SIIM CMIMI24
Oct 21-22 | Boston, MA
Conference On Machine Intelligence In Medical Imaging

Advancing Endometriosis Detection: A Deep Learning-Enhanced multi-sequence MRI Analytical Model

Mana Moassefi, MD, Mayo Clinic – Rochester; Wendaline VanBuren, MD; Bradley J. Erickson, MD, PhD, CIIP, FSIIM; Shahriar Faghani, MD

Introduction/Background

Endometriosis, a condition characterized by the growth of endometrial-like tissue outside the uterus, affects 5-10% of women of reproductive age. Despite its prevalence, the diagnosis of endometriosis through imaging remains challenging due to the complex anatomy of the pelvis and heterogeneity of the disease itself on imaging, which requires expertise. Advances in deep learning (DL) are revolutionizing the diagnosis and management of complex medical conditions, promoting patient-centered treatment.

Methods/Intervention

We gathered a patient cohort from our institutional database, composed of patients with pathologically confirmed endometriosis from 2015 to 2024. We selected gynecologic MRIs performed within three months prior to diagnostic surgery. We also created an age-matched control group that underwent a similar MR protocol but without a diagnosis of endometriosis. We used sagittal T1-weighted (T1) pre- and post-contrast, as well as T2-weighted (T2) MRIs. We split our dataset at the patient-level and allocated one-eighth of the dataset for testing and conducted seven-fold cross-validation on the remainder. MR images were analyzed using various convolutional neural network (CNN) architectures. Simultaneously, two abdominal radiologists with experience in endometriosis MRI and complex surgical planning and one women's imaging fellow with specific training in endometriosis MRI reviewed a random selection of images and documented their endometriosis detection.

Results/Outcome

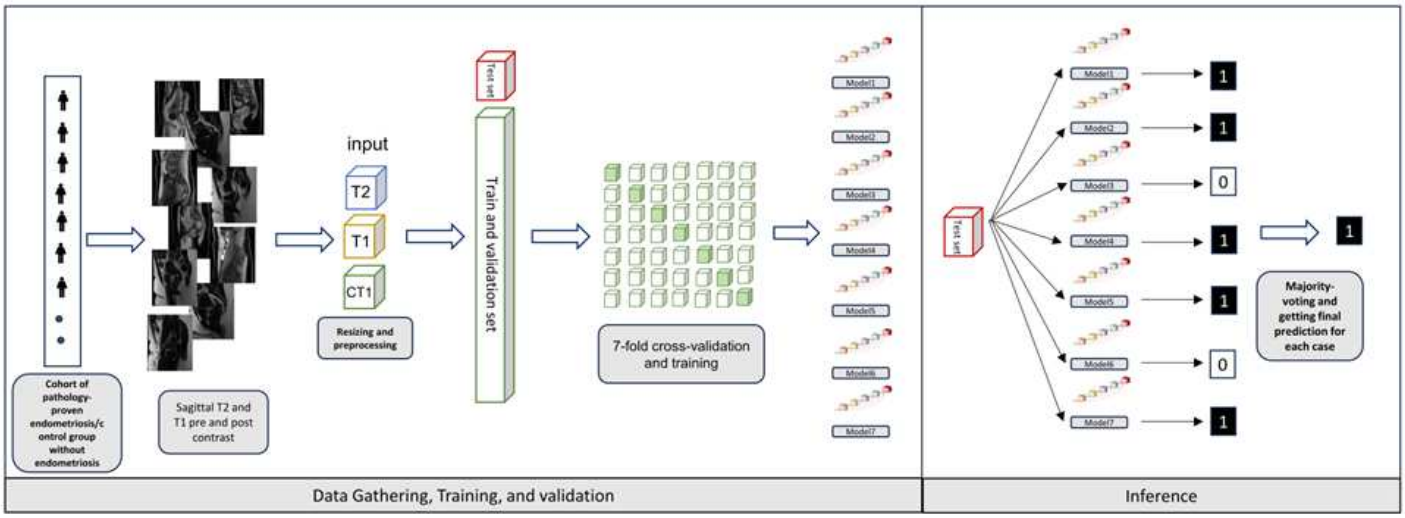
751 patients were included in the case and control groups. The final 3D-DenseNet-121 classifier model demonstrated robust performance. Our findings indicated the most accurate predictions were obtained using T2, T1 pre- and post-contrast. Testing on our test set using ensemble technique resulted in an F1 Score of 0.911, AUROCC of 0.881, sensitivity of 0.976, and specificity of 0.720. Our radiologist readers achieved 72.2% and 78.5% sensitivity without and with AI assistance in detecting endometriosis.

Conclusion

The study introduced the first DL model to use multi-sequence MRI on a large cohort, showing results equivalent to human detection in trained readers in identifying endometriosis. Further external validation of the model is in progress.

Statement of Impact

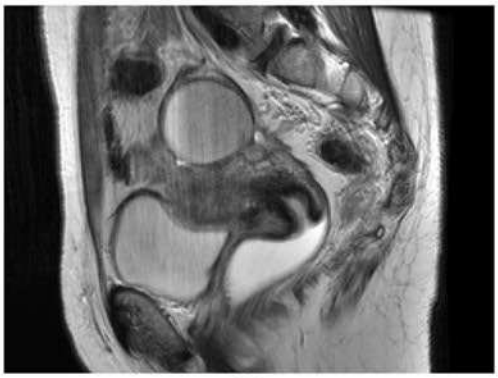
We aim to evaluate DL tools in enhancing the accuracy of multi-sequence MRI-based detection of endometriosis in daily practice.



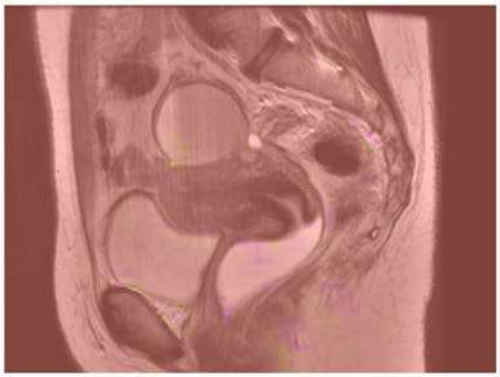
Study pipeline.

The table presents the results of the 7-fold cross-validation and the test set evaluations. area under the ROC curve (AUROCC)

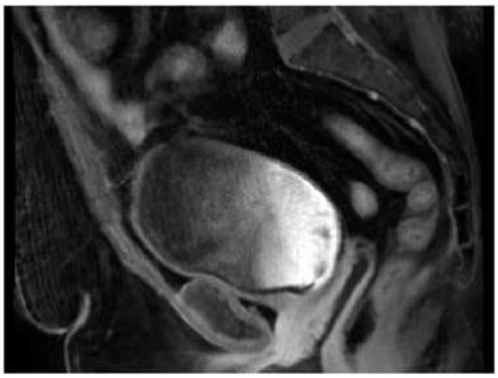
	T2				T2 and T1 Pre-Contrast				T1 Pre and Post Contrast				T2, T1 Pre and Post Contrast			
Fold	**AUROCC**	**F1**	**Sensitivity**	**Specificity**	**AUROCC**	**F1**	**Sensitivity**	**Specificity**	**AUROCC**	**F1**	**Sensitivity**	**Specificity**	**AUROCC**	**F1**	**Sensitivity**	**Specificity**
1	0.791	0.772	0.776	0.549	0.790	0.672	0.667	0.761	0.832	0.800	0.909	0.645	0.912	0.897	0.953	0.800
2	0.921	0.892	0.895	0.661	0.833	0.667	0.714	0.864	0.922	0.880	0.886	0.871	0.814	0.794	0.837	0.720
3	0.703	0.650	0.885	0.772	0.882	0.781	0.769	0.813	0.908	0.824	0.767	0.903	0.843	0.823	0.837	0.800
4	0.781	0.750	0.917	0.776	0.859	0.601	0.615	0.629	0.882	0.864	0.860	0.871	0.955	0.912	0.884	0.960
5	0.802	0.772	0.885	0.442	0.828	0.690	0.681	0.758	0.918	0.905	0.930	0.871	0.888	0.882	0.930	0.800
6	0.840	0.792	0.776	0.791	0.911	0.813	0.834	0.812	0.918	0.864	0.814	0.935	0.834	0.779	0.791	0.760
7	0.828	0.772	0.669	0.648	0.868	0.847	0.850	0.850	0.912	0.864	0.818	0.933	0.807	0.776	0.698	0.917
Mean	0.809	0.771	0.829	0.662	0.853	0.724	0.733	0.783	**0.898**	**0.792**	**0.854**	**0.861**	0.865	0.754	0.847	0.822
STD	0.066	0.070	0.090	0.131	0.039	0.089	0.088	0.079	0.032	0.041	0.058	0.099	0.055	0.055	0.087	0.085
Test Set	0.746	0.704	0.821	0.513	0.856	0.738	0.824	0.713	0.835	0.825	0.909	0.566	**0.881**	**0.911**	**0.976**	**0.720**



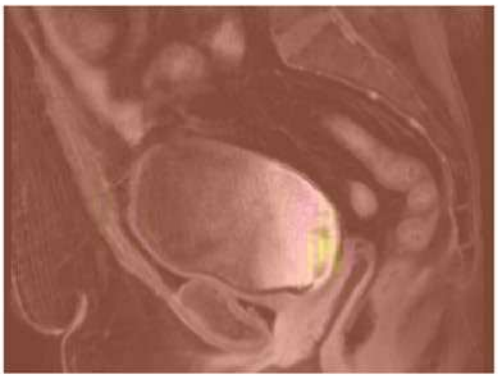
A1



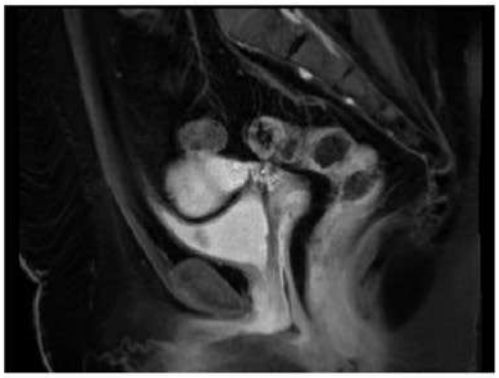
A2



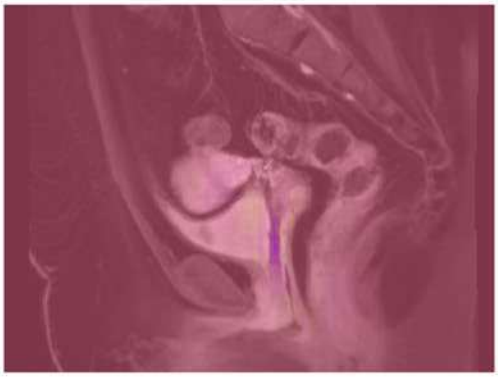
B1



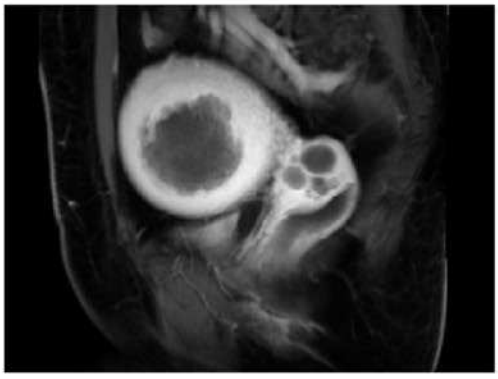
B2



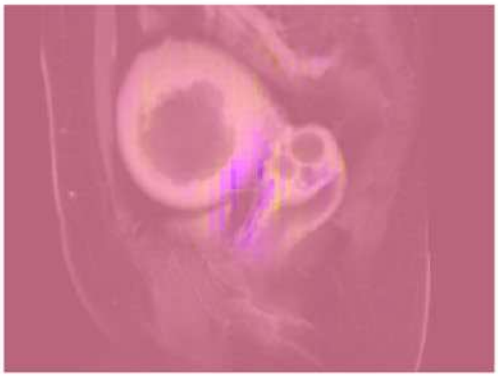
C1



C2



D1



D2

A1 is a sagittal T1 post-gadolinium slice of a patient with endometriosis, and A2 is the same slice with an overlaid occlusion map. The model correctly predicted this case as endometriosis positive. The yellow areas in the map represent pixels that influenced the model's decision toward diagnosing endometriosis. B1 is a sagittal T1 post-gadolinium slice of a patient without endometriosis, and B2 is the same slice with an overlaid occlusion map. The model correctly predicted this case as endometriosis negative. The purple areas in the map represent pixels that influenced the model's decision toward diagnosing the absence of endometriosis. The focus area can vary since there are different cases in the non-endometriosis cohort of our study.

Keywords
Endometriosis; Magnetic Resonance Imaging; Deep Learning