

ACS 2024 Surgeons and Engineers: A Dialogue on Surgical Simulation Meeting

P-A-06

Research-In-Progress

Differences in Objective Performance Indicators Between Expert, Intermediate and Novice Surgeons During Mobilization Steps of Robotic Right Colectomy

Mishal Gillani, MD; Manali Rupji, MS; Patrick Sean Sullivan, MD; Virginia L.O. Shaffer, MD; Glen C. Balch, MD; Mallory Shields, PhD; Terrah Paul Olson, MD; Yuan Liu Liu, PhD; and Seth Alan Rosen, MD

Emory University School of Medicine, Atlanta, GA; Winship Cancer Institute, Emory University, Atlanta, GA; Intuitive Surgical, Seattle, WA; Rollins School of Public Health, Emory University, Atlanta, GA

Introduction: Current tools to assess surgeon skill are time-consuming, subjective and difficult to scale. Objective performance indicators (OPIs), machine learning-enabled metrics calculated from robotic systems data, can provide objective data regarding surgeon movements and robotic arm kinematics. In this study, we identified OPIs that significantly differed across expert, intermediate and novice surgeons during mobilization steps of robotic right colectomy (RRC).

Methods: Endoscopic video synchronized to robotic system data was captured during 25 RRCs. Videos were annotated and OPIs were calculated to analyze hepatic flexure mobilization (HFM) and ascending colon mobilization (ACM) steps. Step-specific OPIs were compared across two expert (≥ 500 robotic colorectal procedures), two intermediate (50-100 procedures) and seven novice (< 50 procedures) surgeons. Comparisons were made using the T-test/Wilcoxon Sum-Rank test as appropriate.

Preliminary Results: RRCs were for adenoma (52%), cancer (36%), and inflammatory bowel disease (12%); indications did not significantly differ between cohorts. Compared to novices, experts exhibited greater acceleration and jerk for camera, dominant and non-dominant arms during all steps. During medial-to-lateral ACM, experts utilized greater dominant arm yaw and pitch, faster non-dominant arm velocity, and less moving time for camera, dominant and non-dominant arms. During lateral-to-medial ACM, experts exhibited faster 3rd arm acceleration, dominant and non-dominant arm velocity. During HFM, experts displayed faster 3rd arm acceleration and more camera movements. Compared to novices, intermediates exhibited greater camera jerk and dominant arm acceleration during medial-to-lateral ACM. During lateral-to-medial ACM, intermediates displayed greater velocity, acceleration and jerk for all arms. During HFM, intermediates had greater camera movements and arm swaps, faster 3rd arm acceleration, greater velocity, acceleration and jerk for camera, dominant and non-dominant arms.

Next Steps: We report OPIs that differ between expert, intermediate, and novice surgeons during mobilization steps of RRC. More studies are needed to evaluate their usefulness for benchmarking, assessing quality and informing training curricula.

Examples of differences in OPIs between expert, intermediate and novice surgeons during RRC steps

OPIs	Step	Comparison groups	Median [IQR]	p value
Camera movements [n]	HFM	Exp vs Nov	19.5 [8 - 37] vs 6 [1 - 9]	0.039
Arm swap [n]	HFM	Int vs Nov	6 [3 - 19] vs 3 [0 - 6]	0.043
Camera path length [m]	HFM	Int vs Nov	0.42 [0.16 - 0.96] vs 0.17 [0.04 - 0.20]	0.033
Camera velocity [m/sec]	HFM	Exp vs Nov	0.12 [0.11 - 0.14] vs 0.06 [0.04 - 0.09]	0.010
Dominant arm velocity [m/sec]	ACM	Exp vs Nov	0.10 [0.08 - 0.15] vs 0.07 [0.05 - 0.08]	<0.001
Non-dominant arm acceleration [m/sec ²]	ACM	Int vs Nov	0.55 [0.46 - 0.67] vs 0.36 [0.25 - 0.40]	<0.001
3rd arm jerk [m/sec ³]	ACM	Int vs Nov	31.92 [26.56 - 42.17] vs 17.19 [12.37 - 22.97]	0.003
Dominant arm EndoWrist pitch [rad]	ACM	Int vs Nov	34.72 [9.09 - 73.73] vs 26.80 [7.01 - 106.38]	0.914

RRC = robotic right colectomy, OPIs = objective performance indicators, HFM = hepatic flexure mobilization, ACM = ascending colon mobilization, IQR = interquartile range, n = numbers, rad = radians, m = meters, m/sec = meters per second, m/sec² = meters per second squared, m/sec³ = meters per second cubed, Exp = expert, Int = intermediate, Nov = novice