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Original Article

A Feasibility Study Determining Surgical Ergonomics in a Live Surgical Setting

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ABSTRACT **Study Objective:** To identify the biomechanical movements of laparoscopic surgeons during laparoscopic gynecologic procedures, and to determine whether such movements can be assessed and measured both temporally and biomechanically.
Design: Prospective descriptive kinematic study (Canadian Task Force classification II-3).
Setting: A tertiary referral hospital in Sydney, Australia.
Study Subjects: Five gynecologic laparoscopic surgeons.
Interventions: Video recording from a variety of fixed positions to assess surgeon stance, time spent in specific postures, and relative change of limb angles during laparoscopic surgical procedures.
Measurements and Main Results: Postoperative review of surgical movements during laparoscopic surgery was able to provide quantitative data. Motion and timing could be classified by angle banding ranges among surgeons. The most extreme shoulder abduction angles occurred during trocar insertion (61°) and insertion or removal of laparoscopic instruments (63.5°), with procedures involving morcellation requiring the greatest number of instrument insertions or removals (n = 57). The elbow is most frequently in a neutral position in TLH, and the shoulder spends the most time in abduction during myomectomy.
Conclusion: This proof-of-concept study confirms that detailed ergonomic assessment is possible within live surgical settings, with identified limitations. This study may allow for a larger-scale study to determine at-risk movements during the various phases of a laparoscopic surgery and possibly control for some of these hazardous behaviors. Journal of Minimally Invasive Gynecology (2015) 22, 626–630

Keywords: Surgical ergonomics; Gynecologic laparoscopy; Workplace injuries

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Laparoscopic surgery provides well-recognized patient benefits with reduced perioperative morbidity, accelerated recovery postoperatively and improved cosmesis [1]. However, reports involving electromyography and surgeon-orientated surveys have indicated that benefits to patients are accompanied by poorly developed surgeon ergonomics [2]. The changing nature of surgical practice has seen a reduction in the risks to the surgical team of sharps injury and infection however these have been replaced by musculoskeletal overuse syndromes [3]. Previous studies have outlined the unique physical nature of laparoscopic compared with open surgery including indirect operative access and visualization, reduced degrees of freedom and counterintuitive instrument manipulation [1]. Risk factors for developing musculoskeletal disorders in a laparoscopic setting include static muscle loading, repetitive fine motor handling techniques, extreme joint angulations as well as work duration and load [4]. Currently, there are no studies evaluating the biomechanical movements of laparoscopic

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surgeons with time in the live surgical environment. This pilot study aims to describe the motions performed by laparoscopic surgeons during routine surgical procedures and to demonstrate that ergonomic assessment is possible in a live surgical setting.

Methods

Ethical approval for this study was sought from and granted by the South Eastern Sydney Illawarra Area Health Service Northern Hospital Network Human Research Ethics Committee (Reference no. 13/230). Initial filming was undertaken to assess whether quality footage of surgical motions may be attained and evaluated using defined metrics while not interfering with the performance of the surgical procedure. This required positioning of cameras in the operating theatres to capture the surgeon's stance at various angles and then assessing the playback postoperatively. The most effective camera positions for optimal visualization of the main surgeon were established over 4 procedures. Figure 1 shows the camera locations used in our study. We have a standardized personnel for all procedures of a primary surgeon (position X in the Fig. 1), surgical assistant (position Y), and scrub nurse (position Z). It was not possible to document a complete side-on perspective of the surgeon owing to the mandatory positions of surgical equipment, with the best images providing footage of the surgeon's shoulder, elbow, and wrist only. Although a surgical assistant was present for all procedures (position Y in Fig. 1), for the purpose of establishing a model for analysis, only the primary surgeon (position X) was filmed.

The footage was analyzed using Windows Media Player 11 (Microsoft, Redmond, WA) with angles of surgical motion (shoulder to torso; forearm to arm) acquired using Iconico Screen Protractor version 4.0 (Iconico, New York, NY). Analyses were done by procedural steps, such as insertion of all trocars, insertion and removal of laparoscopic instruments (including those for biopsy specimen collection), and the main surgical phase of the operation (e.g., excision of endometriosis or myomectomy). Some movements were specific to the operation performed (e.g., morcellation during myomectomy, vault suturing at TLH). Times of specific components of the surgery (e.g., trocar insertion), as well as measurements of shoulder and elbow angles using the Iconico Screen Protractor, were recorded in a database using SPSS 20 (IBM, Armonk, NY).

After we recorded several procedures and reviewed the playback, it became apparent that surgical movements needed to be described within an angle range to make a suitable analyses possible, for example, the durations of surgeon's elbow angle between 0° and 90° and between 90° and 180°, as depicted in Figure 2. An attempt to further reduce these ranges to 45° blocks (i.e. 0°–45°) made analysis too difficult to accurately record. For the shoulder, however, abduction was banded between 0° and 45° and between 45° and 90°, because these ranges could be more easily differentiated on film. For the purpose of our study, we defined 0° of flexion/extention/elevation/depression/protraction/retraction/abduction at the shoulder and 90° of flexion at the elbow as representing the neutral positions for the surgeon, following a survey of the surgeons involved regarding how they usually performed laparoscopic surgical procedures [5]. It was determined that further movement away from these positions increases the biomechanical load on the arms and may predispose to injury.

Surgeon demographic data, including position held (e.g., resident in training, attending), age, body mass index (BMI), approximate operating hours per week, and years of

Fig. 1

Schematic representation of the operating theater setup.

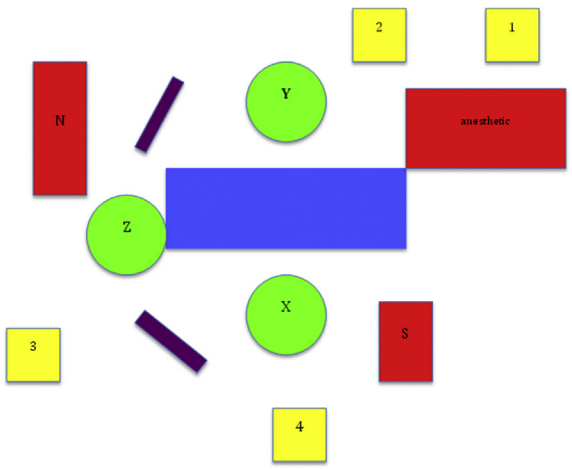

Fig. 2

Example of banding analysis of the elbow within the 90° to 180° range using the Iconico Screen Protractor.