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Comparaison de fonctions de coût pour la détection automatique de fil guide sur des images fluoroscopiques de Cholangiopancréatographie Rétrograde Endoscopique

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Comparison of Loss Functions for Guidewire Automatic Detection on a Limited Dataset of Fluoroscopic Images for Endoscopic Retrograde CholangioPancreatography

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MEDICAL CONTEXT

Endoscopic Retrograde CholangioPancreatography (ERCP)

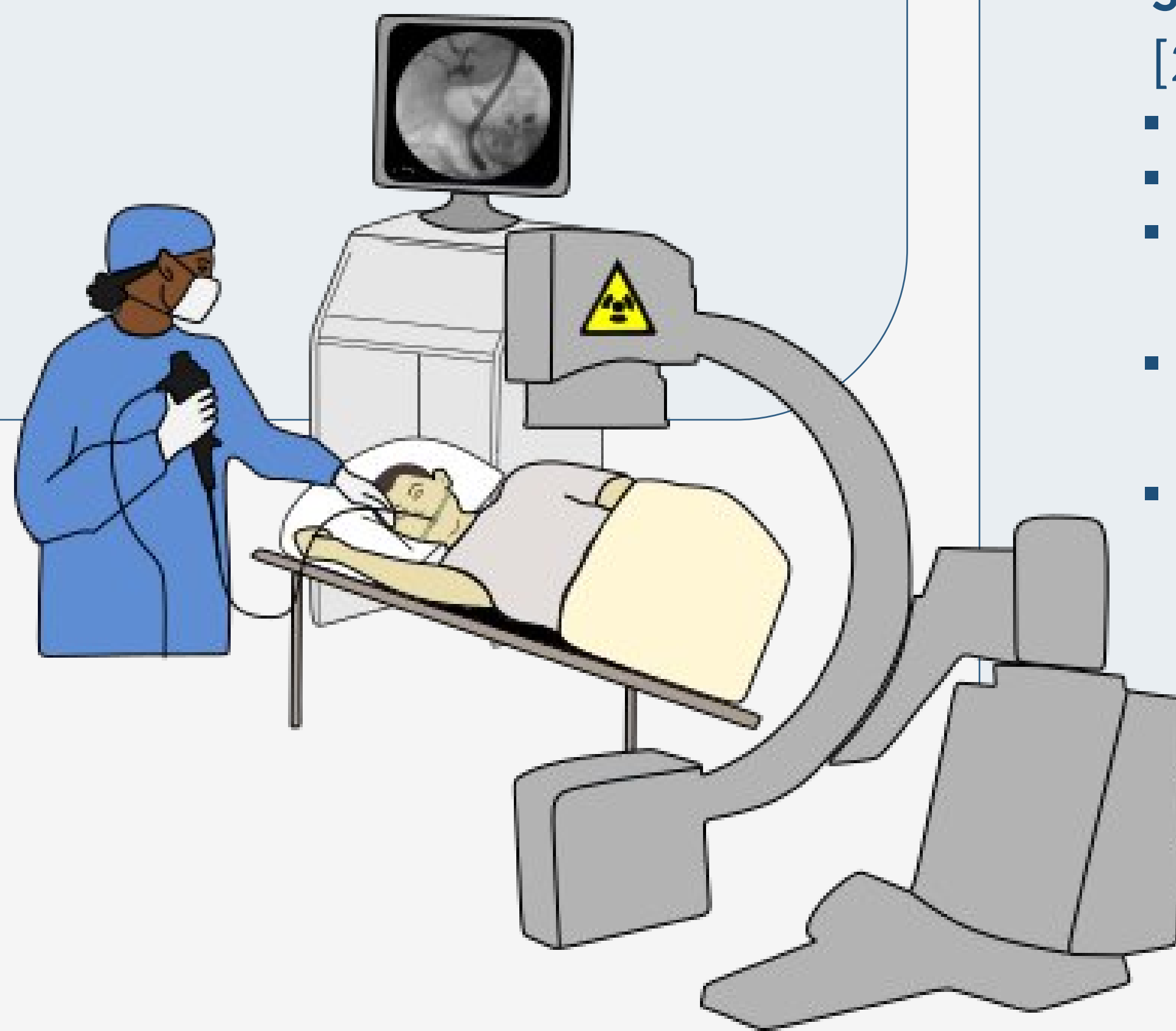
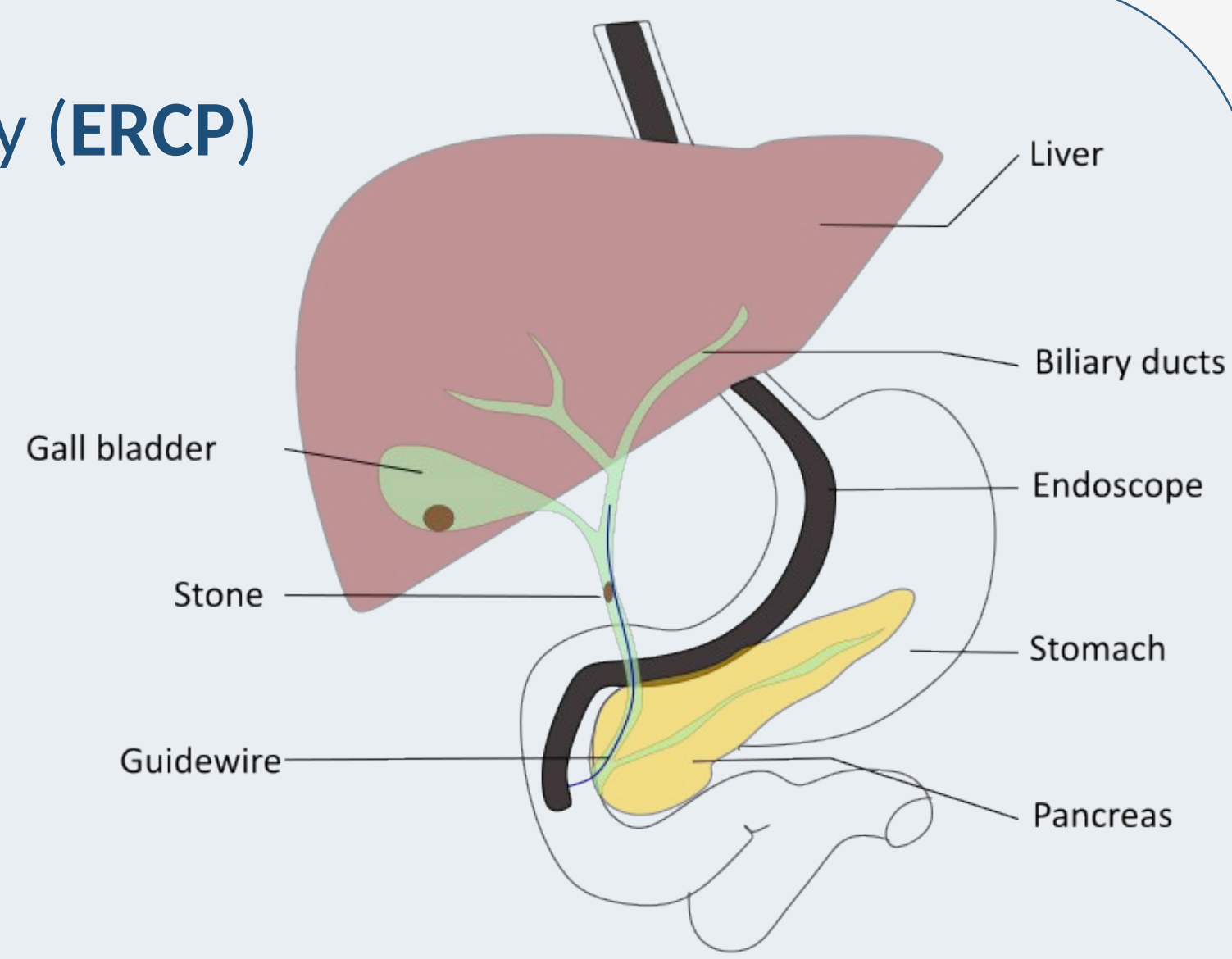
- Draining of the bile ducts
- Minimally invasive procedure

Problems

- High inter-patient anatomical variability
- Loss of 3D information with 2D X-ray
- Contrast agent increases the risk of cholangitis

State of the art

- None in ERCP
- Similar field: Endovascular (different images)
- U-Net paired with another method



METHODS

2 Datasets :

- Saint-Antoine (SA)
- Henri Mondor (HM)

Dataset	Image Size	Total nb of images	Train	Validation	Test
SA	1024 x 1024	47	31	6	10
HM	1536 x 1536	73	50	13	10

- Baseline: nnU-Net [1]
- Study of different loss functions with U-Net [2]
 - Dice
 - Dice + Cross Entropy
 - Tversky [3]
 - Weight differently false positives and false negatives
 - Dice + Focal [4]
 - Adapted for class imbalance
 - Dice + Vessel [5]
 - Adapted for segmentation of thin and elongated structures

Training

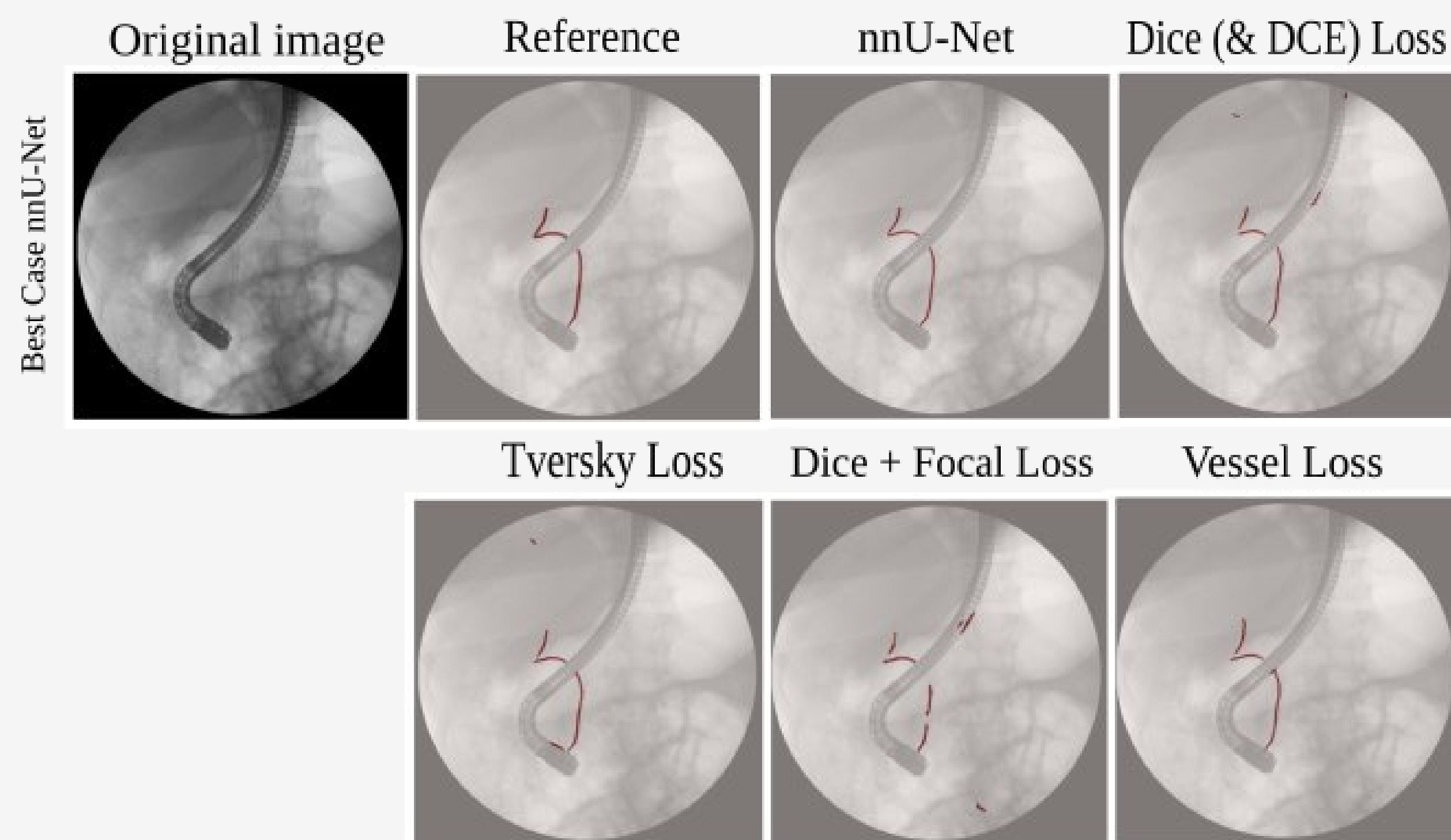
- 3-fold cross-validation
- SA dataset, 500 epochs
- HM dataset pretrained on SA

OBJECTIVES

To segment the guidewire on 2D X-ray fluoroscopy with a limited dataset with varied loss functions

RESULTS

Saint-Antoine Dataset

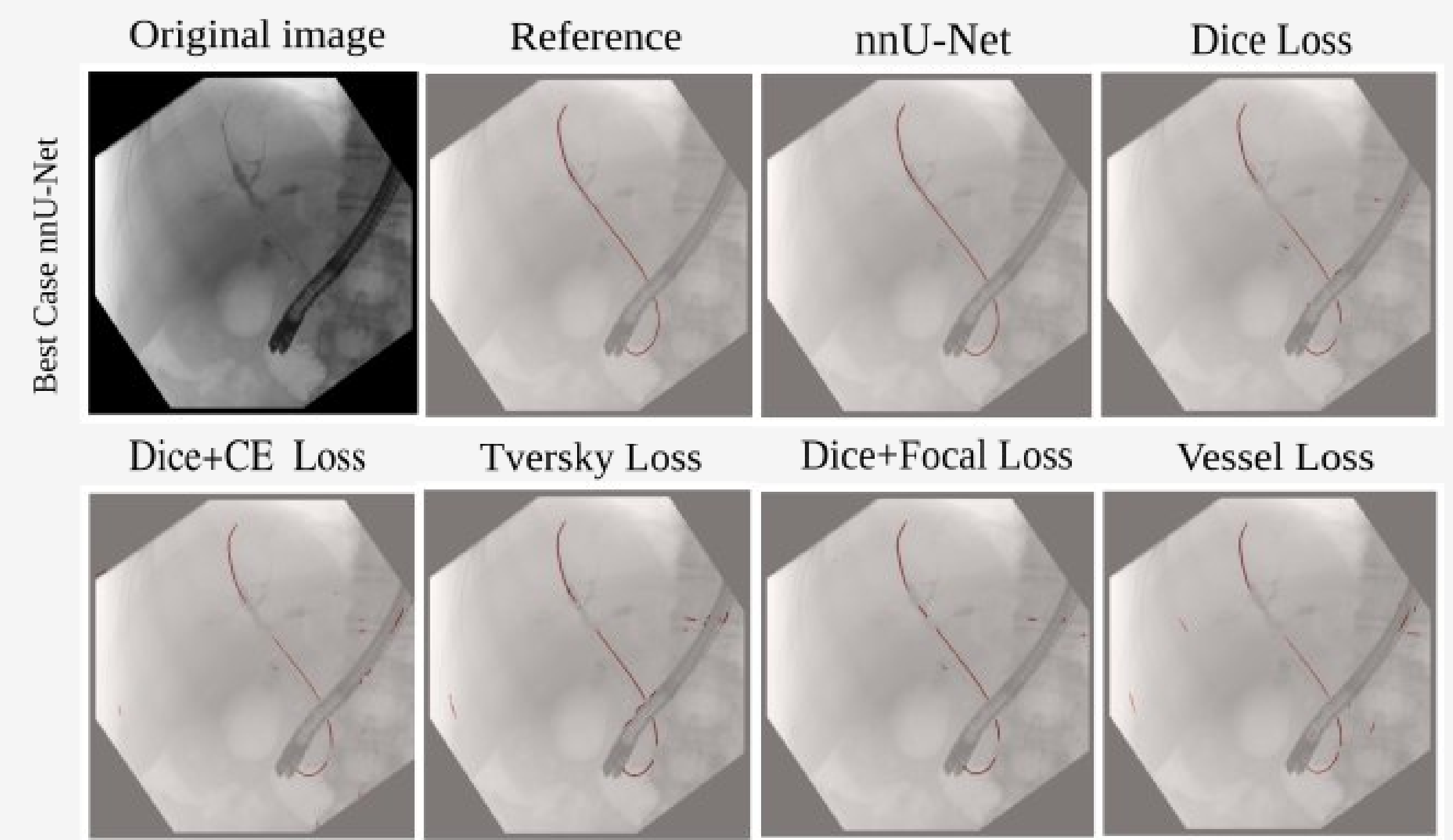


METHOD	DICE	CIDice	TVERSKY	MCC	HD	Diff CC
nnU-Net [1]	0.78 ± 0.04	0.94 ± 0.05	0.74 ± 0.05	0.89 ± 0.02	25 ± 28	1
Dice/Dice + CE	0.59 ± 0.06	0.69 ± 0.09	0.57 ± 0.04	0.80 ± 0.03	336 ± 107	6
Tversky	0.65 ± 0.03	0.76 ± 0.03	0.61 ± 0.03	0.83 ± 0.01	233 ± 45	3
Dice + Focal	0.66 ± 0.03	0.74 ± 0.01	0.64 ± 0.02	0.83 ± 0.01	271 ± 48	4
Dice + Vessel	0.61 ± 0.04	0.72 ± 0.05	0.57 ± 0.03	0.81 ± 0.02	242 ± 71	4

For nnU-Net: Training time = 33 hours & Inference time = 6.2s/ image

For any U-Net with specific loss function: Training time = 3 hours & Inference time = 0.69s/ image

Henri Mondor Dataset



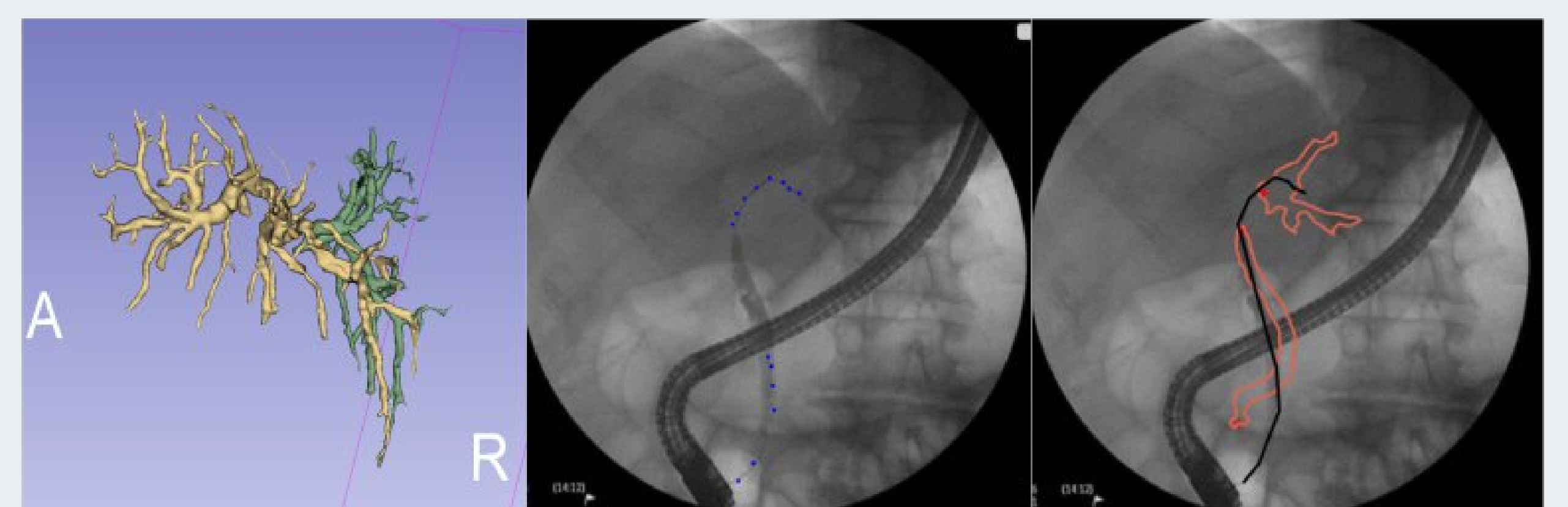
METHOD	DICE	CIDice	TVERSKY	MCC	HD	Diff CC
nnU-Net [1]	0.79 ± 0.05	0.90 ± 0.05	0.79 ± 0.05	0.89 ± 0.03	92 ± 215	2
Dice	0.64 ± 0.04	0.72 ± 0.06	0.60 ± 0.08	0.83 ± 0.02	408 ± 5	6
Dice + CE	0.65 ± 0.01	0.75 ± 0.04	0.63 ± 0.02	0.82 ± 0.01	625 ± 183	7
Tversky	0.58 ± 0.01	0.70 ± 0.05	0.58 ± 0.02	0.79 ± 0.02	619 ± 43	8
Dice + Focal	0.62 ± 0.03	0.70 ± 0.03	0.60 ± 0.04	0.81 ± 0.01	376 ± 40	6
Dice + Vessel	0.61 ± 0.01	0.69 ± 0.01	0.59 ± 0.01	0.81 ± 0.01	582 ± 72	8

For nnU-Net: Training time = 52 hours & Inference time = 9.4 s/ image

For any U-Net with specific loss function: Training time = 4.5 hours & Inference time = 0.98 s/ image

CONCLUSION & CLINICAL APPLICATION

- Simple and well known method
- Comparison of multiple loss functions
- Reduce training and inference time by 10
- Result of segmentation usable for 2D/3D fusion to predict in which bile duct the guidewire is and improve navigation



References

[1] Isensee, *Nature Methods*, 2020 [2] Ronneberger, *MICCAI*, 2015 [3] Salehi, *MICCAI*, 2017 [4] Lin, *ICCV*, 2017 [5] La Barbera, *Medical Image Analysis*, 2023