DEVELOPMENT AND EVALUATION OF AN AI MODEL FOR IDENTIFYING CRITICAL ANATOMICAL STRUCTURES IN TEP INGUINAL HERNIA REPAIR

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Background: In the 1970s, the potential impact of computer science on medicine was anticipated, with predictions that computers could greatly improve healthcare. Surgical procedure recordings could create detailed anatomical maps, integrating augmented reality (AR) and deep machine learning to extract information like anatomical landmarks, tissue characteristics, and procedural phases. This would enhance surgical interventions, improve visualization, and aid in robotic surgery training. AR can overlay real-time anatomical data onto the surgeon's view, offering guidance during complex surgeries like hernia repair, enhancing precision and reducing complications.

Introduction: Our preliminary study aims to investigate the use of AI models to recognise critical structures in Totally Extra-Peritoneal (TEP) Inguinal Hernia Repair. Anterior anatomy of Inguinal canal is commonly taught, but Posterior Repair like TEP or Transabdominal Preperitoneal (TAPP) requires a different understanding of the posterior anatomy of the Inguinal Region and the Myopectineal Orifice of Fruchaud (MPO). Dissection of MPO and identification of critical structures are key factors for a successful endo-laparoscopic hernia repair. Furthermore, TEP has steep learning curve of 50-100 cases which affects the propagation of the technique, hence we are exploring the use of AI to facilitate the learning of TEP, shortening the process to acquire proficiency.

Methods: Out of 1000 frames captured in high-resolution recording of TEP laparoscopic inguinal hernia repair, 267 frames were identified and annotated by experienced surgeon using Coco Annotator. Critical structures and regions include: Pubic Bone, Inferior Epigastric Vessels, Testicular Vessels, Vas Deferens, Triangle Of Doom, Triangle Of Pain. The machine learning model, YOLOv8, was trained on recognising the landmarks and critical structures using the 267 annotated frames to allow the model to understand characteristics and features of each landmark and critical structure. Performance of the model was then tested through the accuracy of structure recognition in the annotated frames.

Results: Validation of model through mean average precision (mAP50), calculated by the Intersection over Union (IOU) of recognised versus actual structure at the threshold of 50%. Overall mAP50 achieved was 70.7%. Specific landmark detection accuracies were: Triangle of pain - 88.1%, Testicular vessels - 83.6% Vas Deferens - 70.7%, Inferior Epigastric Vessels - 66.0%, Triangle of Doom - 79.4%, Pubic Bone - 73.3%

Discussion: In our preliminary study, the AI model demonstrated ability to correctly identify critical structures in myopectineal orifice (MPO), and can be improved by training with larger dataset of annotated images, training with frames in different surgical conditions. Another study, STARE (Structured Analysis of the Retina) which is trained to identify blood vessels in retinal photography achieved mAP50 of 80%; variance may be due to: higher complexity of MPO, contrast of surgical video compared to still photography, and smaller dataset.

Our model can be adopted in intra-surgical systems in laparoscopic view to allow surgeons to identify landmarks with greater confidence and reduce accidental damage to critical structures; It can also be adopted in surgical training, allowing structure recognition from video recordings and using reverse engineering to create quizzes for structure recognition with model validation; Furthermore it can be applied in other approach of endo-laparoscopic inguinal hernia repair like transabdominal pre-peritoneal (TAPP) approach.

Conclusion: Our AI model shows promise in facilitating TEP inguinal hernia repair by improving landmark identification. This advancement not only supports surgical practice but also enhances training for surgical trainees, potentially reducing the learning curve and improving overall procedural outcomes.

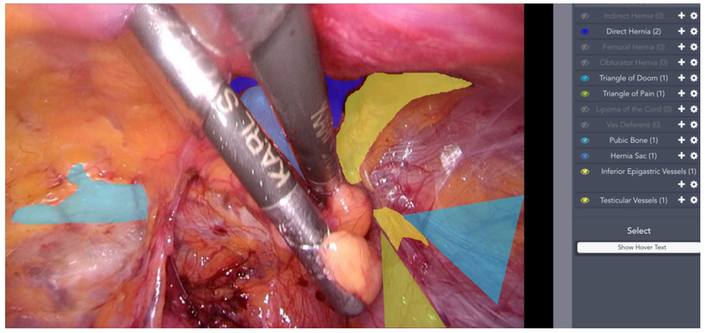


Fig. 1 Example of Annotation

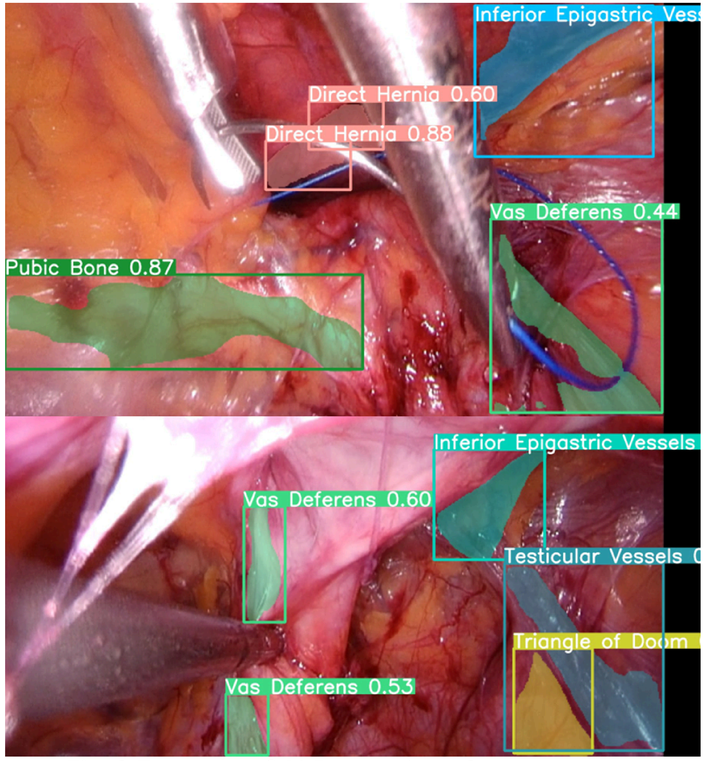


Fig. 2 Example of AI Recognised Structures