Evaluating the burst pressure of simulated closure of bowel enterotomies in deep body cavities using the reverse half-hitch alternating post knots and square knots: A randomized controlled trial.

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DISCLOSURES

The authors have no actual or potential conflicts of interest in relation to this educational program.
## FUNDING SOURCES

### Potential Funding Sources

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<td>2</td>
<td>Intramural grant</td>
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<td>Hospital QI/PI Process</td>
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<td>12</td>
<td>Not for Profit or Professional Society</td>
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Other
• **Square knot:**
  – Gold standard for surgical procedures
  – High knot strength
  – Difficult to perform in confined spaces

• **Reverse Half-Hitch Alternating Post (RHAP) knot:**
  – Equivalent tensile strength to square knots\(^1\)
  – Easier for novices to learn\(^2\)
  – Easier to hand tie at depth \(^2\)

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**MOTIVATION:** The use of the RHAP knot for enterotomy closures in confined spaces has not been studied.

**PURPOSE:** Compare RHAP and square knots for closure of bowel enterotomies in simulated deep body cavities following proficiency-based training in surgical knot tying.

**HYPOTHESIS:**

*Maximal burst pressure for enterotomy closure using the RHAP knots are non-inferior to square knots in simulated deep body cavity.*
STUDY DESIGN

• Single Center Randomized Control Trial:
  – Queen’s University – Kingston, ON, Canada

• Inclusion Criteria: Undergraduate Students (Age > 19)

• Exclusion Criteria: Prior training in enterotomy closure or bowel anastomosis

• Study Outcomes:
  1. Time to surgical knot tying proficiency → Validated surgical knot tying checklist
  2. Time required to complete enterotomy closures
  3. Quality of enterotomy closure → Burst pressure
STUDY DESIGN

Undergraduate Students (Queen’s University)  
n = 20

Random Participant ID Assignment

Participant Randomization to RHAP or Square groups (In Silico)

RHAP-knot Group  
n = 10

Square-knot Group  
n = 10
METHODOLOGY

Surgical Hand-Tie Practice & Proficiency Assessment

Instruction & deliberate practice of Enterotomy Closure

Bowel Enterotomy Closure (Flat Surface)

Blinded Burst Pressure Testing

Bowel Enterotomy Closure (Simulated Deep Cavity)
RESULTS: TIME TO KNOT PROFICIENCY

• No statistical difference RHAP and square knot tying proficiency at baseline.

• No statistical difference in time to achieving proficiency between RHAP or Square knot groups
RESULTS: TIME TO ENTEROTOMY CLOSURE

- RHAP group was statistically faster at closing enterotomies in simulated deep body cavities than the square knot group (16±2 vs 21±1 min; p=0.02)
RESULTS: QUALITY OF ENTEROTOMY CLOSURES

- RHAP knot closures on a flat surface were non-inferior to those completed with square knots (128±40 vs 101±35 mmHg; p=0.31)

- RHAP knot closures in simulated deep body cavities were statistically higher than those completed with square knots (105±39 vs 35±14 mmHg; p=0.05)
For learners proficient at knot tying, the RHAP knot is:

1. Faster for closing enterotomies in confined spaces compared to square knots.
2. Non-inferior to the square knot for enterotomy closures on a flat surface.
3. More secure than square knots when closing enterotomies in deep body cavities.

CONCLUSION:

RHAP knots should be incorporated into proficiency-based knot tying curricula along with the square knot for surgical training of medical students and residents.
LIMITATIONS & FUTURE DIRECTIONS

• Process of enterotomy closure not assessed objectively
  – Only looked at the final product (burst pressure)

• Results may not be generalizable to:
  – Performance in the operating room
  – Other types of sutures with different characteristics (monofilament)
  – Other techniques of closure (running suture)

• FUTURE DIRECTIONS:
  Evaluate the performance of hand sewn-enterotomy closures using RHAP knots in-vivo
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  – Clinical Simulation Center – Financial Support & Facilities
  – Department of Surgery – Financial Support

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THANK YOU!
APPENDIX
**SURGICAL KNOT APPRAISAL**

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<th>Criteria</th>
<th>Description</th>
<th>Score</th>
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<tr>
<td>Secure Post</td>
<td>Is first knot square and taught against surface? [Yes:1/No:0]</td>
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<tr>
<td>Correct Distance</td>
<td>Is the surgical knot being tied at 6 cm away from surface? [Yes:1/No:0]</td>
<td></td>
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<tr>
<td>Grasp</td>
<td>Are the suture ends being grasped with fore-finger and thumb? [Yes:1/No:0]</td>
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<tr>
<td>Gather</td>
<td>Does the participant gather the excess suture to shorten for laying of knot? [Yes:1/No:0]</td>
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<tr>
<td>Lay down</td>
<td>Does the participant use fore-finger to lay down successive throws? NOTE: RHAP throws should be laid with alternating fore-fingers.</td>
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<tr>
<td>Air knot</td>
<td>Does each successive knot lie flush against the previous throw? [Yes:1/No:0]</td>
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<tr>
<td>Knot technique</td>
<td>Was the proper knot thrown for each of the throws?</td>
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- *Surgical-knot appraisal checklist by Wu et al. (provide an actual reference)*
Fig. 3. Schematic for construction of reversing half-hitch alternating post (RHAP) knot, 5-throw configuration. The arrow depicts standing post. A) 1-throw, B) 2-throw same post, C) 3-throw alternating post, D) 4-throw alternating post, E) 5-throw alternating post.