Creating a Human Derived Model to Simulate Means to Minimize Firings Across Lower Anterior Resection

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Introduction

Despite advances in minimally invasive surgery, colorectal surgeons still face challenges in maneuvering laparoscopic instrumentation within the male pelvis. The male pelvic outlet is longer and narrower than that of the female, which poses challenges in performing common procedures such as laparoscopic low anterior resection (LAR).[1] Colorectal surgeons strive to minimize the number of stapler firings to reduce the risk of anastomotic leaks and perform a precise transection during an LAR[2]. The purpose of this study was to create a clinically accurate computer model to estimate the number of firings needed to transect the rectum in an LAR using different endocutter surgical stapling devices.



Figure 1. Two electronically powered endocutters, Echelon™ 3000 (above) and Signia™ (right)

Methods

A 3D computer model of a male pelvis was built using Pelvic CT and MRI scans from a previous anatomy characterization study[3]. Amongst representative males at the 50th percentile for height, the sample at the median pelvic width was selected for the model. Rectal transection was then simulated using rounds of 10,000 Monte Carlo simulations placing the end-effectors of four staplers (Echelon™ 3000 [ECH3] 45 mm and 60 mm, Ethicon, Cincinnati, OH; and Signia™ [SGN] 45 mm and 60 mm, Medtronic, Minneapolis, MN) in the pelvis across the rectum at various distances from the dentate line. The primary outcomes were chance of complete transection with a single firing and degree of perpendicularity of the staple line.

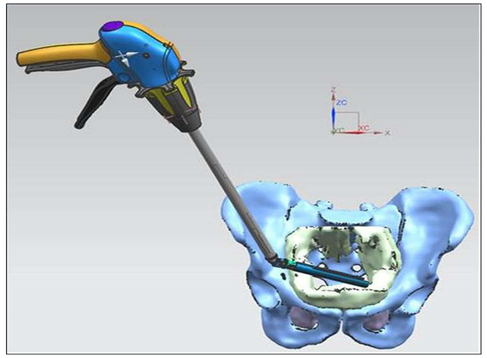


Figure 2: Virtual placement of the stapler within the pelvis at a specific distance above the dentate line.

Results

ECH3 60 mm showed a 19.4% chance of completing the transection with one firing compared to 14.9% with SGN 60 mm, while ECH3 45 mm showed a 98.4% chance of completing the transection after two firings compared to 88.8% with SGN 45 mm. The ECH3 60mm perpendicularity angle was 56.6 degrees versus 58.4 degrees for SGN 60 mm. The ECH3 45mm perpendicularity angle was 61.9 degrees versus 63.5 degrees for SGN 45mm. ECH3 60 mm device demonstrated a 7.3% greater chance to complete the transection with one firing over the SGN 60 mm, while the ECH3 45mm device showed a 3x greater chance than the SGN 45 mm.

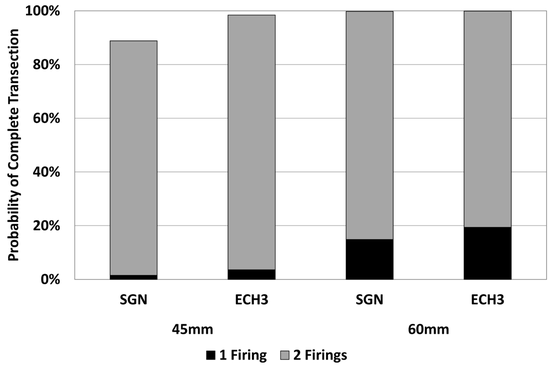


Figure 3. Probability of completing transection at 7 cm above the dentate line

Conclusions

All stapling devices modeled showed decreased ability to transect in a single firing relative to published rates including male and female patients[4], consistent with modeling of a narrower male pelvis. All staplers showed high rates of complete transection with 2 or fewer firings, with ECH3 trending towards greater chance of transecting in a single firing. This study demonstrates effective simulation of stapling in laparoscopic LAR using human derived data.

References

1. Akiyoshi T, Kuroyanagi H, Oya M, et al. Factors affecting the difficulty of laparoscopic total mesorectal excision with double stapling technique anastomosis for low rectal cancer. *Surgery*. 2009/09/01 2009;146(3):483-489. doi:10.1016/j.surg.2009.03.030
2. Eriksen JD, Emmertsen KJ, Madsen AH, Erichsen R, Bachmann TN, Hjerrild Iversen L. The impact of multiple firings on the risk of anastomotic leakage after minimally invasive restorative rectal cancer resection and the impact of anastomotic leakage on long-term survival: a population-based study. *International Journal of Colorectal Disease*. 2022;37(6):1335-1348. doi:10.1007/s00384-022-04171-1
3. Saffarzadeh M, Eckert CE, Nagle D, et al. Pelvic and Lower Gastrointestinal Tract Anatomical Characterization of the Average Male. *Surgical Innovation*. 2019;26(2):180-191. doi:10.1177/1553350618812317
4. 1. Eriksen JD, Emmertsen KJ, Madsen AH, Erichsen R, Bachmann TN, Hjerrild Iversen L. The impact of multiple firings on the risk of anastomotic leakage after minimally invasive restorative rectal cancer resection and the impact of anastomotic leakage on long-term survival: a population-based study. *International Journal of Colorectal Disease*. 2022;37(6):1335-1348. doi:10.1007/s00384-022-04171-1