Does Introduction of New Technology Disrupt Surgical Workflow? A 5-Year Gastric Bypass Case Series Study

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INTRODUCTION

With the advances in technology, minimally invasive surgery (MIS) is moving from laparoscopic to robotics procedures which result in new instruments being introduced in the procedure workflow. How surgeons adapt to using these new instruments and what adjustments and changes in the workflow they need to make in order to be able to fully take advantage of these technology is missing from the current literature.

OBJECTIVE

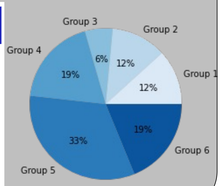
In this study, we investigate the impact of the introduction of new technology on surgical workflow. A procedure consists of multiple tasks and how a surgeon transitions to and from each task intraoperatively is referred to as surgical workflow. Quantitative measures of surgical workflow help understand its variability due to introduction of advanced technology. Understanding surgical workflow and factors contributing to its variability is critical to studying its effect on procedure efficiency, quality improvement and patient outcome.

METHODOLOGY

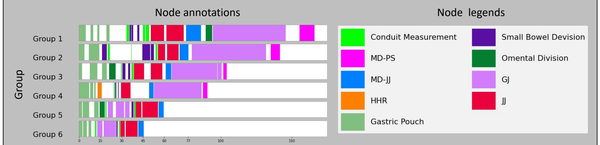
To quantify surgical workflow, relevant tasks were grouped into a node and Markov network was used to show transition between nodes. The likelihood of transitioning into or out of nodes, were quantified using two new measures, forward and backward entropy. A single surgeon's 5-year gastric bypass procedure case series, which included 84 cases from the first year of adopting robotic platform in 2015 through 2019 was used in this study. The cases were separated into 6 chronological groups identified by the surgeon and based on instrumentation.

Dataset

Method	Instrument	Timeline
Group 1	lap dominant, heavily lap 75% (most tasks lap), lap stapler	4/2015 - 5/2015
Group 2	less lap tasks 40-50%, lap staples, hybrid tasks	7/2015 - 9/2015
Group 3	robotics tasks, robotic needle driver, hand sewn	10/2015 - 11/2015
Group 4	robotic dominant (most tasks robotic)	11/2015 - 3/2016
Group 5	robotic, endo-wrist stapler	8/2016 - 7/2018
Group 6	robotic, SureForm stapler	11/2018 - 6/2019



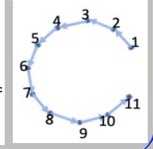
Node annotations



Quantifying surgical workflow

Node Arrangement

1: Start of surgery
2: Gastric pouch creation
3: Omental division
4: Conduit measurement
5: Small bowel division
6: Gastrojejunostomy
7: Jejunojejunostomy
8: Jejunojejunostomy mesenteric defect closure
9: Petersen's space closure
10: Leak test
11: End of surgery



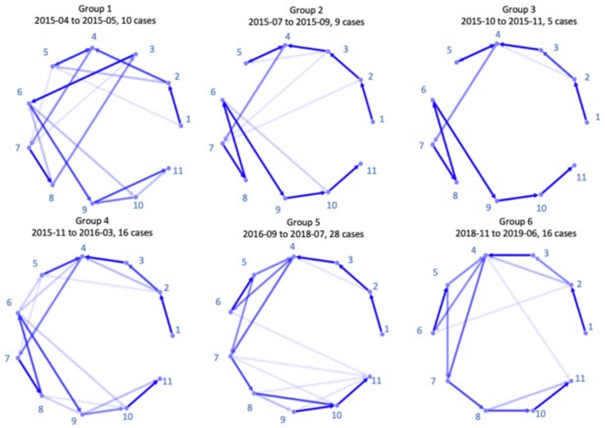
Morkov Model

$$\begin{pmatrix} T^{00} & T^{01} & \dots & T^{0n} & \dots & T^{0D} \\ T^{10} & T^{11} & \dots & T^{1n} & \dots & T^{1D} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ T^{m0} & T^{m1} & \dots & T^{mn} & \dots & T^{mD} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ T^{D0} & T^{D1} & \dots & T^{Dn} & \dots & T^{DD} \end{pmatrix}$$

Workflow representation and metrics

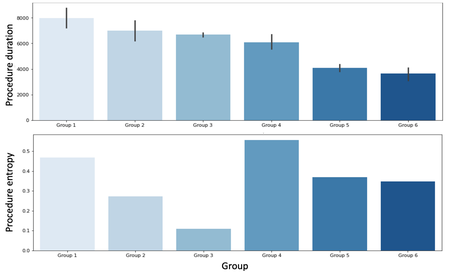
- Line densities in the Markov representation of the network show the likelihood of transitioning between nodes.
- Forward entropy: likelihood of transitioning from a node to any other node
- Backward entropy: likelihood of transitioning to a node from any other node

EFFECT OF NEW TECHNOLOGY ON SURGICAL WORKFLOW



As demonstrated by the Markov Chain analysis on the six different procedure groupings, the surgical workflow changed while the surgeon was adapting to the introduction of the surgical robotic system. The transition between the different surgical activities or nodes was highly varied during the initial procedures. However, over the course of time, the transitions between nodes became more consistent. The transitions between in nodes in the Group 3 procedures were more consistent, leading to the lowest entropy score. However, the total procedure duration did not change significantly as compared to Group 2 procedures. In order to increase the procedure efficiency, the surgical workflow was reorganized to maximize the utility of the introduced technology despite leading to a higher entropy score.

WORKFLOW AND PROCEDURE DURATION VARIATION



Procedure duration shows a continuous decrease from the earliest to the latest group; however, with the introduction of new instruments, an initial increase in workflow variability is observed presumably while the surgeon is optimizing its use. As the surgeon adjusts the operative workflow, the nodal entropy declines signaling maximum utilization of intended use of the new technology.

CONCLUSION

This study demonstrates that surgical workflow efficiency can be disrupted through the introduction of new technology. Initially, the new technology introduction led to a greater variability within the surgical procedure, as noted by the initial higher entropy scores. With time, the procedure entropy declined as the workflow stabilized. However, entropy stabilization did not lead to maximal utilization of the new technology or maximal surgical efficiency. Increases in surgical workflow efficiency occur only when surgeons learn how to maximize the utility of the new technology.