Identification of Early Learning Curve Changes in Objective Performance Indicators during Robotic Cholecystectomy

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Introduction

- Objective performance indicators (OPIs) are metrics calculated directly from robotic data streams that have been used to quantify surgical efficiency and quality in robotic-assisted urologic surgery.
- There is a paucity of OPI data during the learning curve of a surgeon when switching from laparoscopic to robotic cholecystectomy, especially for single surgeons. This is the first study to include such data.

Type of OPI	OPI Name
Event	Number of Times of Master Clutch
Kinematic	Acceleration for Specific Robotic Arm
Temporal	Total Duration to Complete Step

Table 1. Examples of Objective Performance Indicators (OPIs) Included in This Study.

Hypothesis

We hypothesize that as an expert surgeon who is transitioning from laparoscopic to robotic cholecystectomy performs more robotic assisted cholecystectomies, surgical efficiency increases, reflected in OPI changes.

Methods

- A single surgeon's robotic event, kinematic, and temporal data during robotic cholecystectomy with the DaVinci XI platform was collected using the Intuitive Data Recorder over a 2-year period (2020-2022).
- Cases were segmented into surgical steps by professional annotators, and OPIs were calculated for each step.
- Thirty-three procedures (7-39th career robotic cholecystectomy) were analyzed for step-specific changes in OPIs over time, across all the different steps of cholecystectomy, using Spearman rank correlation.
- A Cumulative Sum Analysis was performed on various OPIs such as total duration for the whole procedure, duration spent on each step, and idle time of all robotic arms.

Results

- Cumulative Sum Analysis only revealed a standard learning curve for the time that all robotic arms remained still for the ligation/division of the cystic duct step, indicating greater efficiency in clip loading, instrument exchange, and surgeon retaking control once the 22nd cholecystectomy within this study had been performed.

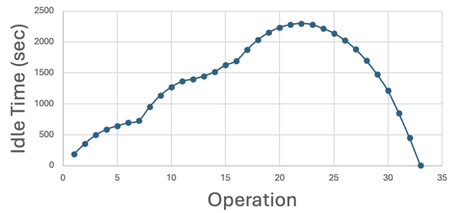


Figure 1. Cumulative Sum for Idle Time of Robotic Arms on Ligation/Division of Cystic Duct Step.

Results

- The total time that all robotic arms moved during the ligation/division of the cystic duct step decreased as more operations were performed (p = 0.04184). This was associated with a reduction in the total time that the dominant and nondominant robotic arms moved during this step (p = 0.02251 and p = 0.004607, respectively), This trend could indicate greater efficiency in completing this task.

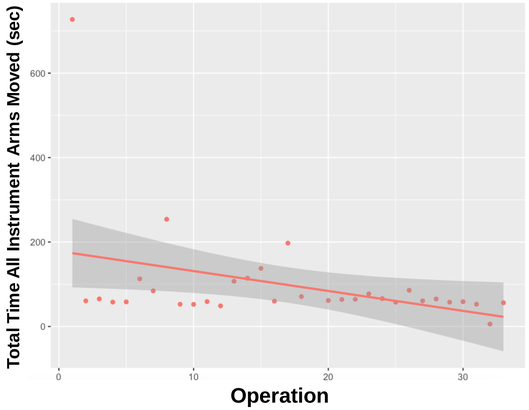


Figure 2. Total Active Time for All Instrument Arms per Operation Decreased In The Ligation/Division of Cystic Duct Step As More Operations Were Performed.

- During the dissection of the triangle of Calot step, there were many changes in the angular velocities of the dominant arm, but this finding did not correlate to a reduction in step duration.
- In the removal of adhesions, dissection of triangle of Calot, ligation/division of cystic artery, and dissection of gallbladder off the liver bed steps, there were statistically significant changes in the velocity and acceleration of the robotic arm controlling the camera.

Results

- Master clutch was used more during the ligation/division of the cystic artery step as more operations were performed (p = 0.009396). It's unclear what this trend indicates. Perhaps there was learning in how to use the clutch without inadvertently engaging the clip, or perhaps later operations in the study were more complex and required larger movements and thus more positional adjustments.

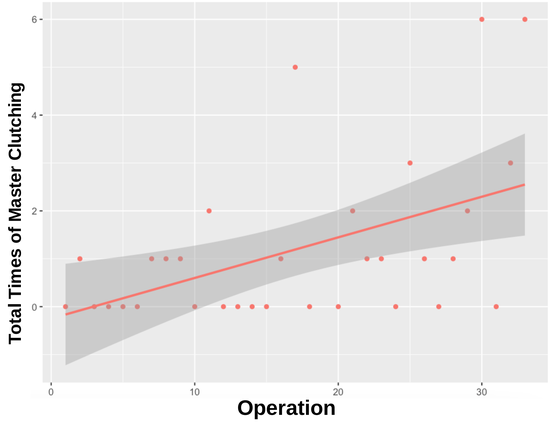


Figure 3. Total Number of Times The Master Clutch Was Used per Operation Increased in the Ligation/Division of Cystic Artery Step As More Operations Were Performed.

Conclusions and Next Steps

- As the first study to evaluate truly objective metrics throughout a learning curve in robotic cholecystectomy, this work identifies active time of robotic arms, number of times the master clutch was used, and idle time as critical steps for proficiency tracking in the future.
- This study uncovers OPIs, such as active time of movement of all robotic arms, that impact the ligation/division of the cystic duct step, which has a steep learning curve in the transition from laparoscopic to robotic cholecystectomy.
- More studies are needed to validate and compare such OPIs of interest throughout critical segments of surgery.