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Perceptual, visuospatial, and psychomotor abilities correlate with duration of training required on a virtual-reality flexible endoscopy simulator

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Abstract

Background: Trainees acquire endoscopic skills at different rates. Fundamental abilities testing could predict the amount of training required to reach a performance goal on a virtual-reality simulator.

Methods: Eleven medical students were tested for fundamental abilities. Baseline endoscopic proficiency was evaluated with the GI Mentor II VR simulator (Simbionix, USA, Cleveland, OH). Subjects trained on the simulator with a defined performance goal. Subjects who achieved the goal were then reassessed.

Results: All subjects completed at least 10 trials or reached the performance goal. The <10 trial group (n = 6) tested better for all fundamental abilities and baseline endoscopic performance than the >10 trial group (n = 5). The number of trials required to reach the performance goal correlated significantly with both perceptual ($r = .92$, $P = 0.001$) and visuospatial ability ($r = .76$, $P = .03$). Multiple regression showed strong correlation of all three abilities with duration of training ($r = .95$, $P = .015$).

Conclusions: Most of the variability in acquisition of endoscopic skills can be accounted for by differences in fundamental abilities of trainees. Testing of fundamental abilities could help identify trainees who will require additional training to achieve desired performance objectives.

Keywords: Abilities; Flexible endoscopy; Objective assessment; Simulation; Visuospatial abilities

Surgical training in the United States is undergoing a major paradigm shift. As a direct result of the Libby Zion case 1 and the "To Err is Human" report issued by the Institute of Medicine [2], training time for residents has been significantly decreased. Because of these changes, program directors across the country are faced with the problem of ensuring that residents finish training with the same surgical and endoscopic skill set as their resident predecessors despite having less time to train. In this new era of training, efficient use of training time and resources is of paramount importance.

In general surgery, one of the areas of training that is significantly challenged by these new restrictions is flexible endoscopy. Although the American Board of Surgery requires all residents to be exposed to flexible endoscopy [3], no clearly defined training guidelines exist. Similarly, the Accreditation Council for Graduate Medical Education encourages exposure to and tracks performance of flexible endoscopic procedures, but no minimum case requirements exist for successful completion of residency. This lack of clear guidelines makes training in flexible endoscopy a likely casualty of the new resident training-time restrictions.

The importance of skill in flexible endoscopy to the practicing general surgeon cannot be overstated. Recertified surgeons report that flexible endoscopy is performed as frequently as hernia repair in most general surgery practices, second only to cholecystectomy [4]. Therefore, to adequately prepare residents for practice as general surgeons,

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we must ensure that adequate proficiency in flexible endoscopy is achieved.

Acquiring flexible endoscopic skills can be difficult, and the rate of skill acquisition varies greatly among trainees. This variability is mirrored by the minimum case number recommendations for competency in flexible endoscopy required by international endoscopic societies ranging from as low as 50 to as high as 300 cases [5–9]. With the new era of decreased training time, coupled with the uncertainty and variability surrounding the accepted standards for competency, the ability to determine which trainees will require more training to reach proficiency and which will require less would be highly beneficial.

We hypothesized that one way to distinguish between those who will require more or less training is the assessment of fundamental abilities. Abilities have been defined as fundamental mental aptitudes that are essentially determined at birth or in early childhood. This is compared with skills, which denote developed proficiencies [10]. Visual perceptual ability has been shown to correlate with performance of minimally invasive surgical tasks on both a box trainer and on a virtual-reality trainer [11]. Psychomotor abilities have been correlated to trainees' initial performance of flexible nasotracheal endoscopy [12]. No work to date has been done to examine the relationship between fundamental psychomotor and visuospatial abilities and performance of gastrointestinal endoscopy. Our objective was to determine whether perceptual, visuospatial, or psychomotor abilities would correlate with the duration of the learning curve on a virtual-reality flexible endoscopy simulator.

Methods

Subjects

Sixteen fourth-year medical students enrolled in an elective course to teach surgical anatomy and train surgical skills using animate, inanimate, and virtual-reality simulation. All students were eligible for the study, but participation was voluntary and in no way affected the students' graded evaluation. Collected demographic data included sex, age, hand dominance, hand size, need for vision correction, and previous endoscopy experience.

Ability testing

All students in the course were assessed for perceptual, visuospatial, and psychomotor abilities. Perceptual ability was measured with the pictoral surface orientation test (PicSOr) [13]. This computer-based test requires subjects to determine the 3-dimensional orientation of a 2-dimensional grayscale cube. Thirty-nine consecutive cubes are presented, and subjects are required to estimate the slant of a representative surface of the cube. The PicSOr score is generated by correlation of perceived slant and actual slant, thus rewarding consistency of perception over any single accurate or inaccurate interpretation. PicSOr has been previously validated as a measurement of visual perception [11]. Visuospatial ability was measured with the cube-comparison test taken from the manual of kit factor reference tests commonly used for psychometric testing [14]. This test requires subjects to compare two 2-dimensional renderings of 3-dimensional cubes and determine if the cubes could be the same. Finally, psychomotor ability was measured by performance on the Minimally Invasive Surgical Trainer–Virtual Reality (MIST-VR, Mentice, Sweden). Subjects performed all 6 Core Skills 1 tasks on the medium setting, and the composite scores were summed for all 6 tasks. This method has been previously validated to assess psychomotor ability [15].

Flexible endoscopy performance

The GI Mentor II (Simbionix United States, Cleveland, OH) was used for flexible endoscopy assessment and training. The Endobubble task of the Cyberscopy module was used. This task requires users to navigate a virtual pipe with a flexible endoscope and burst balloons without contacting the walls of the pipe. On level 1, there are 20 large balloons. On level 2, there are 40 small balloons that disappear if not reached in a finite time period. Level 2 has been previously validated to differentiate between novice and experienced endoscopists [16,17]. All participating subjects had baseline flexible endoscopy performance assessed with a single trial of the Endobubble task on skill-level 2. The were then instructed to train on skill-level 1 with a performance goal of bursting all 20 balloons in $\leq$90 seconds with no wall strike errors. This level of performance had to be demonstrated on 2 consecutive trials for the performance goal to be reached. This goal was based on unpublished data from performance of 8 experienced endoscopists on Endobubble level 1 collected in the E*STAR laboratory. It was not intended to be a well-established level of proficiency, merely a reasonable performance goal for the training subjects to reach. Once this level of proficiency was reached, subjects were again evaluated with a single trial of skill-level 2.

Statistical analysis

Data analysis was performed using InStat version 3.05 for Windows XP (GraphPad software). Means of continuous variables were compared using unpaired Student t test with Welch correction. Differences in dichotomous variables were compared using Fisher's exact test. Correlations were determined using Pearson's product moment correlation coefficient. Statistical significance for all tests was $P < .05$.