Using Operative Times to Analyze Instrument Motion Smoothness in Robotic Cholecystectomies

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Introduction

Technical skill in the operating room is critical for achieving optimal patient outcomes, however these are hard to measure objectively. Objective performance indicators (OPIs), metrics that can measure the precise movement of instruments in time and space during a robotic procedure, can also determine the smoothness of instrument motion, an important assessment of the quality of movements made by a surgeon. In this study, we aim to analyze smoothness metrics for robotic cholecystectomies. We hypothesize that tasks that take longer than average (i.e., are more difficult) will have less smooth movements.

Methods

The Intuitive data recorder was used to record 57 robotic cholecystectomies from 5 surgeons at our tertiary hospital center. Five smoothness OPIs, movement arrest period ratio(MAPR), normalized speed, speed peaks, non-dimensional jerk(ndjerk), and spectral arc length(SAL), were analyzed for 6 operative steps: initial exposure, dissection of Calot's triangle, ligation of cystic artery, ligation of cystic duct, gallbladder dissection off liver, and hemostasis of liver bed. The average duration for each step was calculated and smoothness metrics were analyzed for the steps that took longer than the average plus one standard deviation. An independent samples t-test was used for statistical analysis.

Steps	Left Instrument	Right Instrument
Initial Exposure	mapr(p<.001) norm speed(p=.028) ndjerk(p=.003)	speed peaks(p=.002)
Dissection of Calot's Triangle	SAL(p=.049)	SAL(p=.012) mapr(p<.001) norm speed(p<.001)
Ligation of Cystic Artery	speed peaks(p=.040) SAL(p=.010)	ndjerk (p=.043) SAL(p=.004) speed peaks(p<.001) mapr(p<.032)
Ligation of Cystic Duct	ndjerk(p=.013)	ndjerk(p=.014) normspeed(p<.001) speed peaks(p<.001)
Gallbladder dissection off Liver		speed peaks(p=.046) SAL(p=.049) mapr(p=.003) normspeed(p=.047)
Hemostasis of Liver Bed	speed peaks(p=.004)	ndjerk(p=.002) mapr(p=.018) normspeed(p<.001)

Results

MAPR, normalized speed, speed peaks, and NDjerk were found to be significantly different for 5 of the steps and SAL was found to be significantly different for 2 steps. All significant results are reported in table 1.

Conclusions

Surgeons make rougher instrument movements when steps take longer than average. This is the first step in objectively understanding surgical movements during difficult cases. Using this data, surgeons' specific movements can be targeted and improved through OPI based feedback

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