



EP08.02. AI-based three-dimensional visualization of pulmonary venous–left atrial connections in fetal cardiac ultrasound screening

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Objectives:

Total anomalous pulmonary venous connection (TAPVC) is a severe congenital heart defect with low prenatal detection rates. Accurate diagnosis requires visualization of the pulmonary venous–left atrial (PV–LA) connection. We developed a deep learning–based approach for automated 3D segmentation, reconstruction, and detection of the PV–LA connection.

Methods:

Dataset:

Fetal cardiac ultrasound sweep videos

- Normal fetuses: 100 cases, mean 20 weeks (19–30)
- TAPVC fetuses: 6 cases, mean 26 weeks (20–33)

Training dataset

Normal fetuses

7,079 Labeled Images
(100 videos / 94cases)
5-fold cross-validation

Annotation

9,061 still images
from ultrasound videos
manual annotation of
PV and LA

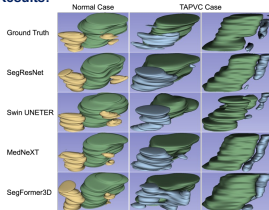
Segmentation models

3D deep learning models
SegResNet
Swin UNETR
MedNeXt
SegFormer3D

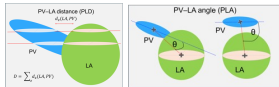
Evaluation metrics

1. Automatic Visualization of PV–LA Connections
2. Quantitative PV–LA connection indices
 - PV–LA distance (PLD)
 - PV–LA angle (PLA)

Results:



Automatic Visualization of PV–LA Connections



Model	PLD		PLA	
	Normal Mean $\pm$ SD	TAPVC Mean $\pm$ SD	Normal Mean $\pm$ SD	TAPVC Mean $\pm$ SD
SegResNet	1.19 $\pm$ 0.28	1.31 $\pm$ 0.29	38.6 $\pm$ 15.8	57.4 $\pm$ 9.26
Swin UNETR	1.78 $\pm$ 2.43	4.22 $\pm$ 6.10	43.2 $\pm$ 16.0	51.1 $\pm$ 12.0
MedNeXt	1.23 $\pm$ 0.42	5.15 $\pm$ 9.35	40.6 $\pm$ 18.8	48.2 $\pm$ 15.7
SegFormer3D	1.94 $\pm$ 2.75	2.07 $\pm$ 1.37	47.3 $\pm$ 13.0	43.4 $\pm$ 13.2

Quantitative PV–LA connection indices

- The MedNeXt model showed the best performance for PLD (AUC: 0.844)
- The SegResNet model showed the best performance for PLA (AUC: 0.840)

Conclusions:

This 3D deep learning system has the potential to support automated screening and improve prenatal detection of TAPVC.