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Who Should Do NOTES? Initial Endoscopic Performance of Laparoscopic Surgeons Compared to Gastroenterologists and Untrained Individuals

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Abstract
Introduction Natural orifice transluminal endoscopic surgery (NOTES) is a multidisciplinary surgical technique. If conventional endoscopic instrumentation can be easily mastered, surgeons with laparoscopic experience could head NOTES interventions.
Materials and Methods Thirty individuals were tested for endoscopic dexterity. Group 1 included seven gastroenterologists, group 2 included 12 laparoscopically experienced surgeons lacking endoscopic experience, and group 3 included 11 interns who had no hands-on endoscopic or surgical experience. Each individual repeated an easy (T1), medium (T2), and difficult (T3) task ten times with endoscopic equipment on a NOTES skills-box.
Results Group 3 had significantly poorer performances for all three tasks compared to the other groups. No significant differences were seen between groups 1 and 2 for T1 and T2. The initial T3 performance of group 1 was better than that of group 2, but their performance after repetition was not statistically different. Groups 2 and 3 improved significantly with repetition, and group 2 eventually performed as well as group 1.
Conclusions The data indicate that laparoscopic surgeons quickly learned to handle the endoscopic equipment. This suggests that a lack of endoscopic experience does not handicap laparoscopic surgeons when performing endoscopic tasks. Based on their knowledge of anatomy and the complication management acquired during surgical education, surgeons are well equipped to take the lead in interdisciplinary NOTES collaborations.

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Introduction

Natural orifice transluminal endoscopic surgery (NOTES) represents an entirely new surgical concept dating back to Kalloo's initial publication in 2004[1] and even earlier presentations at international conferences. Since that time, both surgeons and gastroenterologists have worked on the method of puncturing one of the visceral organs in order to perform intraabdominal surgical procedures.[2] American and European gastroenterological and surgical societies have formed collaborative organizations, such as the Natural Orifice Surgery Consortium for Assessment and Re-

search™ (NOSCAR™, USA)[3] and the EURO-NOTES Foundation (Europe),[4] in order to foster further developments in this surgical field. Though initially, gastroenterologists were more engaged and already reported in 2005 that "they have taken the lead,"[5] most human procedures have been performed by surgeons.[6–10] Still, the question of who should perform NOTES in the future, surgeons or gastroenterologists, remains actively discussed.

Evaluating the demands of NOTES may be helpful to answering the question. NOTES, in its current form, require expertise in advanced flexible endoscopy. In addition, procedure-specific surgical and anatomical knowledge is essential, and potential intra- and postoperative complications require surgical know-how and adequate and competent treatment. A NOTES physician has to have detailed knowledge to access the abdominal cavity translumenally, such as how to determine the correct access point and avoid injury to adjacent organs. Furthermore, the flexibility of the endoscope tip complicates the understanding of its distal orientation and requires detailed knowledge of tip placement relative to adjacent anatomic structures, especially when performing retrograde maneuvers.[11] Other, not yet discovered, challenges may be awaiting NOTES-performing physicians. Though gastroenterologists are experts at handling flexible endoscopes, surgeons have more knowledge of the procedure. Therefore, both gastroenterologists and surgeons could potentially qualify as the future NOTES physician; either specialist would have to learn and combine parts of the other's routine practice to be successful at NOTES. Important questions for the future may be to determine which part of the lacking knowledge is easier to acquire and whether gastroenterologists easily learn the procedure-related surgical knowledge or if it is easier to teach surgeons to handle the conventional flexible endoscopes.

We hypothesize that surgeons rapidly learn to handle the flexible endoscopes and that their initial performance is better than that of surgically untrained individuals. Furthermore, we assume that, for basic tasks and tasks of moderate difficulty, the performance is comparable between surgeons and gastroenterologists.

Materials and Methods

Participants

Thirty individuals were tested for endoscopic dexterity. Group 1 (G1) included seven gastroenterologists (GE) who had extensive experience in flexible endoscopy by having performed >200 endoscopies. Group 2 (G2) included 12 laparoscopically trained surgeons who lacked endoscopic experience but had performed at least 100 laparoscopic procedures. Group 3 (G3) included 11 interns who had no significant training for any surgical or laparoscopic device or endoscopes; they also never experienced any selection towards a manually oriented field of medicine (Table 1). Each participant executed each of three tasks exactly ten times after one initial warm-up attempt to verify a correct understanding of the task. No additional option for task training was given.

Equipment

All tasks were performed with flexible endoscopic equipment on a self-designed and constructed NOTES skills-box. A commonly used flexible endoscope (GIF-H180 Olympus Medical Systems Europe GmbH, Hamburg, Germany) and flexible endoscopic grasper (FD-410LR Olympus Medical Systems Europe GmbH, Hamburg, Germany) were utilized for all tasks.

Tasks

We considered task 1 (T1) to be a fairly basic task. It required the precise and single-handed maneuvering of the tip of the endoscope as well as the endoscopic grasper. Task 2 (T2) was of moderate difficulty and focused on hand–eye

Table 1 Distribution and Experience of Participants

Speciality	*N*	Gender	Median age (years)	Professional experience		Laparoscopic experience		Endoscopic experience	
				years	*n*	Number of procedures	*n*	Number of procedures	*n*
GE	7	1 ♀	37	≤6	2	0		>200	7
		6 ♂		>6	5				
Surgeon	12	2 ♀	38	≤6	3	100–200	3	0	
		10 ♂		>6	9	>200	9		
Trainee	11	6 ♀	24	0–1	8	0		0	
		5 ♂		<4	2				

GE Gastroenterologist

coordination and spatial orientation. Task 3 (T3) was assumed to be the most difficult task and combined the requirements of T1 and T2.

In T1, participants had to introduce the gastroscope, with retracted grasper, into the NOTES box, after 23 cm pass a 50-mm high barrier, advance the scope another 22 cm to the end of the box, approximate a target on the opposite wall, and ultimately touch a 5-mm diameter bull's eye with the endoscopic grasper (Fig. 1a).

In T2, participants had to introduce the gastroscope into the NOTES box, pick up a small fabric ball (swab, diameter 8 mm) from a height of 20 mm in the center of a 5-mm deep basket, and lay the swab down in a basket of the same size 35 mm lateral to the first one (Fig. 1b).

In T3, participants had to pick up a fabric ball with the grasper in a 90° flexion. The ball was on a small shelf approximately 20 cm from the box entrance at the right wall and at a height of 8 cm. The fabric ball was then placed in a basket approximately 8 cm to the left of the shelf (Fig. 1c).

Each participant assessed the difficulty of the tasks using a postperformance visual analog scale (VAS), from 1 for a very easy task to 10 for a very difficult task, in order to assess the individual appraisal of difficulty. The time needed to complete each task was measured and evaluated.

Statistical Analysis

A comparison of means between several groups was performed by one-way analysis of variance (ANOVA; Tukey–Kramer multiple-comparison test for statistical differences between groups). The Mann–Whitney *U* test was used to compare means between two means, and ANOVA for repeated measures was used to assess the differences in task performance through repeated executions. $P<0.05$ was considered significant. NCSS 2001 software (Number Cruncher Statistical Software, Kaysville UT, USA) was used for statistical calculations.

Results

Interns Executed All Tasks Slower than Gastroenterologists or Surgeons, Who Performed Similarly for T1 and T2

Groups 1 and 2 completed T1 [G1 median 23.3 s, 95% confidence interval (CI) 21.1–34.6; G2 median 30.6 s, 95% CI 19–38.8] and T2 in a comparable amount of time (G1 median 31.3 s, 95% CI 13.9–40.6; G2 median 29.8 s, 95% CI 25.9–36.7; Fig. 2a,b). Group 1 performed T3 faster than group 2 (G1 median 60.4 s, 95% CI 33.5–94.9; G2 median 68.4 s, 95% CI 57.4–93.3), but the difference was not significant (Mann–Whitney *U* test; Fig. 2c). Group 3 performed all tasks (T1 median 96.8 s, 95% CI 60.6–118.2; T2 median 57.7 s, 95% CI 42.7–67; T3 median 146 s, 95% CI 92.2–161.2) at a significantly slower pace than groups 1 and 2 ($P<0.0001$ for all tasks, ANOVA; Fig. 2a–c).

Subjective Difficulty of the Tasks was Perceived Equally Between the Groups and Independent of Task Performance

Individual appraisal of task difficulty on a VAS revealed no significant differences between the groups. The mean score for T1 was 4.7 (95% CI 3.8–5.6) for G1, 4.5 (95% CI 3.7–5.3) for G2, and 4.4 (95% CI 3.7–5.15) for G3 (Fig. 3a). For T2, the corresponding values were 4.7 (95% CI 3.4–5.3), 3.7 (95% CI 2.8–4.5), and 4 (95% CI 2.6–5.4) for G1, G2, and G3, respectively (Fig. 3b). Task 3 was rated as 7.1 (95% CI 5.9–8.3) by G1, 7.1 (95% CI 6.5–7.7) by G2, and 6.4 (95% CI 5.1–7.7) by G3 (Fig. 3c).

Improvement by Task Repetition was more Pronounced in the Surgical Group

Improvement in task performance through repetition, as measured by speed, can give an indication of how quickly a lack of experience in the handling of complex instruments

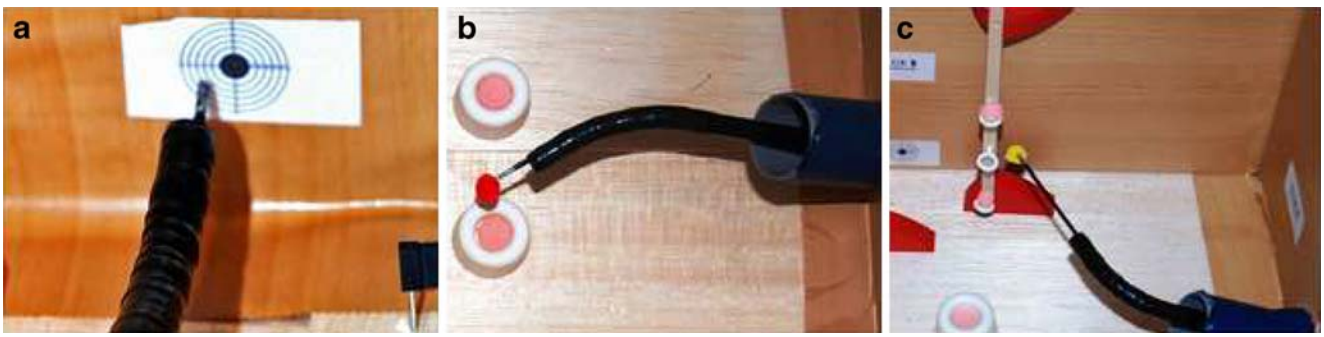

Figure 1 Tasks used to test for dexterity. **a** The approximation of the target in task 1, which involved touching the bull's eye with an endoscopic grasper. **b** Task 2 required grasping the fabric ball out of one basket and placing it into the second basket. **c** Task 3 required grasping the fabric ball from the middle ring on the shelf and laying it down into the right basket.

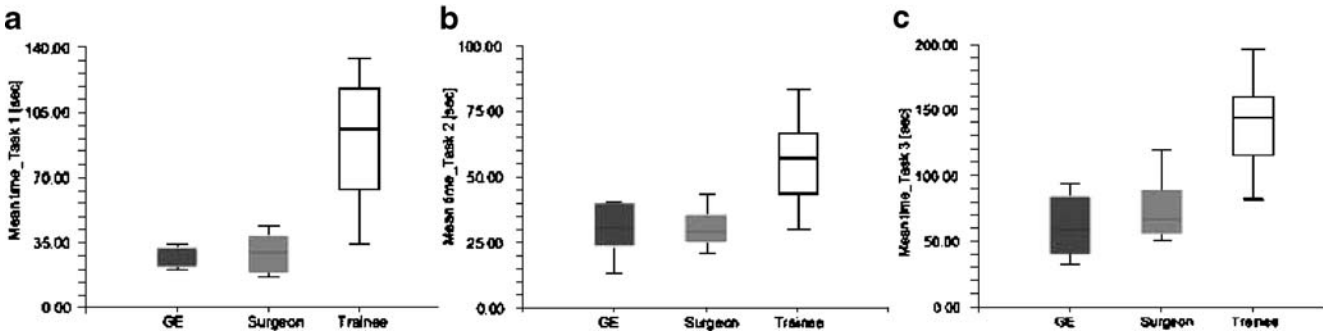

Figure 2 Boxplot comparisons of performance between groups for **a** task 1, **b** task 2, and **c** task 3. *Box lengths* represent the interquartile range (IQR) of 50% (from 25% to 75%), the *middle lines* represent the medians, and *T-bars* 75%/25% plus/minus 1.5 times the IQR. *GE* gastroenterologist.

and spatial adaptation can be overcome.[12,13] When considering who should perform novel tasks that require several degrees of knowledge, including basic surgical and anatomical knowledge, spatial orientation, manual dexterity, hand–eye coordination, instrument handling, and the management of potential complications, the steepness of the so-called learning curve in each category is essential knowledge.

Evaluating the improvement by repetition of the three groups showed that gastroenterologists, surgeons, and trainees improved similarly, if repeated task performance was compared to the initial task performance (time to complete task the first time; Fig. 4a,b). Gastroeneterologists showed no improvement by repetition in the difficult task (Fig. 4c). This indicates that this group has already an expertise in solving such difficult tasks and that further improvement cannot be gained by just ten repetitions.

Evaluating the time that surgeons or gastroenterologists needed to complete a task showed that there was no significant difference in improvement for the simpler tasks. (Fig. 5a,b). However, for the most difficult task, the initial performance by surgeons was significantly slower than that of gastroenterologists, but the surgeons improved significantly more over the course of the repetitions compared to gastroenterologists (ANOVA for repeated measures, $P=0.003$; Fig. 5c).

Laparoscopic or Endoscopic Experience Improved Task Performance Speed

Comparing test results between experts who had performed more than 200 laparoscopies or endoscopies and those without any endoscopic or laparoscopic experience found that the experienced groups performed significantly better for all three tasks (laparoscopic vs. inexperienced: T1 $P<0.019$, T2 $P<0.015$, T3 $P<0.055$; endoscopic vs. inexperienced: T1 $P<0.028$, T2 $P<0.088$, T3 $P<0.021$). These findings strongly correlate with the test results when comparing professional experience. Physicians with more than 6 years of experience had significantly better test results for all tasks compared to less experienced or inexperienced physicians ($P<0.001$).

Discussion

The data supports the hypothesis that endoscopically inexperienced laparoscopic surgeons are capable of quickly

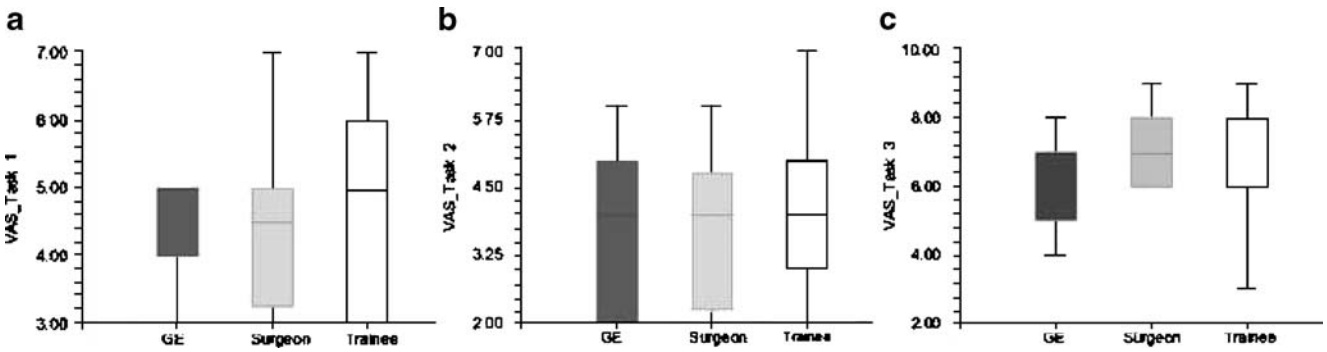

Figure 3 Individual appraisal of task difficulty on a visual analog scale. **a** Task 1, **b** task 2, and **c** task 3. *Box lengths* represent the IQR of 50% (from 25% to 75%), the *middle line*s represent the medians, and *T-bars* 75%/25% plus/minus 1.5 times the IQR. *GE* gastroenterologist.

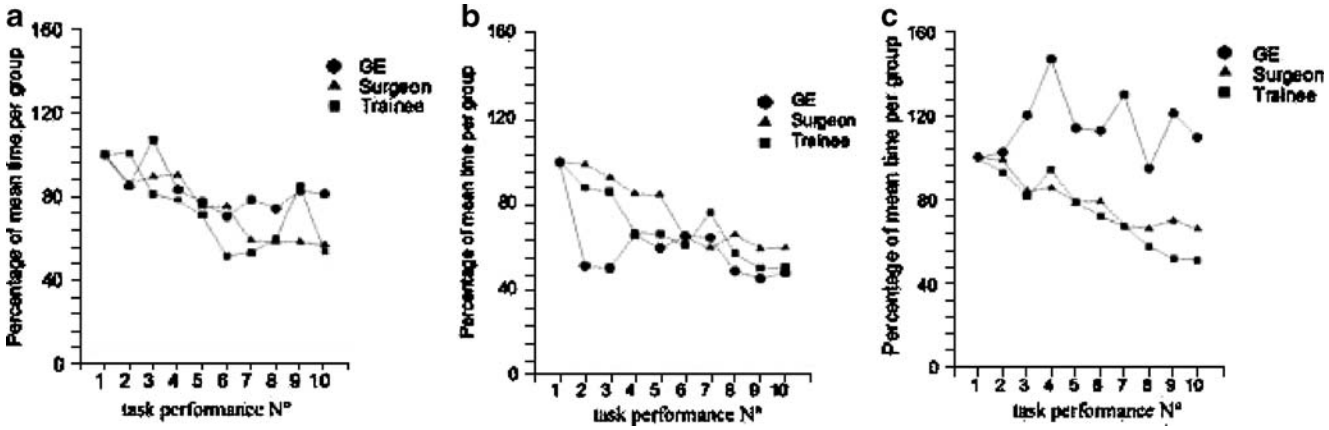

Figure 4 Learning curve adjusted for the mean time of initial execution by groups. **a** Task 1, **b** task 2, and **c** task 3. *GE* gastroenterologist.

(within ten repetitions) mastering the basic handling of a flexible endoscope. Their initial performance is superior compared to laparoscopically or endoscopically untrained persons. The results suggest that laparoscopic and/or surgical experience aids in learning to handle new instrumentation, such as flexible endoscopes. Admittedly, the better performance of experienced surgeons compared to interns may also be due to the selection of surgeon-specific traits and skills that facilitate a faster performance. In other words, young doctors who chose to be trained in the technically oriented field of surgery may be more dexterous than individuals who prefer less manually demanding fields of medicine. In addition, a laparoscopic surgeon who is already at an advanced level in his career has received years of manual training and has gone through a certain selection process by this training. Furthermore, laparoscopic surgeons are very familiar with the spatial orientation of the abdominal cavity and likewise the NOTES skills box.

While the gastroenterologists in our study were most familiar with the flexible endoscopes, they have never intentionally used them in an "open" space outside tubular structures. Overall, gastroenterologists performed the more difficult task better than the other test groups. These findings may be based on the fact that gastroenterologists do not depend on a "stable" visual horizon, which laparoscopically trained surgeons usually use as a benchmark. Furthermore, surgeons are accustomed to performing interventions where the image movements are not linked to the manipulated tools unlike in endoscopy. However, the present study demonstrates that surgeons can overcome these "new" hurdles after a short time of practice and quickly adapt to the required or sometimes helpful rotation of the horizon.

Hence, the limited experience in flexible endoscopy is unlikely to be a major handicap for surgeons for the upcoming NOTES era. The growing industrial interest in this new minimally invasive technique is currently resulting in the development of more NOTES-specific instruments and platforms. Presumably, this makes specific knowledge and the demanding ability to appropriately utilize conven-

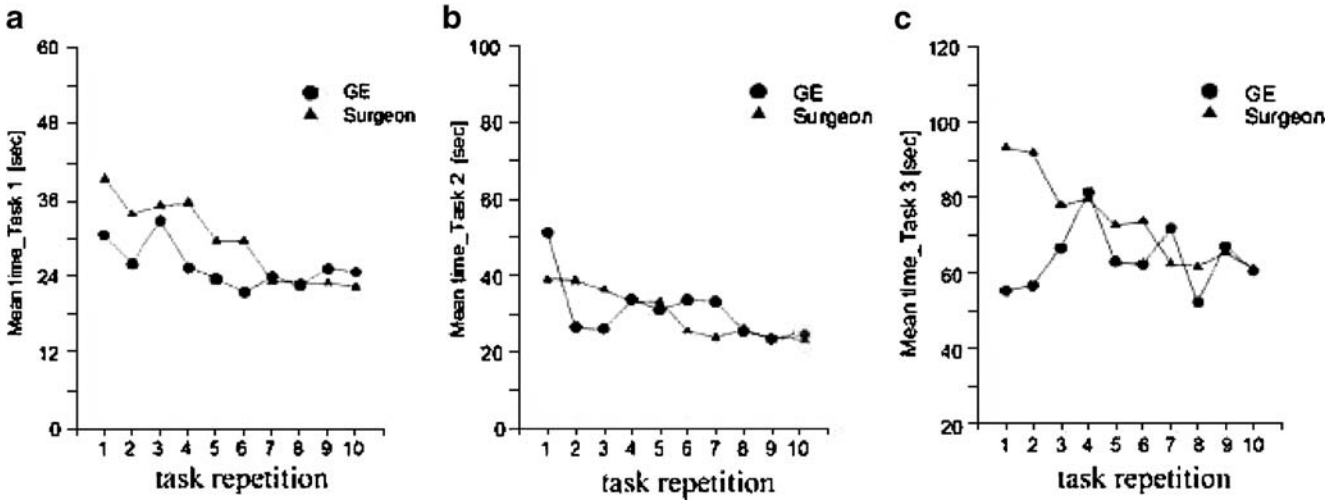

Figure 5 Improvement in task performance, as measured by speed, through repetition. **a** Task 1, **b** task 2, and **c** task 3. *GE* gastroenterologist.

tional endoscopes in NOTES procedures dispensable in the future.[14]

This study has certain restrictions and limitations. The reliability and validity of the chosen tasks for this study are not yet known. It remains unknown if results in our NOTES box correlate with NOTES performance in patients. Yet, we tried to choose realistic tasks, including testing for orientation, precision, and use of instrumentation in both a straight direction and in a 90° flexion. On the other hand, successful performance in NOTES is not only asking for the dexterous handling of a flexible endoscope. Intralumenal skills and experience, a characteristic of gastroenterologists, are crucial for this kind of surgery. Still, knowledge of intraabdominal anatomy and the procedure itself seems to be more important, and it is most certainly mastered by laparoscopic surgeons. Also, pre- and postoperative patient care and control of complications appears to be a surgical domain.

Conclusion

The present study supports the conclusion that surgeons will very quickly learn to handle flexible endoscopes. Because they have procedure-related knowledge and anatomical expertise, it appears logical that surgeons will assume control in NOTES procedures in the future. However, gastroenterologists most likely also have the means to acquire the surgical knowledge and skills and they also have the potential to conserve their role in the field of NOTES. At present, both surgeons and gastroenterologists do not have the complete skills set and applicable universal and intelligence platforms to successfully perform NOTES without each other. Therefore, it seems logical to create interdisciplinary teams to teach one another. In the short term, doctors, regardless of whether they are surgeons or gastroenterologists, with the best skills portfolio will be the NOTES physicians. In the long run, the training curricula for NOTES will be developed, and we may be able to identify who should perform NOTES: surgeons, gastroenterologists, or physicians trained in both fields.

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