Endoscopy news

Vessel and tissue recognition during third-space endoscopy using a deep learning algorithm

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MESSAGE

In this study, we aimed to develop an artificial intelligence clinical decision support solution to mitigate operator-dependent limitations during complex endoscopic procedures such as endoscopic submucosal dissection and peroral endoscopic myotomy, for example, bleeding and perforation. A DeepLabv3-based model was trained to delineate vessels, tissue structures and instruments on endoscopic still images from such procedures. The mean cross-validated Intersection over Union and Dice Score were 63% and 76%, respectively. Applied to standardised video clips from third-space endoscopic procedures, the algorithm showed a mean vessel detection rate of 85% with a false-positive rate of 0.75/min. These performance statistics suggest a potential clinical benefit for procedure safety, time and also training.

IN MORE DETAIL

Endoscopic submucosal dissection (ESD) is an established organ-sparing curative endoscopic resection technique for premalignant and superficially invasive neoplasms of the GI tract.1–7 However, ESD and peroral endoscopic myotomy (POEM) are complex procedures with an elevated risk of operator-dependent adverse events, specifically intraprocedural bleeding and perforation. This is due to inadvertent transaction through submucosal vessels or into the muscularis propria, as visualisation and cutting trajectory within the expanding resection defect is not always apparent.3,4 An effective mitigating strategy for intraprocedural adverse events has yet to be developed.

Artificial intelligence clinical decision support solution (AI-CDSS) has rapidly proliferated throughout diagnostic endoscopy.4–7 We therefore sought to develop a novel AI-CDSS for real-time intraprocedural detection and delineation of vessels, tissue structures and instruments during ESD and POEM.8

Sixteen full-length videos of 12 ESD and 4 POEM procedures using Olympus EVIS X1 series endoscopes (Olympus, Tokyo, Japan) were extracted from the Augsburg University Hospital database. A total of 2012 still images from these videos were annotated by minimally invasive tissue resection experts (ESD experience ≥500 procedures) using the computer vision annotation tool for the categories endoscopic knife, endoscopic instrument, submucosal layer, muscle layer and blood vessel. A DeepLabv3+ neural network architecture with KSAC9 and a 101-layer ResNet backbone10 (online supplemental methods) was trained with these data. The performance of the algorithm was measured in an internal fivefold cross validation, as well as a test on 453 annotated images from 11 separate videos using the parameters Intersection over Union (IoU), Dice Score and pixel accuracy (online supplemental methods) was trained with these data.

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WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Recently, artificial intelligence (AI) tools have been developed for clinical decision support in diagnostic endoscopy, but so far, no algorithm has been introduced for therapeutic interventions.

WHAT THIS STUDY ADDS

⇒ Considering the elevated risk of bleeding and perforation during endoscopic submucosal dissection and peroral endoscopic myotomy, there is an apparent need for innovation and research into AI guidance in order to minimise operator-dependent complications. In this study, we developed a deep learning algorithm for the real-time detection and delineation of relevant structures during third-space endoscopy.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This new technology shows great promise for achieving higher procedure safety and speed. Future research may further expand the scope of AI applications in GI endoscopy.
false vessel detection, and a vessel detection rate (VDR) was determined.

The cross-validated mean IoU, mean Dice Score and pixel accuracy were 63%, 76% and 81%, respectively. On the test set, the AI-CDSs achieved scores of 68%, 80% and 87% for the same parameters. The individual per class values and 95% CIs are shown in Table 1. Examples of the original frames, expert annotations and AI segmentations are shown in Figure 1.

The mean VDR was 85%. The VDR for rectal ESD, oesophageal ESD and POEM were 70%, 95% and 92%, respectively. The mean false-positive rate was 0.75 /min. The algorithm spotted seven out of nine vessels, which caused intraprocedural bleeding. It also recognised the two vessels which required specific haemostatic forceps for major bleeding.

To demonstrate the performance of the AI-CDS without computing quantitative performance measures, we show an example of an internal POEM procedure with AI overlay. For visualisation of the experiment, we show six video clips, which were used for the evaluation of VDR in the same video (2× POEM, 2× rectal ESD and 2× oesophageal ESD; online supplemental video 1). For a test in robustness, the algorithm was also applied to a randomly selected highly compressed YouTube video of a gastric per-oral endoscopic myotomy procedure (ENDOCLUNORD 2020, https://www.youtube.com/watch?v=VKF-HWOzYDGM; online supplemental video 2). The individual output is the result of an exponential moving average between the current and past predictions which smooths the predictions and is a simple way to include temporal information.

**Table 1** Performance results of the AI-CDS in the internal cross validation and the test data set: IoU and Dice Score for all categories as well as their means across all categories, pixel accuracy for complete frames and 95% CI in brackets

<table>
<thead>
<tr>
<th>Vessel detection</th>
<th>Tissue differentiation</th>
<th>Instrument detection</th>
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<tbody>
<tr>
<td>Dice Score</td>
<td></td>
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<tr>
<td>Vessel</td>
<td>Submucosa</td>
<td>Muscularis</td>
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<tr>
<td>55.15 (4.10 to 56.18)</td>
<td>75.15 (74.88 to 76.12)</td>
<td>70.64 (69.32 to 71.88)</td>
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<tr>
<td>IoU</td>
<td></td>
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<tr>
<td>38.07 (37.08 to 39.07)</td>
<td>60.65 (59.85 to 61.44)</td>
<td>54.60 (53.05 to 56.10)</td>
</tr>
<tr>
<td>Pixel accuracy</td>
<td>80.99 (80.52 to 81.47)</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 1** Examples of original images (left column) with corresponding expert annotations (middle column) and AI segmentations (right column). The muscle layer, submucosa, vessels and knife are segmented with a coloured overlay.
perforation. In the future, AI assistance may have the potential to accelerate the learning curve of trainees in endoscopy.

The major limitation of this study is the small number of videos used for training and validation; however, every video contained a complete therapeutic ESD procedure with a full range of procedural situations. The study is further limited by the fact that the algorithm was not yet tested in a real-life setting. However, the AI model was tested on externally generated video sequences and was able to recognize submucosal vessels and the cutting plane. Furthermore, surrogate parameters such as the detection of vessels, which bled later during the procedures, give rise to the conclusion that these complications might have been preventable by the application of the AI-CDSS. This is a first preclinical report on a novel technology; further research is needed to evaluate a potential clinical benefit of this AI-CDSS in detail.

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