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Rigid versus Articulating Instrumentation for Task Completion in Single Port Surgery

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Abstract

Introduction: Single port access surgery (SPA) may provide benefits but there is a steep learning curve. We compare traditional in-line instruments with articulating instruments.

Methods: FLS peg transfer task was performed using a three-port approach or SPA device. Standard rigid instrumentation was compared to articulating instrumentation.

Results: 20 surgeons completed all tasks. Average time using a conventional approach was shorter than SPA (144 ± 54 vs. 198 ± 74 sec, $p < 0.001$). Articulating instruments required longer procedural time than rigid instrumentation (201 ± 66 vs. 141 ± 58 seconds, $p < 0.001$). In the conventional model, task time was lower with rigid instruments than with articulating instruments (108 vs. 179 sec, $p<0.001$). Task time in the SPA model was lower with rigid instruments (173 vs. 223 sec, $p=0.013$).

Conclusion: All tasks required longer time to complete in SPA when compared to a conventional approach. Articulating instruments have an increased benefit in SPA surgery.

Introduction

In conventional laparoscopic procedures, numerous ports are placed throughout the abdomen to optimize access and triangulation for exposure and to perform an operation. Single site surgery is carried out through one access site on the abdominal cavity, which poses different challenges to the surgeon as the ability to triangulate is limited. Recently, SPA has gained interest with some proponents advocating fewer scars, shorter recovery time, but some series have shown higher pain scores and rates of hernia formation.[1, 2, 3] Additionally, the operative time for single incision procedures is longer than operative times for multi-port (MP) approaches in the published series.[15, 16] Nonetheless, some patients may prefer this surgical approach due to concerns of surgical trauma and cosmetic considerations.[2, 3] At short to medium follow up, there are mixed report for cosmesis, as some report that surgical approaches with less port sites than those with traditional MP placement have improved outcomes, while in some analyses there are no differences over the same time course .[3, 15, 16] However, surgeons experience greater difficulty in performing an SPA operation compared to conventional laparoscopic surgery.[4-7, 15, 16]

The difficulties with SPA operations results largely from inline placement of multiple instruments through the single port. [1, 6, 7] The limited range of motion between the two operating hands during an SPA procedure makes bimanual manipulation of tissue more challenging than in a conventional MP approach. Unlike conventional laparoscopy where triangulation is created with multiple ports, the co-axial position of the laparoscope and the instruments can impede visualization.

One solution to increase range of motion between the operating instruments is for the surgeon to cross either their hands or instruments, which results in more freedom in tissue

manipulation. The downside of this approach is either un-natural hand movement with crossed hands or crossing of instruments and an associated increase in operative complexity. To overcome this issue, newer instruments with curves in the shaft and articulating shafts or tips may provide more freedom of movement while maintaining normal hand position[9].

Method

Ethical approval for human subject participation in this study was obtained from the Clinic Ethical Review Board of the University of British Columbia (UBC). Resident and attending surgeons in the Department of Surgery were recruited for this study.

A commercially available training box (Laparoscopic Trainer, 3-D Technical Services, Franklin, Ohio) was used to create a standardized working environment for all procedures. The standard box measures 23" long, 11.5" wide, and 13.5" high, including a 10" LCD color monitor, and a centrally mounted video camera (Figure 1). The trainer has two 10 mm standard ports at equidistance from the camera, which were used in the conventional MP setting. In the SPAs setting, a central port on the side wall of the box was created using a SILS ™ Port (Covidien, Mansfield, MA) to perform SPAs tasks (Figure 1). The SILS port accommodates three instruments including a laparoscopic camera and two instruments.

Participants in this study were required to perform a laparoscopic transport task. This surgical task was selected and modified from the peg transport included in the fundamentals of laparoscopic surgery (FLS) program.[10] For this study, participants were instructed to pick up each object with the non-dominant hand, transfer it to the dominant hand in the air above the

pegs, and then place the object on a peg on the other side of the field. After all objects were transferred in this manner, the process was reversed. The participants then picked up each object with the dominant hand, passed it in the air to the non-dominant hand, and then placed it on a peg on the opposite side. This transport task is an ideal evaluation since it requires bimanual coordination and allows assessment of hand movement difficulties. Time required to complete the task including penalty deduction was recorded in seconds. A penalty of five seconds was applied each time an object was dropped outside the field of view. Objects dropped outside the field were left out of play, and were not placed back on the field. Performance was scored based on time to complete the task and penalties accrued during each variation of the task.

An introductory session to the SPA system and articulating instruments was provided, followed by a practice trial to familiarize the surgeon with the SPA port system and instruments. The practice trial consisted of a brief introduction where participants could complete up to one full cycle of a PEG transfer and see how the instruments articulated during this time. The transport task was carried out by each participant once using a MP setup and then once with an SPA setup. For each approach, the surgeons first performed the task using a pair of standard rigid Maryland graspers (Ethicon Endo-Surgery, Cincinnati, Ohio) and then using a pair of articulating Real – Hand graspers (Novare Surgical System, INC, Cupertino, CA). This articulating grasper has a moving tip that can be bent up to 90 degrees. The order of the task layout carried out by each participant was randomly selected to eliminate bias toward either condition.

ANOVA was utilized to compare task performance between the two surgical approaches and the two types of instruments in different task conditions. Results were reported as mean with standard deviation unless otherwise stated. A *P* value less than 0.05 was considered significant.

Results

A total of 20 surgeons were recruited to the study. Seventeen participants completed the task under all experimental conditions. Three initial participants did not complete the tasks, and declined to finish all tasks for personal reasons. The remaining data were analyzed based on these 17 participants who completed all tasks. The group consisted of 5 attending surgeons, 5 senior general surgery residents in the final two years of training, and 7 junior general surgery residents from the initial training years. The average prior laparoscopic experience was one year for the junior residents, 4.5 years for the senior residents, and 10 years for the staff surgeons. All participants had minimal prior SPA experience, with no participant having more than two prior SPA cases.

The average time required for the combined rigid and articulating groups with the MP approach was significantly lower than the SPA approach (144 ± 54 vs. 198 ± 74 seconds, $p < 0.001$). The time required for task completion was significantly lower using rigid instruments when compared to using articulating instruments (141 ± 58 seconds vs. 201 ± 66, $p < 0.001$). This result was similar when subgroups were compared.

For the MP approach, the task completion time was significantly lower using rigid instruments when compared to articulating instruments (108 seconds vs. 179 seconds $p<0.001$). In the SPA approach, the task completion time was significantly lower using rigid instruments

when compared to articulating instruments (177 seconds vs 223 seconds, p=0.013). There was a 66% absolute increase in time for task completion when articulating instruments were used in the MP approach, while there was a 29% absolute increase in time for task completion when articulating instruments were used in the SPA approach.

Discussion

This study demonstrates the effect on surgeon performance in minimally invasive surgery that occurs after changing from a conventional multi-port laparoscopic approach to a single port approach. There is an increased difficulty that is measured as an increase in the time required to complete a standard task. This was seen across all study groups, regardless of type of instrumentation used. This finding is in concordance with published clinical studies looking at SPA cholecystectomy. In published reports of SPA cholecystectomy, all groups unanimously reported a lengthier OR time with 35 to 50% increased time compare to conventional laparoscopy. [4, 7, 11-13, 15, 16]

In an SPA procedure, the surgical instruments and the optical camera are placed through a single port. This alignment creates new challenges that are typically avoided when multiple ports are placed properly. In addition to the coaxial alignment and space limitation, there are additional difficulties faced by the surgeon due to need for camera operation paired with limited ability for hand movement. The close proximity of the instruments leads to increased difficulty with bimanual coordination along with additional challenges in tissue handling.[8, 14]

Instead of triangulation, the surgeon's rigid laparoscopic instruments during an SPA procedure will often cross immediately under the port site. As a result, the instrument positions on the laparoscopic monitor are opposite the hand positions and external location of the

associated graspers. This spatial misalignment coupled with limited range of motion from the port are likely the main reasons that task performance is worse with an SPA approach than with a traditional multi-port approach. The peg transfer task in this study provides a quantitative measurement of the increased difficulty due to the use of an SPA approach.

The use of articulating instruments did not demonstrate a benefit in this study, and the procedural times were longer when using these instruments in both a SPA and MP layout. Interestingly, the use of articulating instruments did partially mitigate the increased time required for task completion with SPA when compared with less of a benefit in the MP setting. This is graphically represented in Figure 2.

Similar results have been presented when curved instruments were used in SPA cholecystectomy.[15] It is possible that with increased training and long term experience, the non-linear instruments will be a tool to facilitate operating with a limited port approach. The use of articulating instruments can also enable the operator to avoid the crossing of instruments inside the operating cavity, which may result in less of an operative challenge. The curved design of the shaft and handle also allows for more hand movement when compared to the use of standard rigid instrumentation.

One limitation to this study is that all participants were grouped together. There was no differentiation based on subject experience performing laparoscopic procedures. It is not clear from this study how much of an effect prior laparoscopic experience has on SPA competency or ability. This study was also limited in that it there is a small cohort and it has limited power due to the small sample size.

Additional limitations of the current study are that the participants only had a single training session with the articulating instrumentation. This data allows for the understanding of

the initial difference in performance when the operator is at the beginning of the learning curve. From this study it is not possible to know how performance would be different in the SPA or MP approaches after increased exposure and practice with these instruments. The study was not intended to account for the learning curve using these instruments or the SPA approach, and these results should not be expanded to what procedural times might be after the initial learning curve. In particular, many of the subjects did not cross their instruments when using articulating instruments with the SPA approach. Participants were allowed to use the instruments how they chose, and did not have to cross instruments. While crossing instruments creates additional challenges for the surgeon, this may allow for improved ability to manipulate structures and perform tasks with a SPA approach.

It is possible that with more training, the performance gap between rigid and articulating instruments could further decrease, and might even reverse in the SPA setting .[9] Prospective studies have demonstrated that SILS skill are retained only for a short amount of time after training, and are lost when subjects retested after a longer period of not training.[17] Additionally, this study is limited in that only one task was analyzed. These results should not be generalized to all tasks, and it is not possible to know for which types of tasks or procedures there may be the greatest benefit to using articulating instruments.

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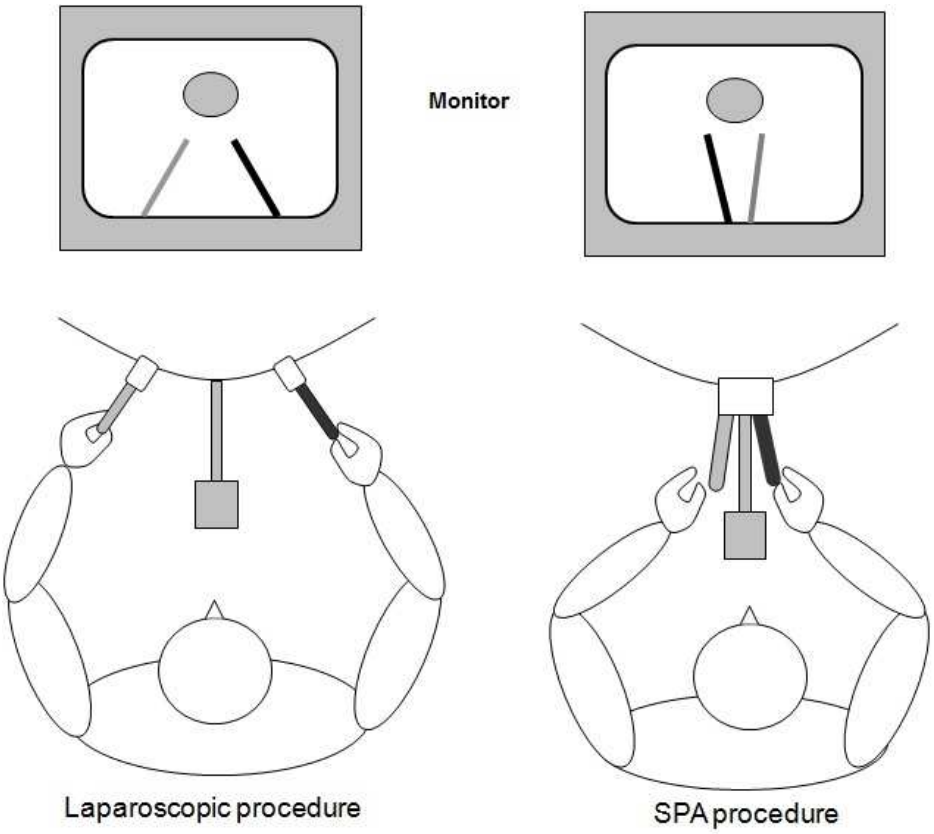
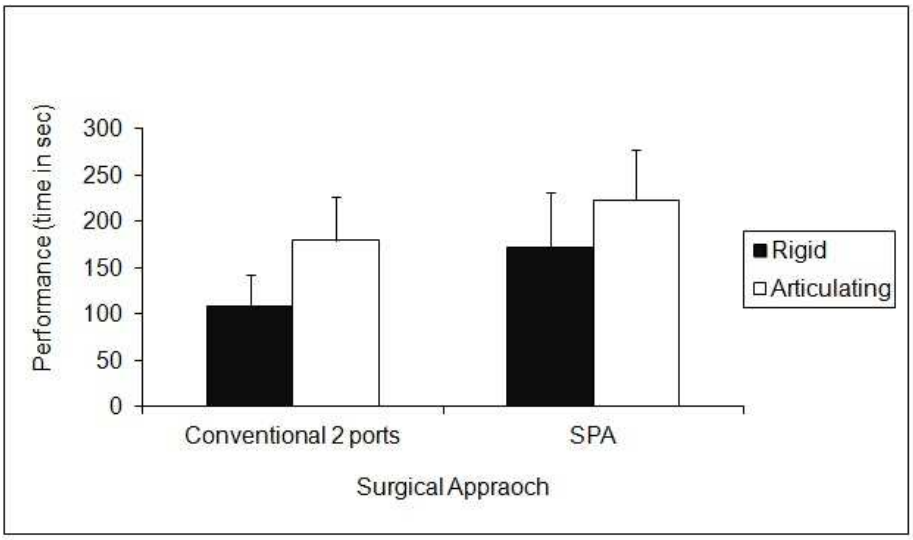
	Surgical Approaches		
Instrument Types	**Multi-port access**	**Single Port Access**	**Combined groups**
Straight rigid instrument	108 ± 34	172 ± 59	140 ± 57
Articulating Instrument	179 ± 46	223 ± 75	201 ± 65
Overall Time	144 ± 54	198 ± 71	

Table 1. Mean time for task completion (in seconds).





DISCUSSION: Erin Gilbert, MD, Portland, OR

The authors were interested in taking a closer look at the effect of both multiple ports versus a single port and straight versus articulated instruments on surgical performance in a simulated setting. They accomplished this as a prospective population based study with 20 surgeons of differing levels of experience. This study is innovative in that it combines both surgical approaches with both types of instruments to assess the effects of each variable on time to complete the simulated modified peg transfer task. As we heard, the best performances were in the setting of combined standard instruments with multiport surgery and the worst was with articulated instruments via a single port. Somewhat unexpectedly, it seemed that the use of straight instruments with the single port improved performance over the articulated instruments which may be a due to existing skill with the instruments overcame the challenges of the coaxial alignment of camera and instruments with the single port approach.

This brings me to my first question… although surgical experience did not correlate either directly or inversely with performance in your study, do you suspect given a larger group, or possibly a completely laparoscopically naïve group, that differences would become apparent and in what way.

Also, based on your observations do you have thoughts as to how to improve instrumentation design with single access surgery.

And finally, in terms of the bigger picture, since 2008 there has been conflicting evidence in the literature in regards to the benefits of single access surgery aside from cosmesis. I am curious, what do you believe the future of single access surgery will be.