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Original Article

Ergonomic Deficits in Robotic Gynecologic Oncology Surgery: A Need for Intervention

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ABSTRACT **Study Objective:** To evaluate surgeon strain using validated ergonomic assessment tools.

Design: Observational study (Canadian Task Force classification III).

Setting: Academic medical center.

Participants: Robotic surgeons performing gynecologic oncology surgical procedures.

Interventions: Videotape footage of surgeons performing robotic gynecologic oncology procedures was obtained. A human factors engineer experienced with health care ergonomics analyzed the video recordings and performed ergonomic evaluations of the surgeons.

Measurements and Main Results: An initial evaluation was conducted using the Rapid Upper Limb Assessment (RULA) survey, an ergonomic assessment and prioritization method for determining posture, force, and frequency concerns with focus on the upper limbs. A more detailed analysis followed using the Strain Index (SI) method, which uses multiplicative interactions to identify jobs that are potentially hazardous. Seventeen hours of video recordings were analyzed, and descriptive data based on RULA/SI analysis were collected. Ergonomic evaluation of surgeon activity resulted in a mean RULA score of 6.46 (maximum possible RULA score, 7), indicating a need for further investigation. The mean SI grand score was 24.34. SI scores >10 suggest a potential for hazard to the operator. Thus, the current use of the surgical robot is potentially dangerous with regards to ergonomic positioning and should be modified.

Conclusion: At a high-volume robotics center, there are ergonomics deficits that are hazardous to gynecologic surgeons and suggest the need for modification and intervention. A training strategy must be developed to address these ergonomic issues and knowledge deficiencies. Journal of Minimally Invasive Gynecology (2013) 20, 648–655 © 2013 AAGL. All rights reserved.

Keywords: Ergonomics; Occupational strain; Rapid upper limb assessment; Robotic surgery; Strain Index

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Ergonomic strain among surgeons performing minimally invasive surgery (MIS) is more pervasive than previously thought. Historically, surgeon strain related to MIS has been quoted at 12% to 18% [1,2]. However, recent studies in the general surgery and gynecologic oncology literature report strain rates as high as 87% to 88% [3,4]. Strain during traditional laparoscopy has been attributed largely to nonergonomic positioning [5,6]. Robotic surgery, a subset of MIS, is widely thought to provide ergonomic benefit while also expanding surgeon capabilities [7,8]. Although strain among surgeons performing robotic surgery is generally thought to be lower than that in surgeons using

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traditional laparoscopy, reported neck and torso strain in robotic surgery remains substantial [9]. The literature indicates that a lack of ergonomic knowledge and training in proper ergonomic technique may be responsible for the strain associated with performing robotic surgery [3,4,10].

Although the Da Vinci surgical system (Intuitive Surgical, Inc., Sunnyvale, CA) has experienced widespread acceptance and growth over the past decade [11–14] and the early literature suggests that it is more ergonomically favorable and potentially less mentally stressful than laparoscopic surgery [15,16], literature evaluating these potential ergonomic benefits is sparse. One such study of gastrointestinal surgeons performing gastric bypass surgery found that laparoscopy caused more discomfort in the shoulders, arms, and wrists, according to Rapid Upper Limb Assessment (RULA) analysis, and that robotic surgery caused more discomfort in the neck and trunk when evaluated using the Body Part Discomfort (BPD) scale [9]. The authors concluded that robotic methods offered both postural advantages and disadvantages for minimally invasive surgeons.

Researchers have used RULA for ergonomic evaluation of MIS because it screens for stressors to the shoulder, elbow, and wrist and prioritizes job tasks for further investigation [17–19]. Using descriptive guidelines, the evaluator assigns numerical values to postures and forces and sums these values to arrive at a grand score. RULA evaluation is conducted for one side of the body at a time. Although RULA uses observations of lower limb and neck positioning, it does not assess ergonomic strain in these areas [19]. RULA grand scores >5 indicate that the individual performing the job task is at increased risk for musculoskeletal injury, and grand scores >7 indicate that the job is probably hazardous. Although RULA makes observations of lower limb and neck positioning, it does not assess ergonomic strain in these areas. To address this caveat, a more comprehensive tool such as the Strain Index (SI) can be used. The SI is a semiquantitative job analysis method designed to identify jobs that are associated with distal upper extremity musculoskeletal disorders vs those that are not [20–24]. The SI is based on multiplicative interactions among variables related to distal upper extremity disorders and enables better characterization of tasks identified using RULA.

While there is general belief that robotic surgery poses less risk of strain than traditional MIS does, the literature contains no data specific to gynecologic robotic surgery. In addition, although previous research evaluated surgeon tasks using RULA and provided conclusions based on the RULA score [9], to our knowledge, no efforts have been made to further evaluate the robotic surgery job tasks identified as risky using RULA. For this reason, we sought to provide information about occupational injury incurred while performing robotic gynecologic surgery using the RULA and SI methods. We hypothesized that although there may be ergonomic benefits, strain related to surgery using the robotics platform will remain a prominent issue for surgeons and that educational strategies are necessary to modify these risks.

Material and Methods

The study was approved by the University of North Carolina at Chapel Hill Institutional Review Board (#12-1072). A subset of robotic surgeries performed at a single high volume robotic surgical center were digitally recorded. In 2012, the center's Department of Obstetrics and Gynecology performed 470 robotic procedures, 351 of which were performed by the Division of Gynecologic Oncology. During the study, 14 consecutive procedures were videotaped. A stationary camera was set up so that the surgeon was in view from head to toe, with full view of both hands and the head, neck, shoulders, arms, and legs. The digital video footage was evaluated by an ergonomics specialist consultant blinded to the surgery and the surgeon.

An initial ergonomics assessment was performed using RULA. A grand score was determined for each side of the body per cycle. A cycle was defined as the duration of time during a video segment in which the participant was performing uninterrupted surgery. Therefore, there could be more than one cycle per surgeon per procedure if there was a change of surgeons at the robotic console. RULA grand scores were averaged for all cycles, and an action level was assigned. To obtain the grand scores using descriptive guidelines, the evaluators rated three variables: i) posture of the upper limbs (upper arms, lower arms, wrist posture, and wrist twist) (Fig. 1 and Table 1), to obtain score A; ii) posture of the neck, trunk, and legs (Fig. 1 and Table 2), to obtain score B; and iii) muscle use and force rates, adding these ratings to scores A and B to obtain scores C and D, respectively (Figs. 2 and 3). A grand score was computed from scores C and D (Figs. 2 and 3). A grand score >5 indicates that the individual performing the job task is at increased risk for musculoskeletal injury, and a grand score >10 indicates that the job is probably hazardous.

If preliminary screening suggested the need for further ergonomics investigation, a second analysis using the SI was performed [20]. The SI enables systematic evaluation and prediction of risk of development of a musculoskeletal disorder in the distal upper extremity. The SI score represents the product of six multipliers, each corresponding to a task variable: intensity of exertion, percentage duration of exertion, number of efforts/exertions per minute, hand and wrist posture, speed of work, and duration of task exposure per day (Table 3). Scores are cross-referenced with the SI action levels to assess the risk of injury. SI action level ≤ 4 indicates that the job is safe, scores of 5 to 9 indicate increased risk, and scores of ≥ 10 indicate that the job is hazardous.

Intensity of exertion is an estimate of the force required to complete a task and is not related to endurance or stamina. It can be measured subjectively or objectively. In the present study, intensity of exertion was measured objectively using