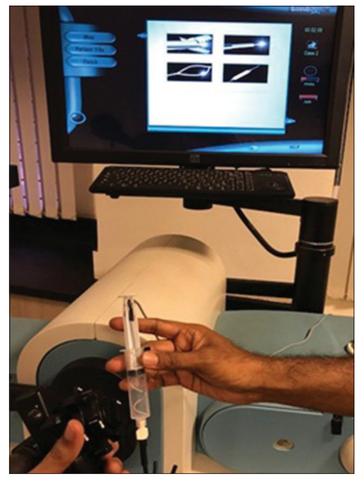

Figure 10: Bronchomentor monitor image along with the proximal end of the injector

on examinee, which can make practice and teaching difficult for trainees and instructors. The training in endoscopy has changed along with the change of scopes used from large diameter short fiber-optic scopes to small diameter long video endoscopes and from diagnostic to more therapeutic indications. One-to-one training provides constant scrutiny and feedback but depends on the relation between the mentor and the trainee.[13]

Simulation-based training programs found improved patient outcomes (better procedural completion rates and a decrease in major complications) in a meta-analysis.[14]

However, simulators currently have limited benefit and useful in early training to familiarize the scope and its maneuverability. Simulator technology will continue to evolve and be more useful in advanced training in the future.[15]

Endoscopic training is often unstructured and in the current era of time-restricted training, requires trainees

Table 1: Comparison of simulator and cadaver models in endoscopic training

Teaching Technique	Cadaver	Simulator
Score 0-5 (0 is bad and 5 is excellent). Proportion giving >3/5 [Figure 7]	-	-
Visualisation of mucosa and spatial relations	80%	90%
Comfort level	50%	80%
	Apprehension of cadaver	Similar to computer/video games
Basic steps: Tip deflection, push/pull/ torque of scope, air insufflation and suction	80%	80%
	Suction of fluid remnant in stomach can be done	Amount of air insufflation and pain feedback can be obtained
Esophageal intubation	20%	80%
	Difficult due to supine positioning of cadaver	Easy
Negotiating pylorus and manoeuvring D2	80%	80%
Retroflexion in stomach	80%	60%
Endoscopic injection - positioning, needle in and out, mucosal elevation	90%	70% [Figures 9 and 10]
	Regular accessories used	Though feedback is given, submucosal plane not identified
	Submucosal plane identified	
	Realistic tactile feel noted	
Endoscopic submucosal dissection - lesion marking, mucosal pre-cutting, inscision & hemostasis	Only in cadaver [Figure 8]	NA
	No hemostasis	
	90%	

to acquire basic skills, and rapidly progresses to advance training as soon as possible. Teaching complex skills like these on patients presents formidable obstacles as the trainer's role as an assistant is more limited as patient care is priority.

However, there are no reports of endoscopic training in human cadaver from India. The current model can be used for training basic steps of endoscopy, needle injection, tattooing, snare polypectomy, and few steps of ESD. It takes a lot of time to train fellows, and if endoscopists are trying to maintain productivity, training fellows may get in the way. Human cadavers give the tactile feedback, routine endoscopic accessories can be used, and real-time anatomy and tissue can be handled as compared to a simulator. Human cadavers have liquid stasis in fundus as compared to simulator and help in training of suction and air/water insufflation buttons.

Competency in therapeutic endoscopy may consist of knowledge, skills, attitude, performance, patient safety, quality initiatives, and cost consciousness.

Endoscopic techniques and technologies will continue to evolve, and there will be further dissemination of procedures that most endoscopists are not currently performing. It is important to keep endoscopy moving forward, as new technologies and techniques may prove to be safer and more cost-efficient. Simulator training followed by cadaver training can appropriately integrate simulators and cadavers into the learning curve and maintain the benefits of both training methodologies.

Conclusions

Simulators help in gaining basic anatomy and provide feedback. Human cadaver can be used for training therapeutic endoscopy. Diagnostic endoscopy, EI, and ESD can be performed on the human cadaver. The human cadaver model and simulator can be used as a bridge in training programs before proceeding to supervised training on patients.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Ziv A, Wolpe PR, Small SD, Glick S. Simulation-based medical education: An ethical imperative. Simul Healthc 2006;1:252-6.
2. Grantcharov TP, Kristiansen VB, Bendix J, Bardram L, Rosenberg J, Funch-Jensen P. Randomized clinical trial of virtual reality simulation for laparoscopic skills training. Br J Surg 2004;91:146-50.
3. Zendejas B, Cook DA, Bingener J, Huebner M, Dunn WF, Sarr MG, *et al.* Simulation-based mastery learning improves patient outcomes in laparoscopic inguinal hernia repair: A randomized controlled trial. Ann Surg 2011;254:502-9.
4. Seymour NE, Gallagher AG, Roman SA, O'Brien MK, Bansal VK, Andersen DK, *et al.* Virtual reality training improves operating room performance: Results of a randomized, double-blinded study. Ann Surg 2002;236:458-63.

5. Sedlack RE. The state of simulation in endoscopy education: Continuing to advance toward our goals. Gastroenterology 2013;144:9-12.
6. Desilets DJ, Banerjee S, Barth BA, Kaul V, Kethu SR, Pedrosa MC, *et al.* Endoscopic simulators. Gastrointest Endosc 2011;73:861-7.
7. Hochberger J, Euler K, Naegel A, Hahn EG, Maiss J. The compact Erlangen Active Simulator for Interventional Endoscopy: A prospective comparison in structured team-training courses on "endoscopic hemostasis" for doctors and nurses to the "Endo-Trainer" model. Scand J Gastroenterol 2004;39:895-902.
8. Hochberger J, Neumann M, Maiss J, Hohenberger W, Hahn EG. EASIE (Erlangen active simulator for interventional endoscopy)-A new biosimulation model: First experiences gained in training workshops. Gastrointest Endosc 1998;47:AB 116.
9. Di Giulio E, Fregonese D, Casetti T, Cestari R, Chilovi F, D'Ambra G, *et al.* Training with a computer-based simulator achieves basic manual skills required for upper endoscopy: A randomized controlled trial. Gastrointest Endosc 2004;60:196-200.
10. Blackburn SC, Griffin SJ. Role of simulation in training the next generation of endoscopists. World J Gastrointest Endosc 2014;6:234-9.
11. Goenka MK, Reddy DN, Kochhar R, Sharma P. Endoscopy training: Indian perspective. J Dig Endosc 2014;5:135-8.
12. Cohen J. Simulation training in endoscopy. Gastroenterol Hepatol (N Y) 2008;4:25-7.
13. Kozarek R. Endoscopic training: Past, present, and future. Gastroenterol Hepatol (N Y) 2014;10:838-40.
14. Singh S, Sedlack RE, Cook DA. Effects of simulation-based training in gastrointestinal endoscopy: A systematic review and meta-analysis. Clin Gastroenterol Hepatol 2014;12:1611-23.e4.
15. Deas TM Jr. Advanced endoscopic training. Gastroenterol Hepatol (N Y) 2013;9:171-2.