Cognitive Models for Mentally Visualizing a Sharp Instrument in a Blind procedure

Mueller FE, Arif MA, Bachar A, King GW, Stylianou AP, Sutkin G

Background

Motor skill learning is challenging in procedures that rely on blind passage of a sharp instrument near vital organs. Our objective was to understand the cognitive strategies used by surgeons to mentally visualize navigation of a surgical instrument through blind space.

Methods

We conducted semi-structured interviews with 7 expert and 8 novice participants following simulated retropubic trocar passage on 3D-printed models of three patient's pelvises segmented from preop MRIs. We chose this procedure from the midurethral sling surgery because the instrument is blindly passed between the urethra, bladder, iliac vessels, and bowel using haptic feedback from the suprapubic bone (SPB) for guidance. Our conceptual foundation was Lahav's study of the blind person's cognitive mapping of spaces using haptic cues.[1] We asked participants to detail how they mentally pictured the trocar's location relative to vital anatomy. We coded all responses and used constant comparative analysis to generate themes, confirmed with member checking.

Results

Expert and novice participants utilized multiple cognitive strategies combined with haptic feedback to accomplish safe passage of the trocar. They visualized the curved path around the SPB as a "straight line" or tunnel because visual clues (entry and exit points) could not guarantee success. Some used a step-by-step route strategy, passing through sequential 2D axial images of anatomy adjacent to the SPB. Others used a map strategy, forming global 3D pictures of surrounding organs. Although these mental pictures vanished when they were "lost," a safe zone could be reestablished by touching the SPB. Experts were more likely to relate their core body position to the trocar path and rely on minor variations in resistance (i.e.: gritty scraping against bone). Experts described minor recalculations in trocar path, based on visualizing trocar position relative to surface angles and width of the SPB. Novices were more likely to "start, aim and pray you don't hit anything" and employ backtracking of the trocar.

Conclusion

Our findings may be extended to any blind surgical procedure. Teaching visualization strategies and incorporating tactile feedback can be used intraoperatively to help learners navigate their instrument safely around vital organs.

Figure

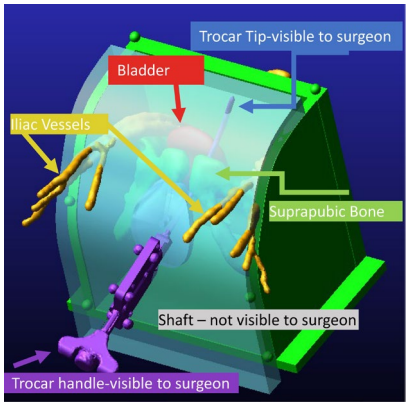

Image of steel trocar passing through the simulation phantom. The tip has passed through the anterior abdominal wall, and the handle and the tip of the trocar are visible, but the shaft of the trocar is invisible inside the gel of the model, passing between the bone, urethra, bladder, iliac vessels, and bowel. This is analogous to the procedure when the trocar must be guided blindly past these structures.

Reference

1.Lahav et al, *Computers in Human Behavior*, 2003.