Performance of a Convolutional Neural Network in Identifying Local Regrowth Among Watch and Wait Patients

Hannah Williams MD[1], Aneesh Rangnekar PhD[2], Hannah Thompson MD[1], Harini Veeraraghavan PhD[2] and Julio Garcia-Aguilar MD PhD[1]

[1]Department of Surgery, Colorectal Service [2]Department of Medical Physics, Memorial Sloan Kettering Cancer Center, New York NY

Introduction

Convolutional neural networks (CNN), a form of machine learning, have shown a promising ability to interpret medical images. Given the increasing interest in Watch and Wait (WW) programs for rectal cancer patients, several groups have developed CNNs that differentiate with moderate accuracy between rectal tumors with a complete (cCR) and incomplete (iCR) clinical response to neoadjuvant therapy.[1,2]

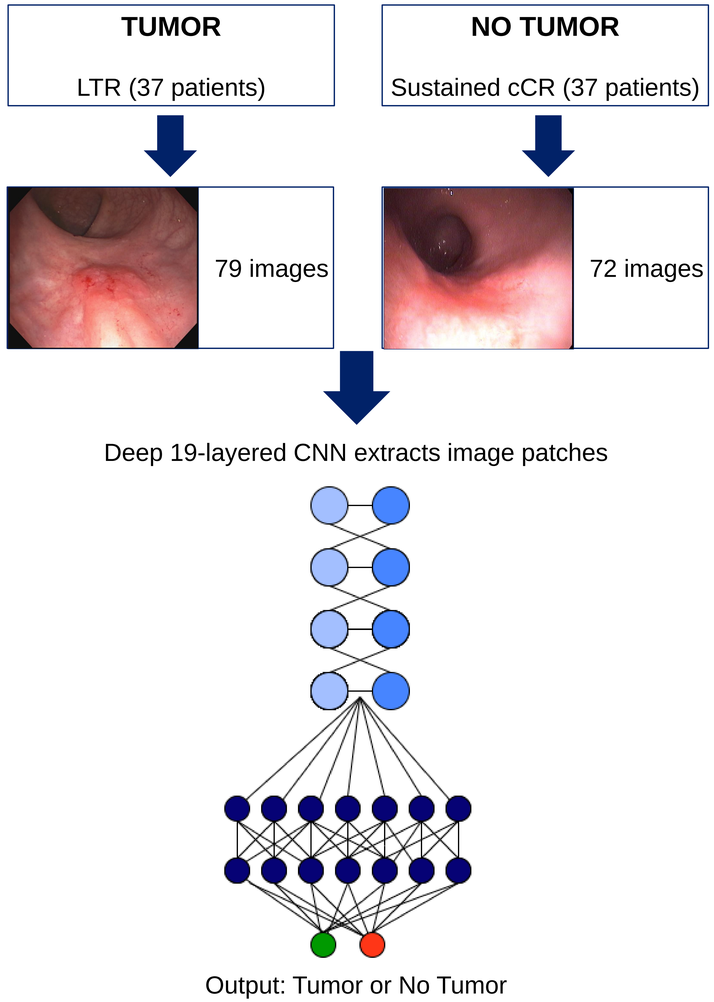
Developing a model that recognizes the subtle mucosal changes seen during local tumor regrowth (LTR) is critical for the clinical application of any CNN, as close to 30% of WW patients experience regrowth during surveillance.[3] This study evaluates a CNN model's ability to identify tumor among non-overlapping endoscopic images of WW patients with LTR.

Methods

Clinical and endoscopic data from our institution were retrospectively collected for patients with stage II/III rectal cancer treated with total neoadjuvant therapy (TNT) between 2013-2020. LTR was defined as a tumor with a cCR to TNT and subsequent local regrowth during WW. Images were presented as two distinct test sets to a deep, 19-layered CNN model trained using three-fold cross-validation to distinguish between the presence and absence of tumor

The first test set included images of LTR and images from a matched negative control group of patients with a sustained cCR for 2 years after TNT (Figure 1). The groups were matched by TNT regimen (induction or consolidation) and time from restaging to endoscopic assessment. Sensitivity, specificity, negative predictive value, positive predictive value and accuracy were calculated to evaluate the model's performance. The second test set consisted of images from LTR patients taken by the surgeon at the endoscopic assessment directly preceding diagnosis of local regrowth.

Figure 1: Test set of patients with local tumor regrowth



Results

The first test set consisted of 152 images taken from 74 patients, with 37 in each cohort. 83.7% of patients in each group received induction TNT. Images from LTR diagnosis were taken at a median of 288 days after restaging, compared to 283 days in the sustained cCR cohort.

Table 1: CNN performance in detecting local tumor regrowth

Sensitivity	Specificity	PPV	NPV	Accuracy
0.78	0.71	0.75	0.75	0.75

Images from the endoscopic exam prior to regrowth were taken at a median of 3.9 months before diagnosis. At this time, surgeons documented suspicious endoscopic findings for 8 patients. The model identified tumor in images from 75% (n=6) of these patients.

Conclusions

Our model showed a promising ability to correctly classify subtle mucosal changes as LTR, with an accuracy of 0.75. The CNN also demonstrated a potential to detect concerning features several months before a definitive diagnosis. Machine learning models need further refinement before they are appropriate for use in clinical practice. To improve our model, we plan to incorporate Bayesian learning, enhance performance by introducing endoscopic videos to the training pipeline and improve overall representation learning by using a multi-time step analysis.

References

[1]Thompson H, Kim JK, Jimenez-Rodriguez R et al. Deep learning-based model for identifying tumors in endoscopic images from patients with locally advanced rectal cancer treated with total neoadjuvant therapy. *Dis Colon Rectum.* 2022; 66(3): 383-391.

[2]Haak HE, Gao X, Maas M et al. The use of deep learning on endoscopic images to assess the response of rectal cancer after chemoradiation. *Surg Endosc.* 2022; 36(5):3592-3600

[3]Garcia-Agular J, Patil S, Gollub MJ et al. Organ preservation in patients with rectal adenocarcinoma treated with total neoadjuvant therapy. *J Clin Oncol.* 2022; 40(23): 2546-2556.