Visuomotor constraints in laparoscopic surgery: a human factors engineering perspective

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Abstract
The purpose of this study was to analyse the system constraints in laparoscopic surgery using a human factors engineering approach. This analysis is a critical first step towards the design of effective technology for advancing the state of the art in laparoscopic surgery in general. A field study was conducted to gather data through interviews, direct observations and video recordings of three different laparoscopic procedures (cholecystectomy, inguinal hernia repair, and fundoplication). Several analyses were performed: 1) a hierarchical task analysis for each procedure, 2) a detailed time and motion analysis for selected tasks (suturing, tying knots, and dissecting), and 3) a cognitive task analysis using the human information processing model. Results indicate four classes of constraints in this system: physical/motoric, safety, precision, and visuomotor constraints. In particular, visuomotor transformations for the purpose of remote manipulation in this environment seems to be the critical element in effective laparoscopic surgery. Surgeons must adapt to a novel and variable arrangement of perception-action loop: indirect manipulation of tissue, a displaced and magnified view of the surgical site, and sometimes an incongruent alignment of the displaced view relative to the surgical site. This affects the perception of position and orientation of organs and tissues, and consequently the accuracy of remote manipulation and success of surgical procedure. In some situations, visuomotor coordination involves a high degree of uncertainty and risk, potentially resulting in errors, slips and mistakes.
This paper discusses the implications of these results for future efforts in endoscopic technology development.