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Multi-Center Validation of Artificial Intelligence-Based Video Analysis Platform for Automatic Evaluation of Swallowing Disorders

So Hee Lee[1], Chang-Won Jeong[2], Dong-Wook Lim[2], Si-Hyeong Noh[2], Hee-Kyung Moon[3], Chul Park[4], Nayeon Ko[5], Min-Su Kim[1]

[1]Department of Rehabilitation Medicine, Chungbuk National University Hospital [2]STSC center, Wonkwang University, [3]Institute for Educational Innovation, Wonkwang University, [4]Department of Internal Medicine, Ulsan Univeristy Hospital, [5]Deparment of Rehabilitation Medicine, Soonchunghyang University Seoul Hospital,

Introduction

- Videofluoroscopic swallow study (VFSS) is the gold standard for evaluating swallowing disorders.

VFSS interpretation requires time-consuming frame-by-frame analysis and may vary depending on the examiner's experience.

Recent studies have applied AI to VFSS interpretation, but most models require manual frame selection and lack external validation.

Therefore, we developed an AI model that automatically analyzes **entire VFSS videos** and performed **multi-center external validation**

Methods

- AI model was developed using **YOLOv9 object detection architecture** to automatically detect swallowing events in VFSS videos.
- VFSS videos were preprocessed into multi-frame sequences and input into the model.
- A total of **309 VFSS videos** from Wonkwang University Hospital were used for model development and internal validation
- External validation was performed using **138 VFSS videos** collected from two independent institutions

Training dataset

- 309 VFSS videos (Q1)
- Wonkwang University Hospital

Split into

Training: 216 cases

Validation: 31 cases

Test: 62 cases

External validation dataset

- 138 VFSS videos (Q1)
- Soonchunhyang University Hospital
- Ulsan University Hospital

- The model classified swallowing events into **aspiration, penetration, no airway invasion.**

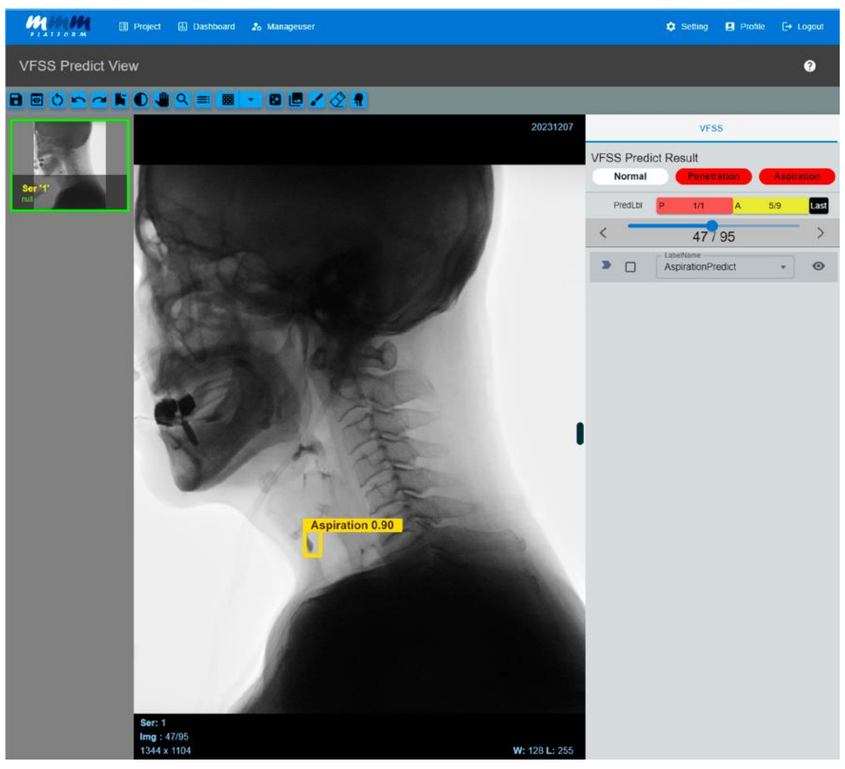

Figure 1. Multi-frame medical image-labeling web application.

Results

Internal Validation

- A total of 309 Q1-quality VFSS videos were used for model development.
- During internal validation, the YOLOv9_c model demonstrated reliable performance in detecting airway invasion events.

Training accuracy	Validation accuracy	Test accuracy
98.1%	**97.8%**	**61.5%**

- Confusion matrix analysis showed:
  Aspiration detection accuracy of 0.76 (AUC=0.70)
  Penetration detection accuracy of 0.66 (AUC=0.65)

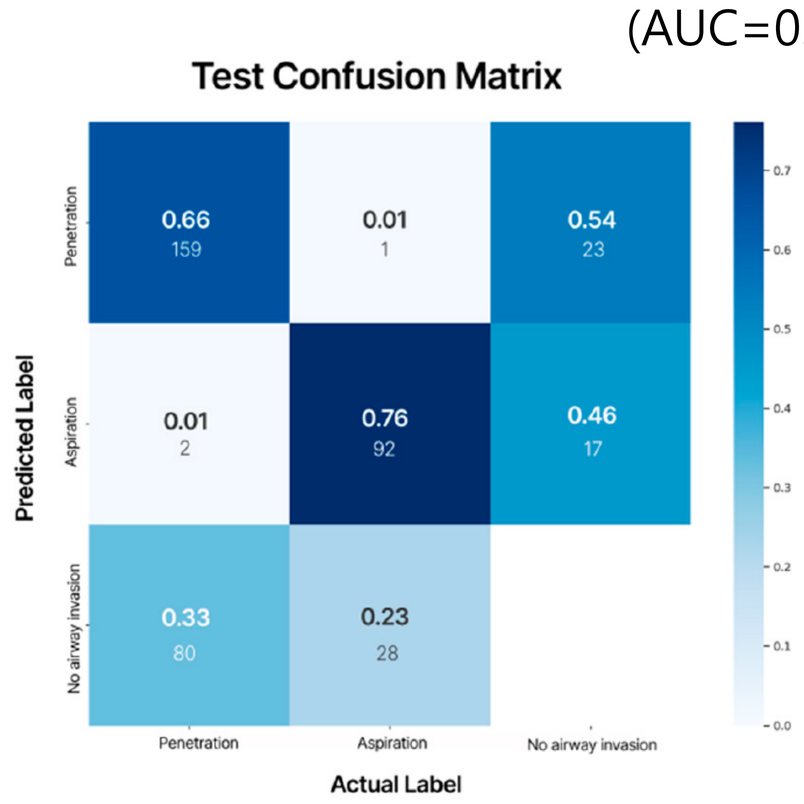

Figure 2. Confusion matrix of the AI model for aspiration and penetration detection.

External Validation

- External validation was performed using 138 VFSS videos from two independent hospitals.
- The AI model achieved an overall **diagnostic accuracy of 80.4%**, demonstrating stable performance across different clinical datasets.

Aspiration Detection	Penetration Detection	No airway Invasion
90.2% (AUC=0.79)	**78.3%** (AUC=0.80)	**63.3%** (AUC=0.82)

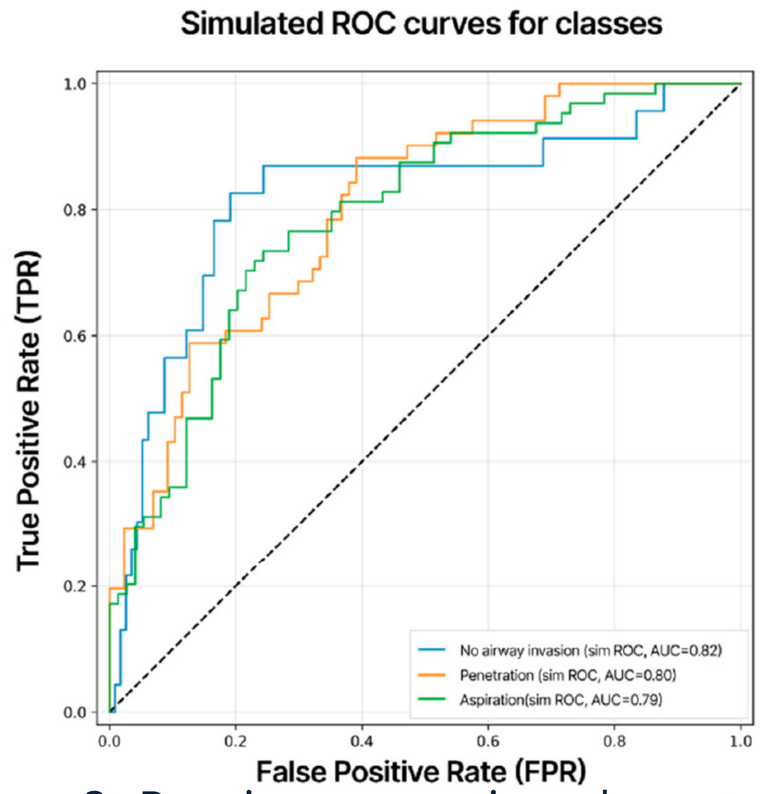

Figure 3. Receiver operating characteristic (ROC) curves of the AI model.

Conclusions

- The developed **YOLOv9-based AI system automatically analyzes entire VFSS videos without additional conversion or preprocessing, and accurately detects aspiration and penetration.**
- Our VFSS AI model showed **high diagnostic accuracy on external multi-center data**, indicating strong generalizability and clinical utility.

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