Prediction of Urinary Continence Recovery Using Artificial Intelligence/Computer Vision Analysis of Intraoperative Robotic-Assisted Radical Prostatectomy Video Recordings

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Purpose:

The objective of this study was to develop an AI algorithm to predict post-RARP surgery continence recovery using only intraoperative video.

Methods:

We selected a group of 50 patients with localized prostate cancer who underwent RARP surgery from a single surgeon (VP). 25 patients had “early” recovery of urinary continence outcomes, defined as not requiring urinary protection pads six weeks post-surgery and beyond. The remaining 25 patients had "prolonged" urinary incontinence, defined as still needing four or more urinary pads per day 12 months after the surgical procedure. For each patient, a set of 7 video segments were extracted from their intraoperative video.

Those segments were defined as follows;

1. Before anterior bladder-neck dissection
2. Following posterior bladder-neck dissection
3. Following incision of Denonvillier’s fascia and posterior dissection/nerve sparing
4. Following apical dissection
5. Following bladder-neck reconstruction
6. Following urethral posterior reconstruction
7. Following urethrovesical anastomosis

Different combination of video segments were analyzed: 5&7, 3&5&7, 3&4&5&7, and All 7 segments.

Four different feature extractor DL models were evaluated:

1. ResNet: Pre-trained on ImageNet
2. RetCCL: Pre-trained CNN on TCGA H&E WSIs
3. TransPath: Pre-trained CNN on histology datasets
4. ViT: Vision Transformer pre-trained on histology datasets

Results:

We evaluated the performance of the developed system using well-established evaluation metrics in a K-fold cross-validation setting based on patient stratification. Our method demonstrate an 84% accuracy, 83% F1 score, 88.0% specificity, and 80% sensitivity for predicting a binary outcome of whether a patient achieves “early” continence or “prolonged” incontinence (Figure 1 and Figure 2).

Figure 1. Single classifier performance.

Classification Head	Video Segments	Feature Extractor	Classification Accuracy (%)	Sensitivity (%)	Specificity (%)	F1 Score (%)
Transformer Architecture	5 & 7	RetCCL	64	56	72	60
		ResNet	60	60	60	6
		TransPath	68	72	64	69
		ViT	66	72	60	68
	3 & 5 & 7	RetCCL [1]	**74**	**72**	**76**	**73**
		ResNet	62	68	56	64
		TransPath	58	60	56	59
		ViT	**76**	**72**	**80**	**75**
	3&4&5&7	RetCCL	**74**	**68**	**80**	**72**

Figure 2. Majority voting performance Using three best performing models for majority voting and final prediction.

Classification Head	Video Segments	Feature Extractor	Classification Accuracy (%)	Sensitivity (%)	Specificity (%)	F1 Score (%)
Transformer Architecture	3&5&7	RetCCL	**84**	**80**	**88**	**83**
		ViT				
	3&4&5&7	RetCCL				

Conclusion

These initial results demonstrate that using AI algorithms and surgical video to objectively evaluate and predict continence recovery outcomes following RARP is feasible and promising. Further research is required with large data set and external validation.