The Use Of A Flexible Robotic Endoscope To Perform Pure Transrectal Natural Orifice Transluminal Endoscopic Surgery (NOTES) Appendicectomy – An Ex-vivo Study

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Background

Pure NOTES procedures are currently not feasible as stiff laparoscopic instruments cannot often be intubated via the flexible gastrointestinal tract, and even if they can, cannot achieve the necessary triangulation and retraction angles when inserted through a single NOTES entry site. Consequently, additional laparoscopic trocar sites and rigid laparoscopes are inserted to achieve triangulation for optimal retraction, resulting in traditional NOTES procedures being mostly hybrid laparoscopic-NOTES procedures.

Objective Of Technology

We aim to develop a novel pure transrectal NOTES appendicectomy technique using only a flexible robotic endoscope, without the need for assistance from additional laparoscopic instruments and a rigid laparoscope.

Description Of Technology And Method Of Its Use

A flexible robotic endoscope with two robotic arms and one working channel was used for the procedure. A computer-controlled master and slave concept was used to operate the flexible robotic endoscope. The two robotic arms – one robotic grasper and one robotic hook diathermy – were controlled remotely by the surgeon using a master console. Both robotic arms have high degrees of freedom allowing for superior manoeuvrability of the instruments and increased dexterity of the operating instruments. The collaboration of these two robotic arms effectively allowed the surgeon to replicate his own two hands in traditional open surgery. Endoscopic resolution clips, endoloops and Roth net were also utilized through the working channel during various dissection steps.

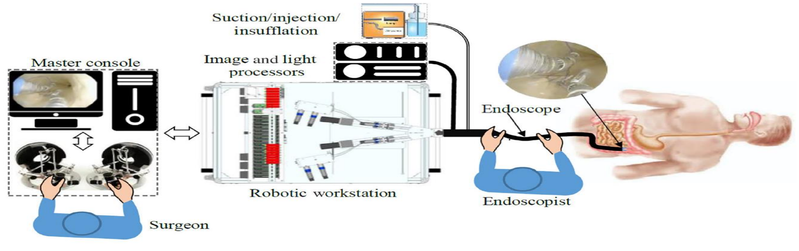




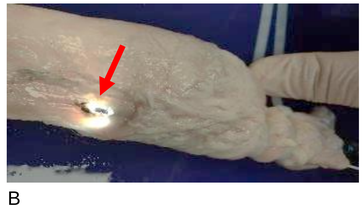
Figure 1: Set-up of flexible robotic endoscope – pictorial diagram with corresponding life photos

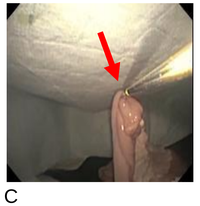
Preliminary Results

Traditional steps of laparoscopic appendicectomy were modified to perform pure NOTES appendicectomy. To simulate NOTES appendicectomy in humans, a length of porcine colon was used to simulate the rectum for transrectal NOTES entry, and the porcine fallopian tube was used to simulate the appendix

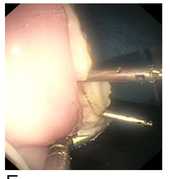
Modified steps for pure transrectal NOTES appendicectomy
1. **Create a full-thickness incision through the wall of the rectum using an endoscopic dual knife. Insert the robotic endoscope through the full thickness incision. The robotic endoscope has a left-sided robotic grasper and a right-sided robotic diathermy hook.**
2. **As there is no appendix in a pig, we use the right fallopian tube and ovary as a substitute. Use an endoscopic resolution clip to attach the tip of the right fallopian tube to the peritoneum.**
3. **Dissect the mesosalphinx using the endoscopic dual knife to isolate the artery.**
4. **Secure the artery using three endoscopic Resolution clips and divide the artery between the clips.**
5. **Secure the base of the right fallopian tube using three endoscopic endoloops and transect the base of the right fallopian tube between the endoloops.**
6. **Remove the appendix through the full-thickness incision in the wall of the rectum using endoscopic Roth net.**
7. **Use the line-assisted complete closure (LACC) technique to close the full thickness incision with endoscopic Resolution clips. Perform air leak test to ensure secure closure of full thickness incision.**


A

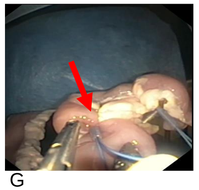

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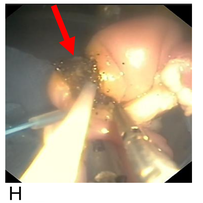

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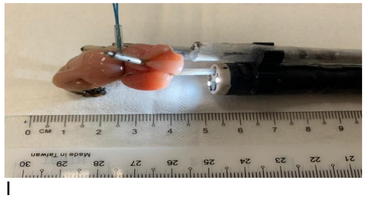

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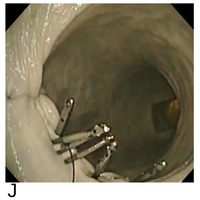

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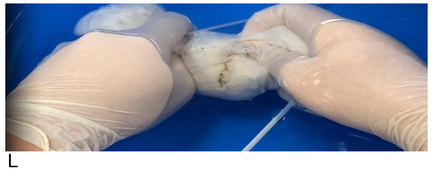

L

Figure 2A-L: Pure transrectal NOTES appendicectomy using flexible robotic endoscope
(A) Endoscopic luminal view demonstrating full thickness incision created in rectum
(B) External view of colon demonstrating full thickness incision created in rectum
(C) Right fallopian tube retracted using endoscopic Resolution clip
(D) Mesosalphinx window created to isolate artery
(E) Artery resecure using endoscopic Resolution clips
(F) Artery divided between endoscopic Resolution clips
(G) Base of right fallopian tube secured using endoscopic endoloops
(H) Right fallopian tube transected between endoscopic endoloops
(I) Resected right fallopian tube retrieved
(J) Full-thickness incision closed using line-assisted complete closure (LACC) technique
(K) External view of full thickness incision closed
(L) Air leak test negative

Conclusion/ Future Directions

The high degrees of freedom afforded by the robotic arm allowed for optimal tissue retraction and triangulation. Additionally, the two robotic arms and one working channel of the flexible robotic endoscope provided the surgeon with three operating instruments simultaneously. These benefits allowed the performance of pure NOTES appendicectomy using only the flexible robotic endoscope. Further animal trials are currently being conducted to validate the pure NOTES appendicectomy technique.