Utility-Based Model for Intraoperative Decision-Making After Right Hemicolectomy: ACS NSQIP

Natalia Torres-Acevedo, Corrado P Marini, Patrizio Petrone, Mordechai Caplan, Roberto Bergamaschi, John McNelis; Department of Surgery, NYCHHC + Hospitals / Jacobi

Introduction

- Primary ileocolic anastomosis (P-ICA) is the standard reconstruction after right hemicolectomy (RHC)
- Anastomotic leak (AL) and mortality are higher in emergency cases
- Existing nomograms predict AL risk but are limited to elderly segmental colectomy patients
- No models incorporate **utility-based outcomes** to guide intraoperative decision-making

Objective

- Develop a utility-based predictive model for the risk of AL
- Quantify the utility loss associated with the treatment of AL
- Identify a leak risk threshold favoring diversion (ileostomy)
- Applicable to both elective and emergency right hemicolectomy

Methods

- **Design:** Retrospective ACS-NSQIP review (2016–2023)
- **Patients:** 63,805 elective & emergency RHC with P-ICA
- **Variables:** age, sex, BMI, urgency, ASA, smoking, COPD, steroids, preop sepsis/shock, wound class, transfusion, operative approach (open vs lap/robotic)
- **Outcomes:** AL & management (reoperation, IR drainage, antibiotics, observation), mortality, LOS

Predictive and Utility Model

- **AL Prediction**: Stepwise logistic regression (70/30 train/test)
- **Variables**: male sex, emergency surgery, ASA, smoking, COPD, steroids, preop abdominal sepsis/shock, wound class, transfusions
- **Mortality**: logistic regression based on predicted AL risk
- **Utility**: compare expected utility of $EV_{P\text{-}ICA}$ vs. EV_{IL}
- **Utility values**: 1 = survival without complications, 0 = death; reduction: reoperation = 0.35, IR drainage = 0.60, antibiotics/observation = 0.95 (adjusted for mortality & LOS)

Predictive Equation

- **Probability of AL**:

$$p = 1/1 + e^{-z}$$

- **Where**:

z = -4.492 + (0.241 *ASA class) + (0.320 * male sex) + (0.329 * Smoking) + (0.582 * EMS) + (0.240 * steroids) + (0.177 * COPD) + (0.190 * preop sepsis/shock) + (0.790 * transfusion) + SWC (0.130 * class)

- **Coding:** 1 = present, 0 = absent (ASA 1–5; SWC 2–4)

Results

Comparison of patients stratified by urgency status

Variable	Total (n=63,805)	Elective (n=47,506)	Emergency (n=16,299)
ASA 3-5	40,138 (62.9%)	27,777 (58.5%)	12,361 (75.8%) *
Wound Class III + IV	15,377 (24.1%)	8,353 (17.6%)	7,024 (43.1%) *
Preop Abdominal sepsis + shock	4,281 (6.7%)	578 (1.2%)	3,703 (22.7%) *
Overall anastomotic leak rate	2,523 (4.0%)	1,295 (2.7%)	1,228 (7.5%) *
Mortality	1,307 (2.0%)	248 (0.5%)	1059 (6.5%) *

The cost and utility components of the model

Treatment	Percentage	Mortality Rate	Treatment Cost ($)	Added LOS (days)	LOS Cost ($)
Reoperation	76.6	15.7%	$40,000	11	$30,800
IR Drainage	11.7	9.0%	$25,000	5	$14,000
Antibiotics	10.6	16.9%	$15,000	3	$8,400
Observation	1.1	15.4%	$ 10,000	3	$ 8,400

- The cost associated with AL: $ 61,483

Treatment	Percentage	Survival	Bs-Ut	Ad-Ut	Weighted Contribution
Reoperation	0.766	0.843	0.35	(0.843 * 0.35) – 0.055 = 0.240	0.766 × 0.240 = **0.1838**
IR Drainage	0.117	0.910	0.60	(0.91 * 0.60) – 0.025 = 0.521	0.117 × 0.521 = **0.0609**
Antibiotics	0.106	0.831	0.95	(0.831 * 0.95) – 0.015 = 0.7744	0.106 x 0.7744 = **0.0820**
Observation	0.011	0.846	0.95	(0.846 * 0.95) – 0.015 = 0.7887	0.011 x 0.7887 = **0.0086**

- $U_{AL,adj}$ = 0.1838+ 0.0609 + 0.0820 + 0.0086 = **0.3353** $\Delta U_{per\text{-}leak} = 1 - U_{AL,adj} = 1 - 0.3353 =$ **0.6647**

Threshold Analysis

- Modeled P-ICA vs diversion (ileostomy) using **expected utility**
- Utility of ileostomy = 0.962 (clinical consensus: ileostomy does not significantly reduce mortality after RHC)
- **Emergency RHC:**
  Set $EV_{P\text{-}ICA} = EV_{IL}$: 1 − 0.6647 p = 0.962 ⇒
  0.6647 p = 0.038 ⇒
  p = 0.038 / 0.6647 = 0.057 **(5.7%)**
- **Elective RHC:**
  Set $EV_{P\text{-}ICA} = EV_{IL}$:
  p = 0.038 / 0.5998 = 0.063 **(6.3%)**

Nomogram & Decision Aid

- Enter patient factors (0/1 for binary; ASA 1–5; Wound class II=2, III=3, IV=4).
- Decision threshold: p(AL) ≥ 59.8 points or 6.31% leak risk → **ILEOSTOMY**; otherwise → **ANASTOMOSIS**

Predictor	Points per unit	Input	Point contribution
ASA (per class)	8.04	2	16.07
Male sex	10.67	0	0.00
Smoking	10.97	1	10.97
Emergency surgery	19.41	1	19.41
Steroids	8.00	0	0.00
COPD	5.90	0	0.00
Preop sepsis/shock	6.34	1	6.34
Transfusion	26.34	0	0.00
Wound class (per step)	4.33	3	13.00
		Total points	54.8
		Predicted AL risk	5.48%
		Decision (6.31%)	**ANASTOMOSIS**

Predictor	Points per unit	Input	Point contribution
ASA (per class)	8.04	2	16.07
Male sex	10.67	0	0.00
Smoking	10.97	1	10.97
Emergency surgery	19.41	1	19.41
Steroids	8.00	0	0.00
COPD	5.90	0	0.00
Preop sepsis/shock	6.34	1	6.34
Transfusion	26.34	0	0.00
Wound class (per step)	4.33	3	13.00
		Total points	65.8
		Predicted AL risk	7.45%
		Decision (6.31%)	**ILEOSTOMY**

Conclusions

- Our model provides a data-driven decision tool for elective and emergency RHC
- Integrates patient-specific leak risk and outcome utility
- Supports intraoperative decision making and discussion with patients regarding AL risk
- May reduce leak-related morbidity, mortality, and costs
- Diversion preferred when predicted leak risk > **5.7%** (emergency) or **6.3%** (elective)
- Ileostomy reduces leaks but not mortality; higher ileostomy mortality raises the threshold