



Comparative Video Image Analysis of Complex Versus Simple Laparoscopic Cholecystectomy Using Artificial Intelligence

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Background

- Laparoscopic cholecystectomy carries risk of bile duct injury due to misidentification of biliary anatomy.
- Artificial intelligence may assist by automatically identifying key anatomical structures during surgery.
- This study evaluates whether an AI-based image analysis system can accurately identify key anatomical features and predict the CVS score across varying levels of surgical complexity.

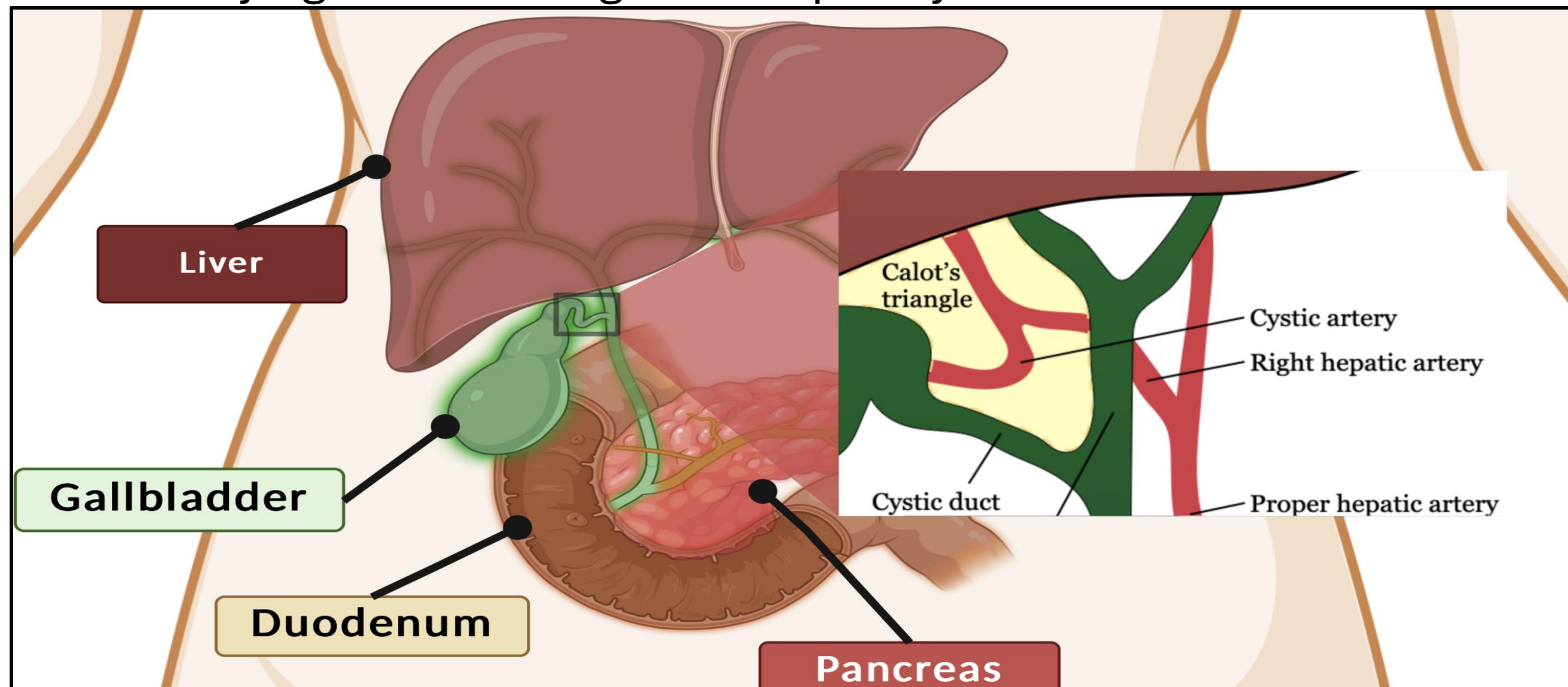
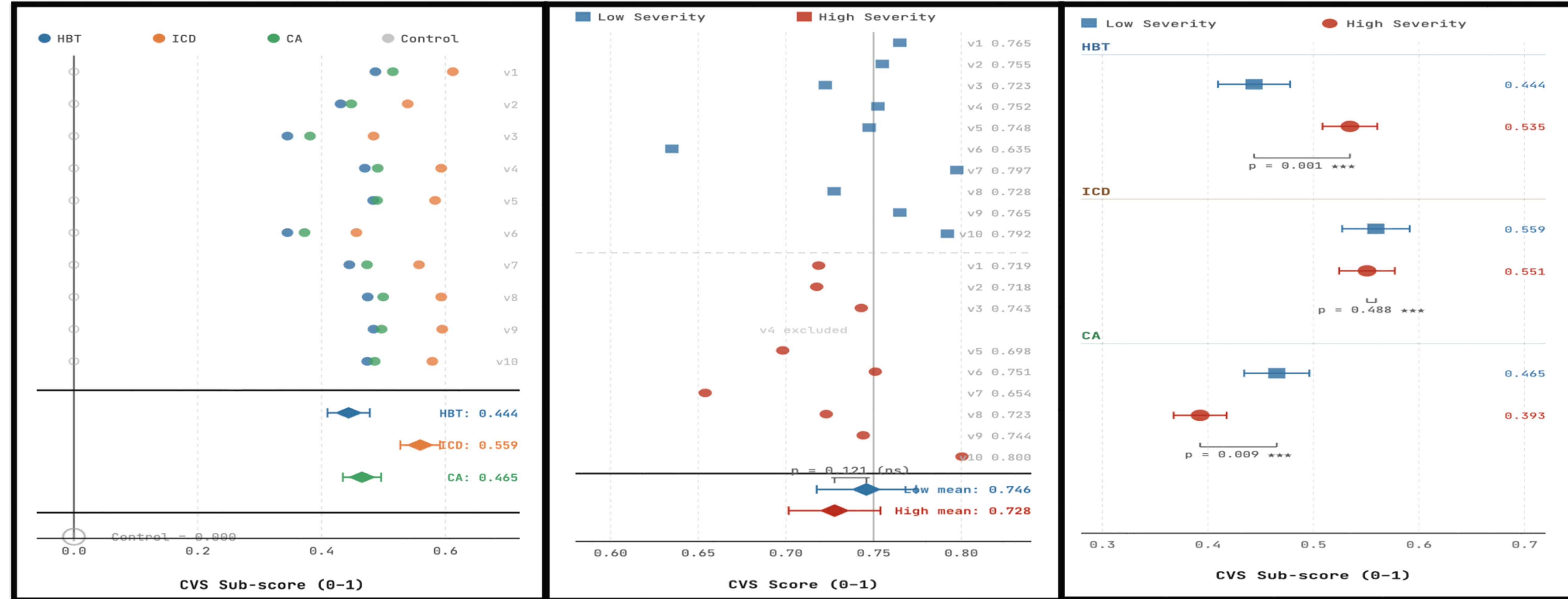
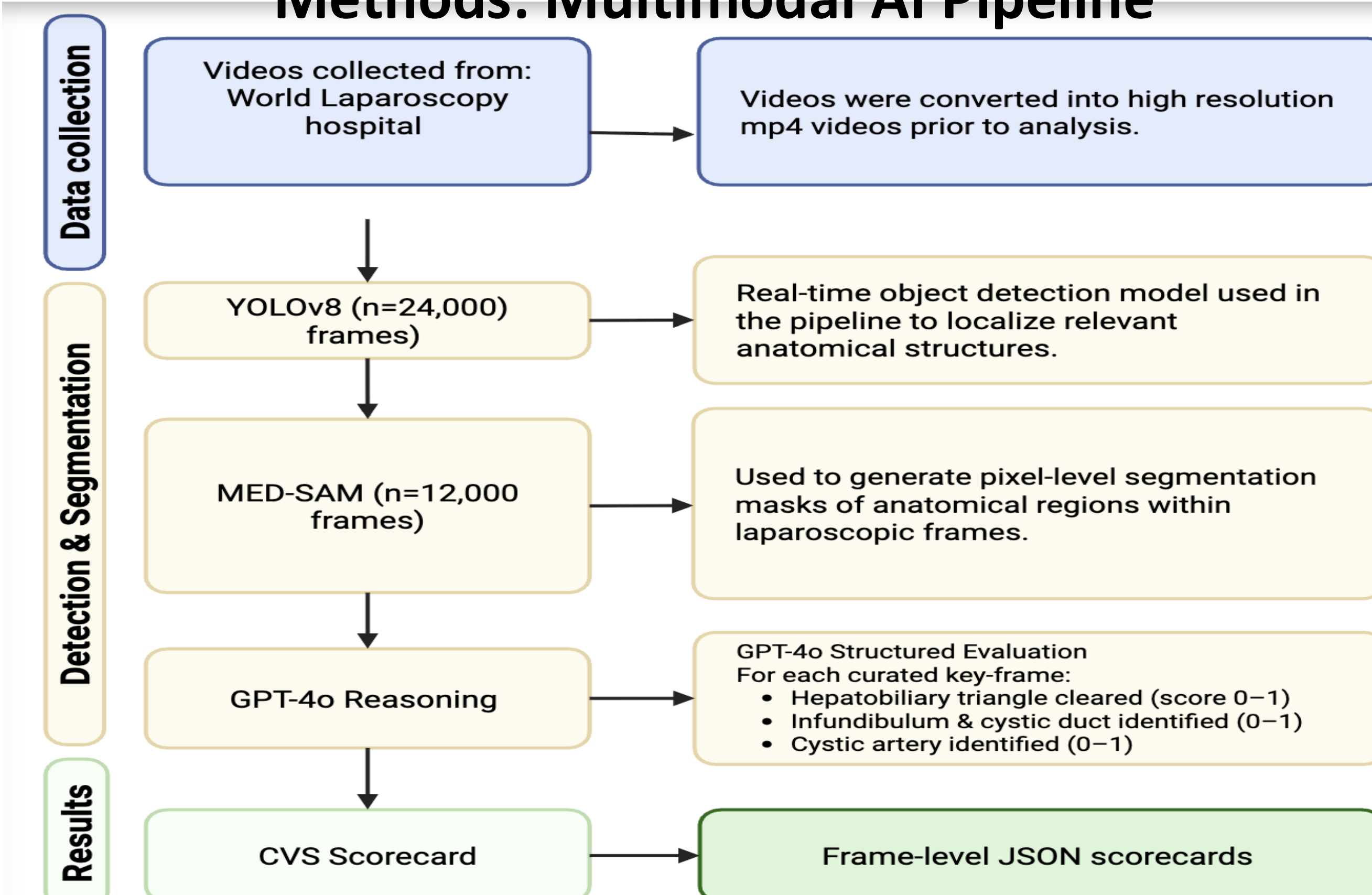


Figure 1: Anatomic Overview

Methods: Multimodal AI Pipeline



CVS Sub-scores by Anatomical Structure
Mann-Whitney U tests revealed significant differences between HBT vs ICD ($p = 0.001$) and ICD vs CA ($p = 0.006$), but not HBT vs CA ($p = 0.104$); all structures differed significantly from zero control ($p < 0.001$).

CVS Score by Video Severity
Mann-Whitney U test showed no significant difference in overall CVS scores between low- and high-severity videos ($U = 64.0$, $p = 0.131$).

CVS Sub-scores: Low vs High Severity
Mann-Whitney U tests showed significant differences between severity groups for HBT ($p = 0.002$) and CA ($p = 0.010$), but not ICD ($p = 0.513$).

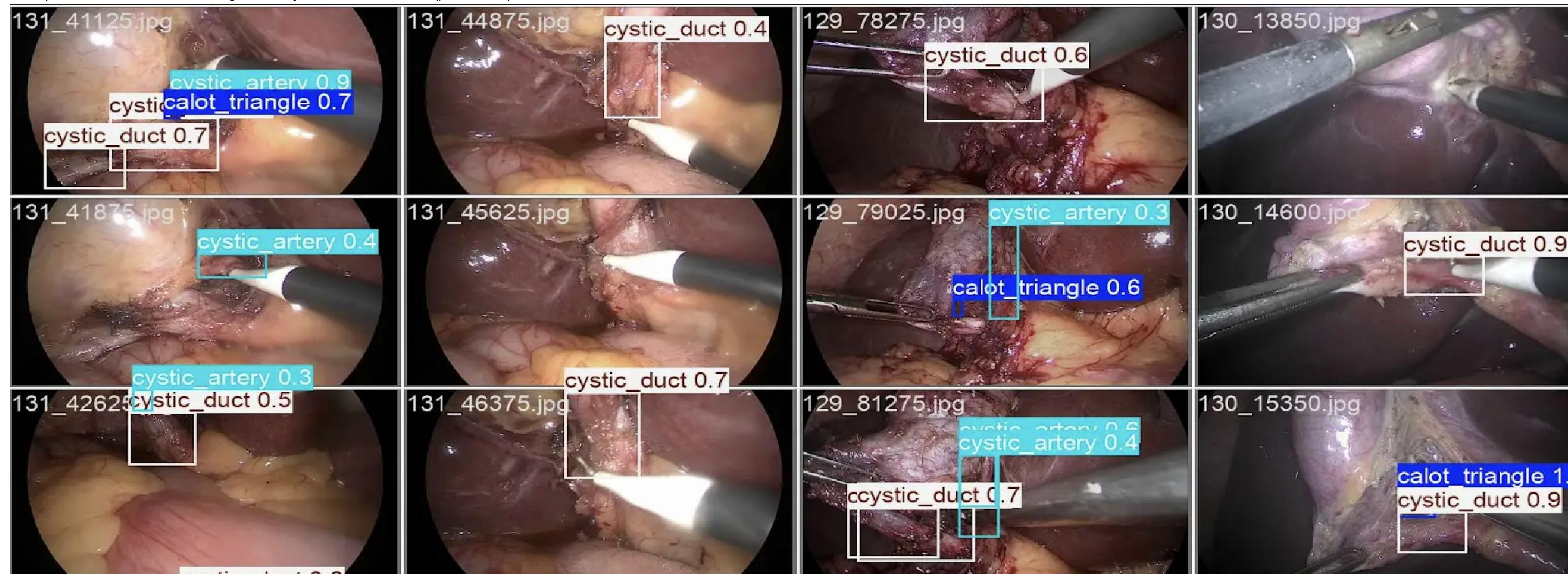


Figure 2: YOLOv8 Object Detection

Abbreviations

HBT –Hepatobiliary Triangle; CVS – Critical View of Safety;
ICD – Infundibulum and Cystic Duct;
CA – Cystic Artery; LS – Low Severity; HS – High Severity

•Infundibulum and cystic duct were detected more reliably than hepatobiliary triangle or cystic artery.

•Overall CVS scores were slightly lower in high-severity cases but differences were not statistically significant.

•Hepatobiliary triangle detection was higher in inflamed cases, whereas cystic artery detection decreased due to obscuration by fibrosis or fat.

Conclusion

AI analysis of laparoscopic cholecystectomy videos can detect key biliary anatomy and estimate the Critical View of Safety across varying operative complexity.

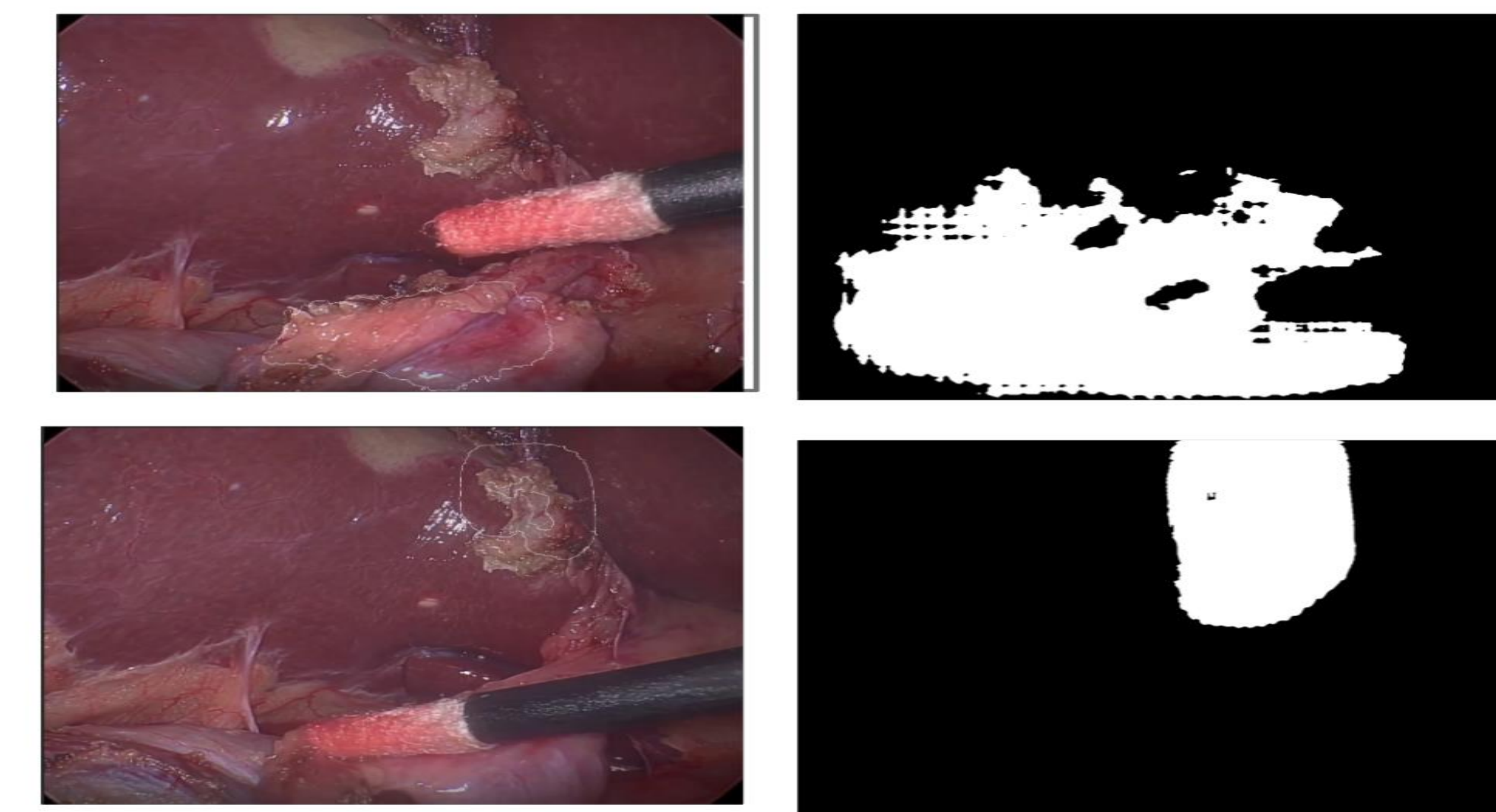


Figure 3: MedSAM Overlay

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