EXPERIENCED SURGEONS VERSUS NOVICE RESIDENTS: VALIDATING A NOVEL KNOT TYING SIMULATOR FOR VESSEL LIGATION

INTRODUCTION

Vessel ligation with a knot is one of the most fundamental tasks surgeons must master. We developed a simulator designed to enable novices to experience knot tying with force feedback. Basic surgical simulators with integrated analytical software offer an affordable practice tool to develop and refine performance. Such platforms can be readily accessible to residency programs around the world allowing international standardization, while overcoming financial disparities between training programs.

METHODS

A bench-top knot-tying simulator with computer acquired assessment, “KNOTI”, was tested on certified surgeons and surgical residents at a tertiary medical center during the years 2017–2018. Dedicated computer software was written using Processing software (Processing. Boston, Massachusetts, US). The simulator measured vertical forces and the time for task completion. Each participant tied a total of eight knots in different settings (superficial vs. deep) and techniques (one handed vs. two hands). Participants were instructed to avoid tissue rupture or loose knots. All knots were square knots (double-throw knot) using the same type of sutures (SofSilk™ 3.0, MEDTRONIC, Minneapolis, Minnesota, US). Statistic analysis was done using Student’s t-test, Mann Whitney or Bonferroni correction.

RESULTS

Fifteen surgeons with 201 years of cumulative surgical experience (13.4 ± 7 years each) and 30 post–graduate year (PGY)-2 surgical residents were recruited for the study.

Experienced surgeons demonstrated:

- Less total force during placement of the knots than the novice residents (3.8 ± 2.0 vs. 9.2 ± 6.1 Newton (N), respectively, p = 0.0005).
- Lower peak force upward (1.31 ± 0.6 vs. 1.75 ± 0.84 N, p = 0.02).
- Shorter time (10.9 ± 3.4 vs. 18.3 ± 7.2 seconds, p=3.4x10⁻⁵).

1.3 N was the average maximum peak force exerted when experts tied a knot with a one-handed technique in a deep setting.

DISCUSSION

Experienced surgeons using KNOTI applied less tensile force than novice residents during tying of surgical knots intended to ligate a vessel. This was evidenced by the difference in overall force exerted and in maximal peak upward force, the latter being a critical contributor to tear of knot or avulsion of tissue by inexperienced surgeons exerting superfluous forces. In addition, the forces exerted by the experienced surgeons were more consistent, having become automated, while the novices exhibited a bigger variance of force measurement. The study determined an expert based cut-off for desired forces on our simulator.

CONCLUSION

The simulator can offer residency programs an affordable bench-top platform to objectively train and assess the knot-tying capabilities of surgical residents.

FUTURE RESEARCH

Our future studies will examine how to apply data from the simulator on forces exerted during knot-tying to develop a visual and auditory feedback mechanism. The simulator will become an integral part of our medical center’s surgery boot camp, to enable interns and residents to practice knot tying with force feedback. It will also be of interest to assess whether skills attained with the improved simulation with feedback are durable and evident weeks and months after practice.

VIDEO

Scan QR code to watch a Video simulation of Knoti

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