Feasibility of AI-Generated Organ Models for Laparoscopic Training: Validation through Expert and Resident Evaluation

AUTHORS: Wouter IJgosse, MD, PhD[1]; Jan-Maarten Luursema, PhD[1]; Luan Duong[2]; Otmar Buyne, MD, PhD[1]; Harry van Goor, Em, Prof, Dr[1]; Bas Verhoeven, MD, PhD[1]. **AFFILIATIONS:** [1]Radboudumc; [2]Grendel Games.

Introduction

Laparoscopic simulation training is essential for surgical trainees before performing laparoscopy in the operating room, where they usually start with laparoscopic cholecystectomy. Although high-fidelity digital simulators are widespread, most fail to implement the anatomical variability and pathologies found in the operating room. This may limit the transfer of skills to the operating room and delay the development of surgical competence.

To introduce real-world anatomical variations in realistic digital organ models for laparoscopic training, we created cholecystectomy-related anatomical models using artificial intelligence techniques in combination with procedural modeling. This study is the first to establish face validity of artificial intelligence-based digital models.

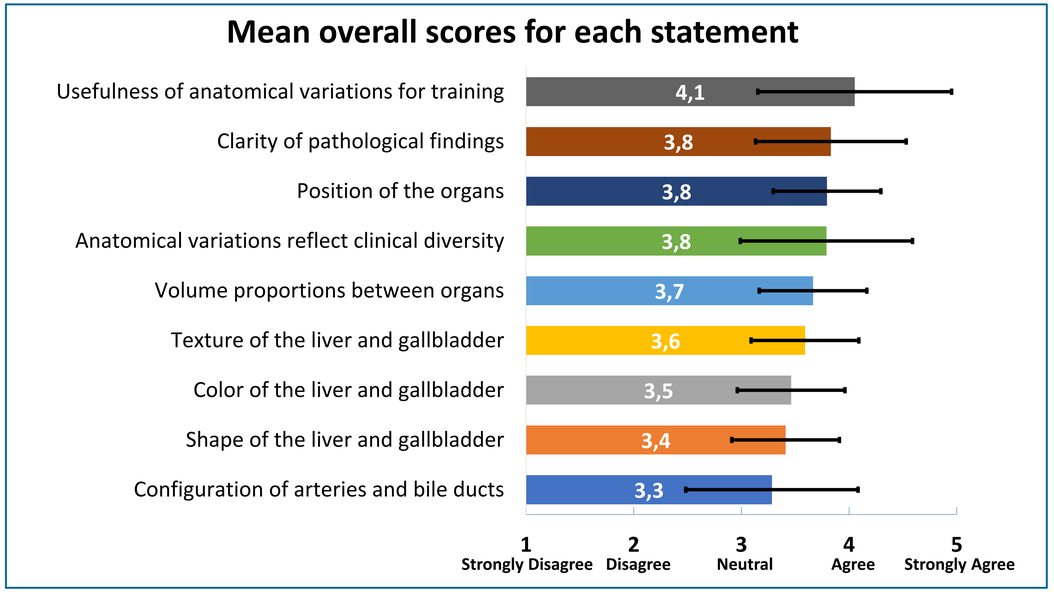
Methods and procedures

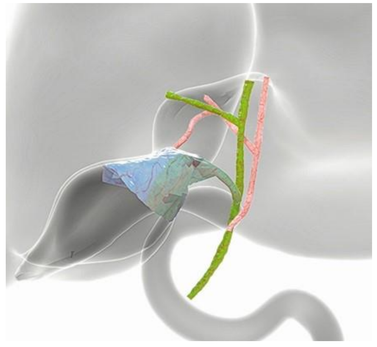
Large organ models were generated using Latent Diffusion Models trained on liver and gallbladder images segmented from computed tomography scans. Fine structures, including small blood vessels, ductal structures, and organ surface, were enhanced and corrected through an overlaid procedural modeling system, guided by established anatomical variations.

Five different organ sets with varying features were independently evaluated by senior surgical residents and expert gastrointestinal surgeons at the Radboudumc. They scored their agreement with statements pertaining to the morphology, configuration, and relevance to surgical training of the models, on a 5-point Likert scale. Suggestions for improvement were provided in free-text format.

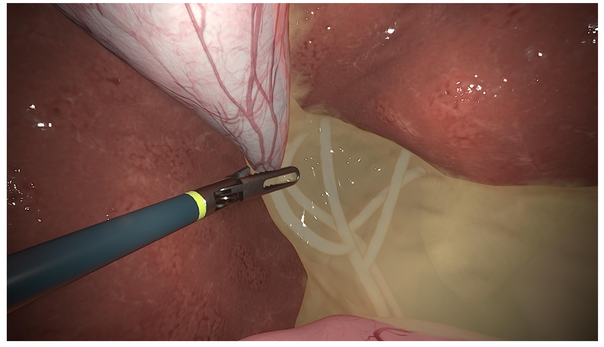
Radboudumc university medical center

grendel medical





Organ model in which the configuration of the arteries and bile ducts, as well as part of the gallbladder, has been highlighted in color.



Organ model within a simulation environment. Ductal structures are displayed for training purposes.

Results

Twenty-five participants (12 senior residents and 13 expert surgeons) completed the assessment. Twenty-one participants (8 senior residents and 13 experts) had served as the primary or supervising operator in more than 100 laparoscopic procedures. Mean scores for all variables including shape, color, texture, and anatomical positioning were between 3 (neutral) and 4 (good), indicating general acceptance. The configuration of bile ducts and blood supply received the lowest ratings, with a mean score of 3.3. The similarity to the diversity of anatomical variants in the operating room was rated positively, with a mean score of 3.8. Suggestions included enhancing the depiction of disease-specific aspects, such as gallbladder hydrops in cholecystitis. Overall, the models were deemed suitable for integration into surgical skills training, with a mean score of 4.1.

Conclusion

Experienced senior residents and expert surgeons provided favorable ratings for overall morphology, coloration, texture, and anatomical positioning, although the configuration of bile ducts and vascular structures received comparatively lower scores. Participants recognized the models' ability to represent real-life anatomical variability and deemed them suitable for surgical skills training. These findings suggest that combining artificial intelligence with procedural modeling can generate anatomically varied digital organ models.

Acknowledgements

The overall project received full funding from the Wellcome Leap SAVE program.

Conflicts of interest

Wouter IJgosse, MD, PhD[1] and Bas Verhoeven, MD, PhD[1] have received research funding from Grendel Games. Luan Duong is a full-time employee of Grendel Games. The remaining authors declare no other conflicts of interest.