Artificial Intelligence for Surgical Coaching: Training and Testing of a Novel Computer Vision Algorithm for Assessing Adequacy of Retraction and Exposure During Laparoscopic Cholecystectomy

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Introduction

- With advancements in AI technology, the potential for real-time coaching during surgeries is becoming a tangible reality.
- Our team has developed a novel AI algorithm, GoNoGoNet, which provides real-time guidance during surgery (Figure 1a).
- A key limitation of the algorithm is its failure to consider scenes where tissue is not appropriately retracted or exposed, crucial components for safe surgery (Figure 1b).

Figure 1a

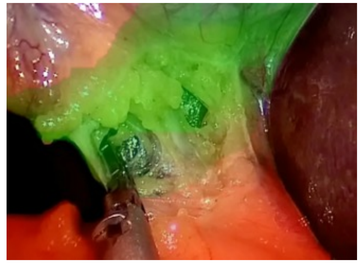
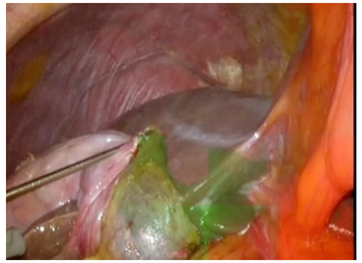


Figure 1b



- This study aims to develop and evaluate the performance of a novel AI algorithm that assesses adequacy of exposure and retraction of the hepatocystic triangle during laparoscopic cholecystectomy.
- A new algorithm name: REXNet(**RE**traction and e**X**posure)

Methods

- Target surgery: Laparoscopic cholecystectomy
- Target scene: Hepatocystic triangle dissection
- Data source: 37 countries
- Annotators: 2 annotators, 1 reviewer
- Annotation work: The adequacy of retraction and exposure

Figure 2a
Ontology for retraction
(Multiclass classification)

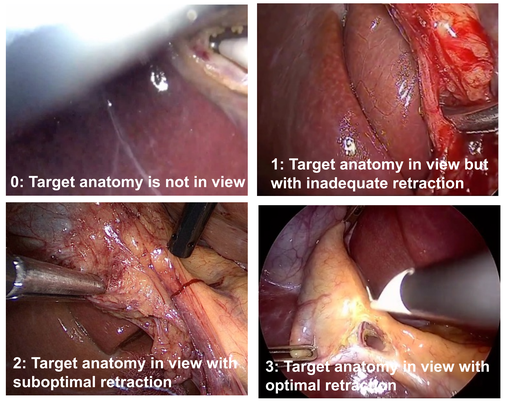
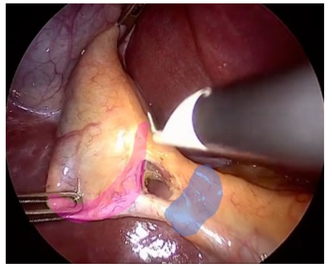


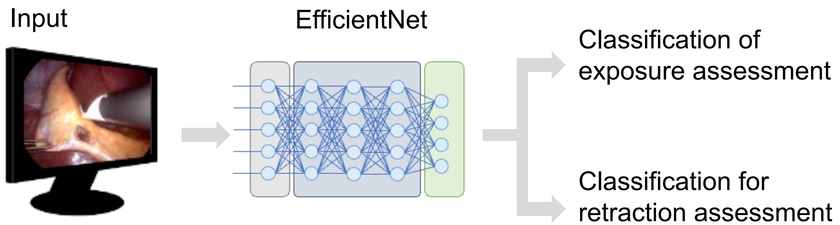
Figure 2b
Ontology for exposure
(Binary classification)



Target anatomy
- Inferior edge of gallbladder
- Line of safety

- Retraction assessment (Figure 2a):
  0: out of context, 1: poor, 2: adequate, 3: optimal
- Exposure assessment (Figure 2b): Determination of whether the target anatomies are visible
- Dataset split: 70% for training, 15% for validation, 15% for testing
- Outcome measure

Inter annotator variability: Cohen's kappa
AI performance: Accuracy, sensitivity, specificity, PPV, NPV, F-1 score



Preliminary Results

- A total of 27,028 frames (244 cases) were procured.
- Inter-annotator variability

0.75 for retraction assessment, and 0.98 for target anatomies

- Primary Outcome

Exposure assessment
Inferior edge of gallbladder: Accuracy 0.71, specificity 0.95
Line of safety: Accuracy 0.63, specificity 0.83
Retraction assessment
Accuracy 0.69, sensitivity, 0.72, specificity 0.54, F-1 score 0.79

- Secondary Outcome

Lag time for model inference was 0.01 ms.

High specificity in determining the target anatomy visibility, functioning as an alert system that aims to avoid false positives.

Future study
- Improve the model's performance.
- Investigate the impact of the integrated algorithm (REXNet + GoNoGoNet) on clinical and educational outcomes.
- Develop a universal algorithm for retraction assessment

Conclusion

We have developed a new AI algorithm capable of assessing the adequacy of retraction and exposure. In the future, our goal is to develop a novel model for AI-assisted surgical coaching by integrating the universal REXNet with GoNoGoNet.

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