ORIGINAL REPORTS

Validation of a Novel Inverted Peg Transfer Task: Advancing Beyond the Regular Peg Transfer Task for Surgical Simulation-Based Assessment

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OBJECTIVE: To evaluate the validity of a novel inverted peg transfer (iPT) task for assessing laparoscopic skills of novices and experts and compare iPT to the regular PT (rPT) task to ensure surgical trainee acquisition of an adequate advanced laparoscopic skills level for safe laparoscopic practice in the operating room.

DESIGN: Prospective crossover study.

SETTING: Multidisciplinary simulation center and motion analysis laboratory, Mayo Clinic.

PARTICIPANTS: Novices were medical students and surgical interns without laparoscopic experience. Experts were surgeons with at least 3 years of experience in laparoscopic surgery.

METHODS: This was the first exposure to iPT for both groups. Completion time and performance metrics were recorded. A scoring rubric was used to calculate a normalized performance score between 0 and 100. Wilcoxon rank sum and Mann-Whitney tests were performed with $\alpha = 0.05$. Receiver-operating characteristic curves were graphed for the 2 task scores to assess the tasks' sensitivity and specificity in differentiating laparoscopic experience level.

MAIN OUTCOME MEASURES: Performance measures of completion time, transferred triangles, dropped triangles (errors), and the overall performance score on both tasks between- and within-subjects (i.e., novices and experts).

RESULTS: Thirty-six novices and eight experts participated. Both experts and novices had longer completion time and lower scores during iPT than rPT ($p < 0.05$). Within iPT, novice completion times were 144 seconds longer ($p = 0.04$), and performance score was 35 points lower than experts ($p < 0.01$). No differences between novices and experts were observed for completion time or performance scores ($p > 0.05$) for rPT. The iPT scores had a higher sensitivity and specificity than the rPT (area under the receiver-operating characteristic curve: iPT = 0.91; rPT = 0.69).

CONCLUSIONS: iPT is a valid assessment of advanced laparoscopic skills for surgical trainees with higher specificity and sensitivity than rPT. As advanced minimally invasive surgery becomes more common, it is important that tasks such as iPT be included in surgical simulation curricula and training assessment. (J Surg Ed ▮:▮▮▮-▮▮▮. ©2017 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: validation study, assessment, in situ simulation, sensitivity analysis, motor skill

COMPETENCIES: Patient Care

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INTRODUCTION

The fundamentals of laparoscopic surgery (FLS) curriculum has become an essential requirement that residents must complete before taking the American Board of Surgery examinations.[1] Although FLS is viewed positively in minimally invasive surgery (MIS) training and surgical safety circles,[2] the educational benefits of FLS are limited in regards to the ability of evaluating surgical trainees' advanced laparoscopic skills.[3]

Despite considerable research aiming to understand the role of simulation in assessing basic laparoscopic skills[4] and transferring laparoscopic skills to the operating room,[5-7] little research has been performed to assess the advanced laparoscopic skills for surgical trainees in the simulation setting. Evaluating the advanced laparoscopic skills in the simulation settings is an important step needed to assess safe independent performance of laparoscopic procedures in the operating room. In 2013, 30% of surgical fellowship program directors report first-year surgical fellows (those having completed 5 years of general surgery training, and having successfully passed the FLS assessment before sitting for the American Board of Surgery Certification Examination) unable to perform basic laparoscopic procedures independently; more than 50% had laparoscopic skill levels below surgical fellowship program directors expectations.[8] Recently, George et al.[9] showed that only 33% of graduating general surgery residents were deemed ready to perform core procedures like cholecystectomy and ventral hernia repair. These findings highlight the need for an advanced laparoscopic surgical simulation curriculum.[10]

Few advanced laparoscopic surgical simulation tasks have been developed for laparoscopic skills assessment.[3,11,12] Those studies had several validity limitations and they are focused on different laparoscopic skills other than bimanual coordination which is considered by 72% of surgeons in different career levels as one of the most important laparoscopic skills that needs to be improved through simulation training.[10] Well-constructed laparoscopic tasks with specific challenges requiring advanced laparoscopic skills in bimanual and eye-hand coordination are needed to prepare surgical trainees for complexities that may arise in the operating room and can be preemptively addressed in a simulation setting.[13] An assessment tool with greater difficulty than standard FLS tests may better discriminate among varying laparoscopic skill and performance levels. An objective method to differentiate which residents can perform laparoscopic procedures safely and independently in the operating room would be useful to trainees, program directors, and patients alike.

The goal of this study was to evaluate the validity of a novel, advanced, laparoscopic surgical task (inverted peg transfer [iPT] task) in laparoscopic skills assessment and differentiation between participants from 2 distinct laparoscopic surgery experience levels (i.e., experts versus novices). Using the relevant sources of validity evidence from Messick's validation model,[14] this study focused on assessing validity based on test content, response processes, internal structure, and relations to other variables. Furthermore, this study assessed the sensitivity and specificity of iPT compared to regular peg transfer (rPT) during laparoscopic skills assessment.

MATERIALS AND METHODS

Development of Advanced Laparoscopic Skill Task (*Content and Response Process Source of Validity Evidence*)

Initially, the iPT test was designed to assess the same laparoscopic skills as the rPT test, but with more difficulty and in a new orientation, simulating a laparoscopic procedure from real practice—for example, laparoscopic ventral hernia repair.[15] The research team believed the iPT task had potential to help in assessment of laparoscopic skills among surgical trainees for several reasons. First, current literature showed a potential gap between the acquired basic laparoscopic skills from current surgical simulation modules and the required advanced laparoscopic skills that match the complexities in practice[10]; iPT was designed systematically with more complexity to better match the real practice. Second, bimanual coordination was reported as one of the highest laparoscopic skills that need to be improved for surgical residents[10]; iPT could test this skill within a more complex task similar in orientation to a laparoscopic ventral hernia repair.

A multidisciplinary team of experts developed the iPT platform using the same elements of the standard of rPT from FLS. Human factors and ergonomics engineers and 2 subject matter experts, MIS surgeons with extensive residency mentorship experience, iteratively designed, tested, and approved the iPT as an advanced laparoscopic skills task for assessment. Subject matter experts agreed iPT would test the same skills tested by rPT (i.e., hand-eye coordination, ambidexterity, and depth perception) with more difficulty and hypothesized that the higher level of difficulty with the iPT would increase its differentiating ability of previously mentioned laparoscopic skills between experts and novices. In addition to ensuring adequate lighting and standardization of the dimensions and target angles according to the rPT design, human factors engineers tested the magnetic strength multiple times so that the triangles stuck to the peg board only if the participant pushed the triangles sufficiently to fix them in a similar manner to fixing the mesh in the laparoscopic ventral hernia repair (i.e., to minimize the impact of the magnet in pulling the triangles from a distance before they touched the peg board or substantially increasing the force required to pick up the triangles from the board, which minimizes the magnetic interference with the actual participant