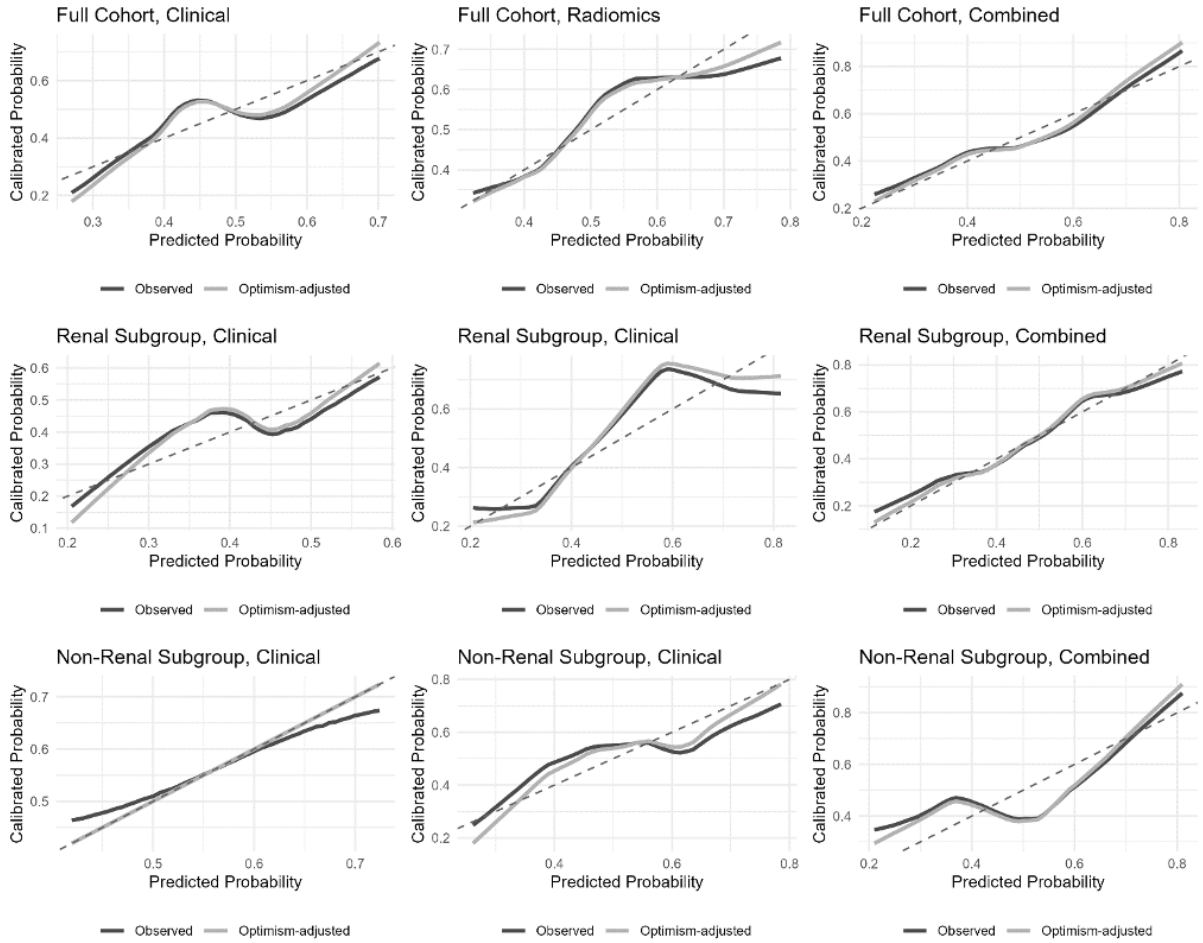
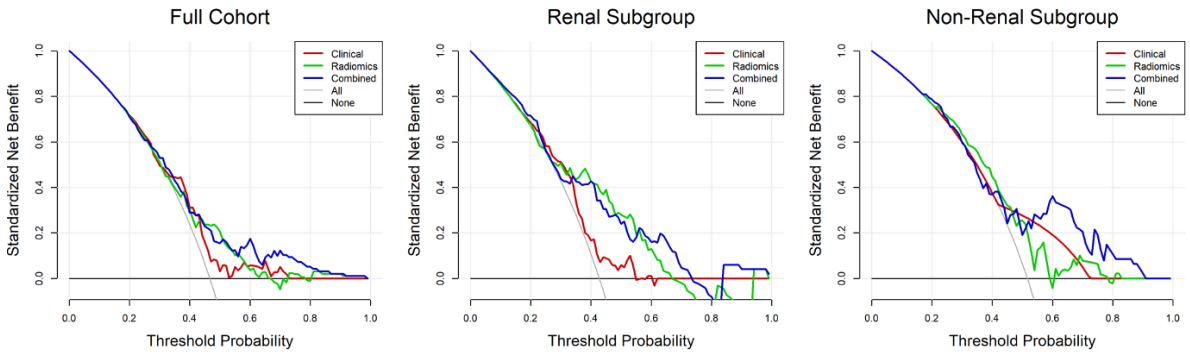
Nguyen et al. Development of a reoperative risk prediction model of muscle-invasive upper tract urothelial carcinoma using clinical and radiomic computed tomography features: Initial results from a multi-institutional, Canadian study

APPENDIX

Supplementary Figure 1. Calibration plots for clinical, radiomics, and combined models for the overall cohort, renal pelvis subgroup, and non-renal subgroup.



Supplementary Figure 2. Decision curve analysis for clinical, radiomics, and combined models for the overall cohort, renal pelvis subgroup, and non-renal subgroup.



Supplementary Table 1. Characteristics of patients with cancer in the renal pelvis		
Variable	**<pT2 (n=67, %)**	**≥pT2 (n=50, %)**
Age, mean (SD)	71.2 (10.7)	74.3 (9.8)
Sex (female)	22 (33.3%)	18 (36.0%)
Missing	1	0
Smoking history		
Non-smoker	25 (38.5%)	24 (49.0%)
Active smoker/quit <1 year	20 (30.8%)	8 (16.3%)
Quit ≥1 year	20 (30.8%)	17 (34.7%)
Missing	2	1
BMI, mean (SD)	27.8 (5.4)	26.6 (7.6)
Missing	13	10
Prior bladder cancer	15 (22.4%)	5 (10.0%)
pT stage		
pTa	39 (58.2%)	0 (0%)
pTis	2 (3.0%)	0 (0%)
pT1	26 (38.8%)	0 (0%)
pT2	0 (0%)	9 (18.0%)
pT3	0 (0%)	35 (70.0%)
pT4	0 (0%)	6 (12.0%)
URS grade - high	8 (28.6%)	13 (81.2)
CT cancer size, mean (SD)	23.7 (16.4)	32.8 (22.8)
Clinical stage		
cTa	9 (18.8%)	2 (5.0%)
cT0	3 (6.2%)	0 (0.0%)
cT1	23 (47.9%)	7 (17.5%)
cT2	7 (14.6%)	7 (17.5%)
cT3	4 (8.3%)	23 (57.5%)
cTx	2 (4.2%)	1 (2.5%)

Supplementary Table 2. Characteristics of patients with cancer located outside the renal pelvis		
Variable	**<pT2 (n=44, %)**	**≥pT2 (n=47, %)**
Age, mean (SD)	71.7 (9.2)	74.3 (10.1)
Sex (female)	17 (38.6%)	15 (31.9%)
Smoking history		
Non-smoker	14 (31.8%)	17 (36.2%)
Active smoker/quit <1 year	14 (31.8%)	10 (21.3%)
Quit ≥1 year	16 (36.4%)	20 (42.6%)

BMI, mean (SD)	27.5 (5.4)	27.1 (5.4)
Missing	6	5
Prior bladder cancer	19 (43.2%)	20 (42.6%)
pT Stage		
pTa	28 (63.6%)	0 (0%)
pTis	4 (9.1%)	0 (0%)
pT1	12 (27.3%)	0 (0%)
pT2	0 (0%)	16 (34.0%)
pT3	0 (0%)	29 (61.7%)
pT4	0 (0%)	2 (4.3%)
URS grade - high	7 (35.0%)	11 (68.8%)
CT cancer size, mean (SD)	20.0 (17.3)	22.5 (13.4)
Missing	14	11
Clinical stage		
cT0	2 (6.2%)	0 (0%)
cT1	11 (34.4%)	13 (39.4%)
cT2	11 (34.4%)	6 (18.2%)
cT3	4 (12.5%)	11 (33.3%)
cTx	2 (6.2%)	0 (0%)
Missing	12	14

Supplementary Table 3. Description of retained radiomic features

Retained radiomic feature	Description
Original shape: Flatness	A shape feature that measures the inverse flatness of the tumor's 3D geometry, calculated as a ratio of its principal axes. Values closer to 0 indicate a flattened lesion, often reflecting tumor growth along the collecting system. Values approaching 1 correspond to a more spherical shape, suggestive of wall invasion and a rounded lesion.
Original shape: Surface:volume ratio	A shape feature that measures the tumor's surface area relative to its volume. A higher ratio indicates a more irregular, complex surface — possibly linked to aggressive behavior.
Original: GLCM: MCC	A second-order texture feature from Gray Level Co-occurrence Matrix capturing intricate gray-level dependencies within the tumor. Higher values suggest more complex tissue architecture, which may correlate with biologically aggressive tumors, but may be affected by contrast in the collecting system at the boundary of tumors.
Original: NGTDM: Contrast/busyness	These Neighborhood Gray Tone Difference Matrix features assess local intensity differences: contrast reflects how much a voxel deviates from its neighbors, while busyness captures

	abrupt intensity changes—both indicate heterogeneity. This may be affected by contrast in the collecting system at the boundary of tumors or affected by the shape of the tumor.
Original: First-order: Skewness	A first order parameter that describes asymmetry in the distribution of voxel intensities. A skewed distribution may indicate areas uneven tissue composition reflecting heterogeneity. This may be affected by contrast in the collecting system at the boundary of tumors or affected by the shape of the tumor.
Original GLSZM: Gray-level non-uniformity	Measures variability in the size of gray-level zones — higher values reflect irregular signal patterns, suggesting heterogeneous tissue composition. This may be affected by contrast in the collecting system at the boundary of tumors or affected by the shape of the tumor
Radiomics score	An aggregated index combining selected radiomic features into a single predictive metric.