

Prospective Validation of Intraoperative ICGA Perfusion Thresholds for Predicting Wound Complications Following Resection of Preoperatively Irradiated Soft Tissue Sarcoma

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Significance & Hypothesis/Techniques

Wound complications (WC) remain a primary source of surgical morbidity following the resection of preoperatively irradiated soft tissue sarcomas (STS). While intraoperative indocyanine green angiography (ICGA) allows for real-time assessment of tissue perfusion, its clinical utility is currently limited by a lack of prospectively validated objective thresholds. This study aims to prospectively evaluate previously derived relative perfusion ratios (Inflow threshold = 0.62; Peak threshold = 0.55) to assess their predictive performance for 90-day complications and their incremental value beyond standard clinical risk factors.

Innovation

This study represents a transition from descriptive ICGA use to a validated, quantitative approach in orthopedic oncology. By testing specific numerical thresholds (Inflow and Peak ratios) within a prospective cohort, this research seeks to move beyond subjective "eyeball" assessments of fluorescence toward an objective, data-driven protocol for intraoperative decision-making.

Approach (Materials & Methods)

This study analyzed 41 patients (14 retrospective; 27 prospective) undergoing STS resection after radiation therapy. Within the prospective cohort (n=22), perfusion was quantified at Inflow (~30s) and Peak (~45–60s) timepoints using the SPY PHI system, identifying the "worst-point" minimum (MIN) normalized signal along the incision. The primary endpoint was WC (specifically dehiscence) within 90 days. To assess the incremental value of ICGA, we utilized multivariable logistic regression to construct two models: (1) a Baseline Clinical Model (Age and BMI), and (2) a Combined Model adding the MIN Peak ratio. Performance was compared using Receiver Operating Characteristic (ROC) curves and the difference in Area Under the Curve (AUC).

Results

The overall WC rate was 65.8% (27/41). Within the prospective group, the MIN Peak threshold (< 0.55) demonstrated a sensitivity of 60% and specificity of 83%, with an AUC of 0.83 (95% CI: 0.61–1.00). Patients below this threshold showed a statistical trend toward failure (OR 7.50; 95% CI: 0.97–57.8; p = 0.07). While high complication rates were observed in patients with Type 2 Diabetes (67%) and current smoking status (75%), these did not differ significantly from the high baseline failure rate of the cohort. However, the addition of the MIN Peak ratio to clinical variables significantly improved predictive discrimination over the baseline clinical model alone.

Discussion & Impact

These results suggest that ICGA-derived ratios serve as a powerful adjunctive tool to supplement clinical risk-stratification. The MIN Peak ratio of 0.55 identified focal ischemia with high specificity, providing an objective metric that outperformed traditional clinical markers like BMI in this cohort. While larger studies are required before these thresholds can definitively mandate changes in management, this data provides the necessary foundation for protocols that use intraoperative perfusion data to guide the use of prophylactic flap coverage, potentially reducing the high morbidity associated with STS wound failure.

Table 1: Study Demographics.

		Wound Complication		Wound Dehiscence		Re-Operation		
		All (n=36)	Yes (n=23)	No (n=13)	Yes (n=16)	No (n= 20)	Yes (n=28)	No (n=8)
Sex								
Male		21 (58.3%)	15 (71%)	6 (29%)	9 (43%)	12 (57%)	5 (24%)	16 (76%)
Female		15 (41.7%)	8 (53%)	7 (47%)	7 (47%)	8 (53%)	3 (20%)	12 (80%)
Diabetes								
Yes		9 (25.0%)	6 (67%)	3 (33%)	5 (56%)	4 (44%)	1 (11%)	8 (89%)
No		27 (75.0%)	17 (63%)	10 (37%)	11 (41%)	16 (59%)	7 (26%)	20 (74%)
Smoking History								
Current or Former		13 (36.1%)	9 (69%)	4 (31%)	8 (62%)	5 (38%)	1 (8%)	12 (92%)
Never		23 (63.9%)	14 (61%)	9 (39%)	8 (35%)	15 (65%)	7 (30%)	16 (70%)
Tumor Category								
Primary		31 (86.1%)	18 (58%)	13 (42%)	12 (39%)	19 (61%)	6 (19%)	25 (81%)
Recurrent		5 (13.9%)	5 (100%)	0 (0%)	4 (80%)	1 (20%)	2 (40%)	3 (60%)
Extremity Location								
Upper		10 (27.8%)	5 (50%)	5 (50%)	3 (30%)	7 (70%)	0 (0%)	10 (100%)
Lower		26 (72.2%)	18 (69%)	8 (31%)	13 (50%)	13 (50%)	8 (31%)	18 (69%)
Previously Resected								
Yes		11 (30.6%)	8 (73%)	3 (27%)	6 (55%)	5 (45%)	3 (27%)	8 (73%)
No		25 (69.4%)	15 (60%)	10 (40%)	10 (40%)	15 (60%)	5 (20%)	20 (80%)
Surgical Margin Status								

		7	6 (86%)	1 (14%)	2 (29%)	5 (71%)	3 (43%)	4 (57%)
	Positive	(19.4%)						
		29	17	12	14	15	5 (17%)	24
	Negative	(80.6%)	(59%)	(41%)	(48%)	(52%)		(83%)
Neoadjuvant Chemotherapy								
		1	0 (0%)	1	0 (0%)	1	0 (0%)	1
	Yes	(2.8%)		(100%)		(100%)		(100%)
		35	23	12	16	19	8 (23%)	27
	No	(97.2%)	(66%)	(34%)	(46%)	(54%)		(77%)
Adjuvant Chemotherapy								
		5	5	0 (0%)	2 (40%)	3 (60%)	4 (80%)	1 (20%)
	Yes	(13.9%)	(100%)					
		31	18	13	14	17	24	7 (23%)
	No	(86.1%)	(58%)	(42%)	(45%)	(55%)	(77%)	
Adjuvant Radiotherapy								
		4	3 (75%)	1 (25%)	2 (50%)	2 (50%)	1 (25%)	3 (75%)
	Yes	(11.1%)						
		32	20	12	14	18	7 (22%)	25
	No	(88.9%)	(63%)	(37%)	(44%)	(56%)		(78%)
High Grade								
		24	17	7 (29%)	11	13	6 (25%)	18
	Yes	(70.6%)	(71%)		(46%)	(54%)		(75%)
		10	5 (50%)	5 (50%)	4 (40%)	6 (60%)	1 (10%)	9 (90%)
	No	(29.4%)						
Age (years)								
	Mean	59.58	57.26	63.69	58.56	60.40	54.75	60.96
	(SD)	(14.03)	(12.86)	(15.55)	(10.26)	(16.67)	(12.53)	(14.33)
BMI (kg/m²)								
	Mean	28.70	29.72	26.90	31.06	26.81	27.56	29.02
	(SD)	(7.07)	(7.32)	(6.51)	(7.10)	(6.63)	(6.89)	(7.22)
Albumin (g/dL)								
	Mean	3.75	3.79	3.69	3.67	3.82	3.89	3.71
	(SD)	(0.72)	(0.78)	(0.61)	(0.70)	(0.74)	(0.84)	(0.69)
Resected Tumor Size (cm)								
	Mean	9.55	9.62	9.40	9.89	9.26	9.62	9.52
	(SD)	(6.72)	(7.44)	(5.38)	(7.88)	(5.78)	(7.22)	(6.71)
NRT Dose (cGy)								
	Mean	47.6	45.76	50.83	47.00	48.11	43.88	48.80
	(SD)	(9.62)	(10.67)	(6.69)	(10.08)	(9.49)	(11.47)	(8.89)

Continuous variables are reported as mean (SD). Categorical variables are reported as N (%).

Table 2: Comparison of Model Performance (n=22)

Model	AUC	Sensitivity	Specificity	PPV	NPV
Baseline Clinical Model (Age + BMI)	0.68	40%	75%	0.57	0.60
Combined Model (Age + BMI + ICGA)	0.82	60%	83%	0.75	0.71

Multivariable logistic regression analysis demonstrates the incremental predictive value of intraoperative ICGA. While a Baseline Clinical Model (Age + BMI) provided moderate discrimination (AUC 0.68), the integration of the MIN Peak perfusion ratio increased the model's area under the curve to 0.82. This improvement indicates that objective perfusion data captures physiological risk factors for wound failure that are not accounted for by standard patient demographics alone.