Surgical Resident Performance on Laparoscopic Virtual Reality Simulation Tasks With and Without Haptic Features

Scott Stegemann DO, Margaret Siu MD, Amanda Duda BS, Neal E Seymour MD
Department of Surgery, University of Massachusetts Chan Medical School-Baystate

BACKGROUND

- Virtual Reality (VR) simulators can be valuable for laparoscopic surgical skill acquisition for trainees
- Haptic feedback may increase fidelity, but it is not known if it enhances resident skill development
- **Objective:** Compare resident performance on identical tasks performed on laparoscopic VR simulators using haptic and nonhaptic interfaces

METHODS

- Ten surgical residents (3 PGY-3, 4 PGY-2, 3 PGY-1) performed 12 iterations of 6 basic skills on two VR laparoscopic simulators, one with haptic and another with nonhaptic feedback
- Interval quartile performance means were compared
- Paired t-test, repeated measure ANOVA





Image 1: Photographs of the VR laparoscopic simulators, both with haptic (right) and nonhaptic (left) feedback mechanisms

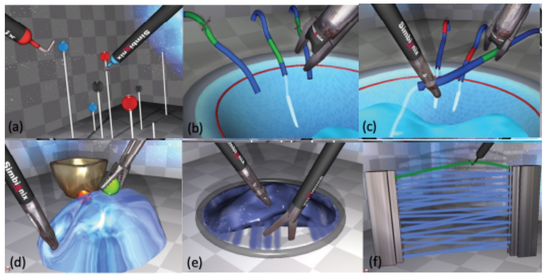
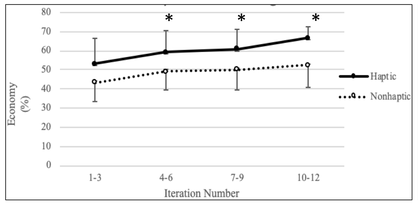


Figure 1: The 6 tasks completed by residents (a) Eye-Hand Coordination (b) Clip Applying (c) Clipping and Grasping (d) Two-Handed Maneuvers (e) Cutting and (f) Electrocautery

RESULTS

Task C: Right Hand Economy of Motion



Task C: Left Hand Economy of Motion

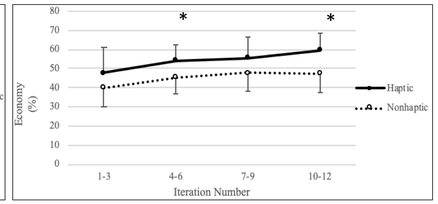
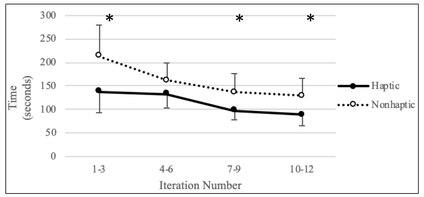


Figure 2: Comparison of economy of motion on haptic and non-haptic performance on VR platforms for Clipping and Grasping task for both right-handed and left-handed instruments for successive iteration quartiles. Astericks (*) signify statistical significant difference ($P < 0.05$)

Task E: Time to Completion



Task E: Percent of Safe Retraction

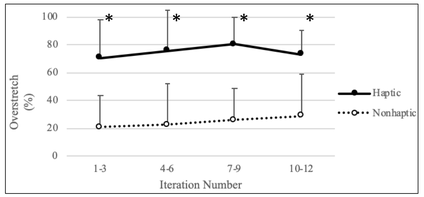


Figure 3: Comparison of performance metrics on haptic and non-haptic VR platforms for Cutting task. Astericks (*) signify statistical significant differences ($P < 0.05$)

CONCLUSIONS

- Higher performance for time to completion, accuracy, efficiency of motion and avoidance of excessive traction force seen on VR simulator with haptic cues
- Sensory interpretation of haptic feedback facilitates performance on selected VR laparoscopic exercises
- Any effect on operative skill acquisition requires further investigation

LIMITATIONS

- Small number of participants, single institution
- Residents of different levels of training included
- Data obtained over a period of months and susceptible to the incalculable variable of resident development from ongoing clinical experience

REFERENCES

1. Siu, M., Debbink, K., Duda, A. *et al.* Expert laparoscopist performance on virtual reality simulation tasks with and without haptic features. *Surg Endosc* **37**, 8748–8754 (2023). https://doi.org/10.1007/s00464-023-10321-5
2. Satava RM (1993) Virtual reality surgical simulator: The first steps. Surg Endosc 7:203–205.
3. Coles TR, Meglan D, John NW (2011) The Role of Haptics in Medical Training Simulators: A Survey of the State of the Art. IEEE Trans Haptics 4(1):51-66. doi: 10.1109/TOH.2010.19, January 2011.
4. Gurusamy K, Aggarwal R, Palanivelu L, Davidson BR (2008) Systematic review of randomized controlled trials on the effectiveness of virtual reality training for laparoscopic surgery. British Journal of Surgery 95(9):1088-1097. doi.org/10.1002/bjs.6344, September 2008.
5. Våpenstad C, Hofstad EF, Bø LE, Kuhry E, Johnson G, Mårvik R, Lange T, Hernes TN (2017) Lack of transfer of skills after virtual reality simulator training with haptic feedback. Minim Invasive Ther Allied Technol 26(6):346-354. doi:10.1080/13645706.2017.1319866, Nov 2017.
6. Zhou M, Tse S, Derevianko A, Jones DB, Schwaitzberg SD, Cao CG (2012) Effect of haptic feedback in laparoscopic surgery skill acquisition. Surg Endosc 26(4):1128-34. doi: 10.1007/s00464-011-2011-8, April 2012.
7. Botden SMBI, Buzink SN, Schijven MP, Jakimowicz JJ (2007) Augmented versus Virtual Reality Laparoscopic Simulation: What Is the Difference?: A Comparison of the ProMIS Augmented Reality Laparoscopic Simulator versus LapSim Virtual Reality Laparoscopic Simulator. World J Surg 31(4):764-772. doi:10.1007/s00268-006-0724-y, April 2007.
8. Guedes HG, Câmara Costa Ferreira ZM, Ribeiro de Sousa Leão L, Souza Montero EF, Otoch JP, Artifon EL de A (2019) Virtual reality simulator versus box-trainer to teach minimally invasive procedures: A meta-analysis. Int J Surg 61:60-68. doi:10.1016/j.ijsu.2018.12.001, Jan 2019.
9. Ko JKY, Cheung VYT, Pun TC, Tung WK (2018) A Randomized Controlled Trial Comparing Trainee-Directed Virtual Reality Simulation Training and Box Trainer on the Acquisition of Laparoscopic Suturing Skills. J Obstet Gynaecol Can 40(3):310-316. doi:10.1016/j.jogc.2017.07.010, March 2018.
10. Salkini MW, Doarn CR, Kiehl N, Broderick TJ, Donovan JF, Gaitonde K (2010) The Role of Haptic Feedback in Laparoscopic Training Using the LapMentor II. J Endourol 24(1):99-102. doi:10.1089/end.2009.0307, Jan 2010.
11. Våpenstad C, Hofstad EF, Langø T, Mårvik R, Chmarra MK (2013) Perceiving haptic feedback in virtual reality simulators. Surg Endosc 27(7):2391-2397.
12. Overtoom EM, Horeman T, Jansen FW, Dankelman J, Schreuder HWR (2019) Haptic Feedback, Force Feedback, and Force-Sensing in Simulation Training for Laparoscopy: A Systematic Overview. J Surg Educ 76(1):242-261. doi:10.1016/j.jsurg.2018.06.008, Jan 2019.
13. Huber T, Paschold M, Hansen C, Wunderling T, Lang H, Kneist W (2017) New dimensions in surgical training: immersive virtual reality laparoscopic simulation exhilarates surgical staff. Surg Endosc 31(11):4472-4477. doi:10.1007/s00464-017-5500-6, Nov 2017.
14. Horeman T, Rodrigues SP, van den Dobbelsteen JJ, Jansen FW, Dankelman J (2012) Visual force feedback in laparoscopic training. Surg Endosc 26(1):242-248. doi:10.1007/s00464-011-1861-4, Jan 2012.
15. Rangarajan K, Davis H, Pucher PH (2020) Systematic Review of Virtual Haptics in Surgical Simulation: A Valid Educational Tool? J Surg Educ 77(2):337-347. doi: 10.1016/j.jsurg.2019.09.006, March 2020.

Baystate Health | UMass Chan Medical School