A NON-INVASIVE ARTIFICIAL INTELLIGENCE APPROACH TO STAGE ESOPHAGEAL ADENOCARCINOMA

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Introduction

- In 2025, 2,700 Canadians will be diagnosed with esophageal cancer [1]
- Endoscopic resection (ER) procedures provides effective treatment for early-stage superficial esophageal adenocarcinoma (ESA) (T1N0) [2]
- Treatment selection is predicated on clinical staging
- ESA clinical stage is assessed through positron emission tomography/ computed tomography (PET/CT) and endoscopic ultrasound (EUS)
- EUS is invasive, costly, and operator dependent with limited accuracy (30%) [3]
- Inaccurate staging impacts the delivery of guideline accordant treatment
- Artificial intelligence (AI) based deep-learning convolutional neural networks offer a promising non-invasive alternative to interpret PET/CT scans

Objective

To develop a deep learning convolutional neural network-based approach to classify early-stage superficial esophageal adenocarcinoma from PET/CT scans alone.

Methods

167 patients from the London Health Sciences Centre treated with upfront esophagectomy between 2009-2020

Diagnostic PET/CT, age, sex and pathological stage collected (Figure 1-1)

3 excluded (unavailable/poor quality scans)

Eligible Patients (n=164)

- 97% male (n=159)
- Mean age of 68 [range 42-88]
- 38% (n=62) presenting with T1N0 staged cancer

- The esophagus, stomach and T5 vertebrae were automatically contoured using TotalSegmentator, a fully automated AI-based segmentation algorithm (Figure 1-2)
- The medical images were pre-processed and cropped based on the generated contours to a size of 64x128x128 voxels (Figure 2)
- A custom Artificial Intelligence based convolutional neural network (ConvNeXt) was developed and tested (Figure 1-4) [4]
- 70% (n=114) of the dataset was used for training, 15% (n=25) for validation and 15% (n=25) for testing the AI model
- Model performance was evaluated based on :
  - Accuracy
  - Area under the receiver operator curve (AUC)
  - Sensitivity
  - Time to inference

Study Design Overview

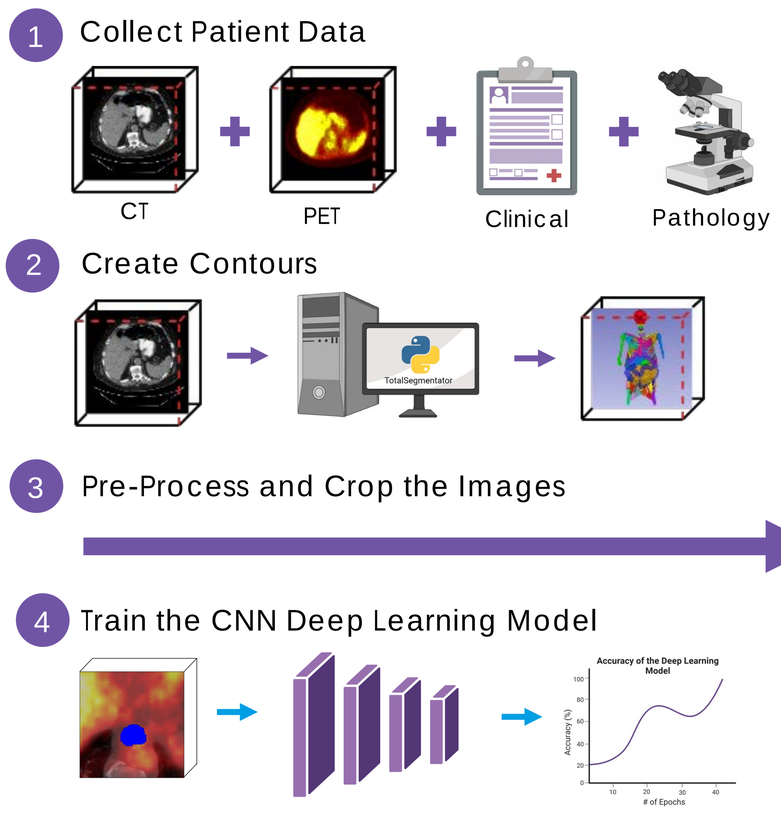

Figure 1: The overall methodology of the study.

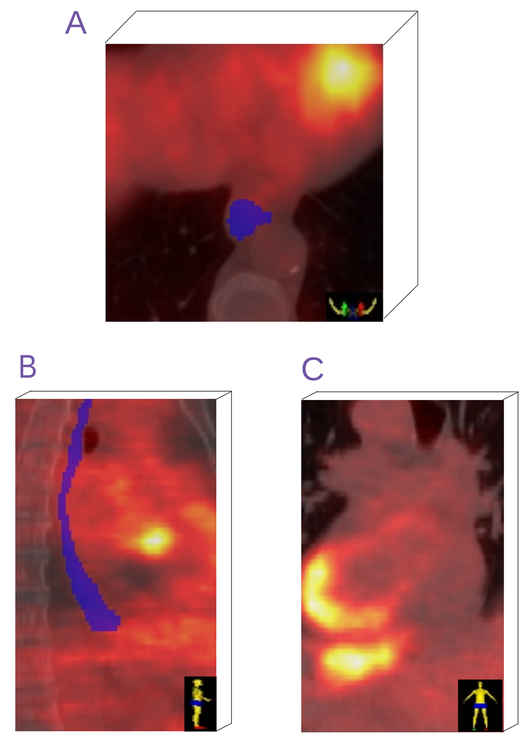

Figure 2: The pre-processed and cropped images in the (A) axial, (B) sagittal and (C) coronal planes used as input to the AI model. The esophagus contour is shown in blue.

Results

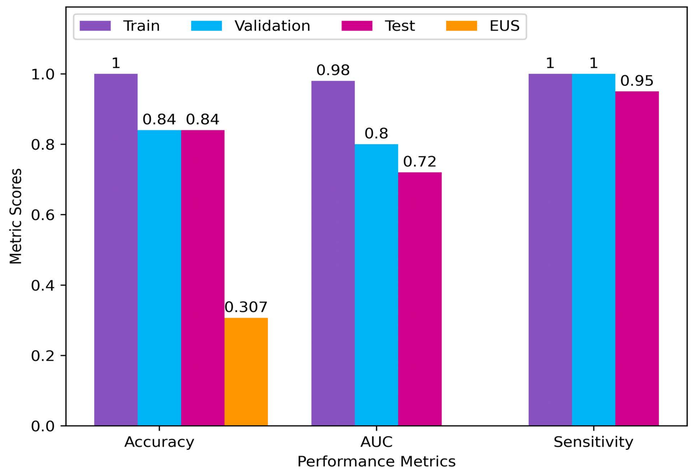

Figure 3: The primary model performance metrics of accuracy, AUC and sensitivity evaluated on the training, validation and testing datasets.

Average time for pre-processing:

20.83±3.5 s

Average time for inference:

1.94±00 s

Figure 4: The average pre-processing and inference time for predictions made by the AI deep learning-model.

Conclusion

- An AI deep learning-based model can classify early-stage superficial ESA with an accuracy that outperforms the currently recommended EUS diagnostic procedure
- Integrating the AI learning model could allow for better assessment of ER eligibility from PET/CT scans alone
- Next steps of creating a custom plugin to be integrated into the clinical workflow, and external validation of the model are underway
- Future work includes refinement of the model to classify the EAC submucosal stage

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GitHub:

References

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