Save our surgeons: an ergonomics evaluation of laparoscopic hysterectomy

Save Our Surgeons:
An Ergonomics Evaluation of Laparoscopic Hysterectomy

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Abstract. This paper presents an investigation of ergonomic issues and coping strategies during gynaecological laparoscopic surgery. Data were collected with questionnaires, postural analysis and interviews. The results suggest that work-related musculoskeletal disorders were present in almost 90% of survey respondents. The workplace factors included equipment dimensions, preference of port positioning and patient size with limited adjustability for all surgeons to perform comfortably and effectively. These findings have implications for service provision (availability of surgeons) and patient safety (human interface design).

Keywords. Gynaecology, musculoskeletal disorders, surgery, postural analysis

1. Introduction

The application of laparoscopic surgery (minimal access surgery: MAS) has been rising since the 1980s due to patient benefits of reduced morbidity, recovery time and inpatient stay as well as enhanced cosmetic external result (Johnson et al, 2005). Laparoscopic surgery is reported to be more physically complex and mentally demanding than traditional open surgery (Adams et al 2013; Berguer et al, 2001), and despite early warnings that physical ergonomics should be considered in laparoscopic surgery workplace design (Crombie and Graves, 1996) surgeon injury report rates have increased to 87%, far higher than traditional open surgery (Park et al, 2010). Physical demands associated with monitor and port positions, static postures (reduced visual field), repetitive motions, inappropriate equipment and poorly adapted environments have been investigated (Tchartichian, 2011, Matern et al, 2001). Female surgeons may be at greater risk of injury due to shorter stature and reach distance, and weaker upper body strength (Berquer, et al 2002; Fransiak et al, 2012; Adams et al 2013; Sutton et al, 2013). This research aimed to investigate physical ergonomic issues during gynaecological laparoscopic surgery and explore coping strategies to manage the risk factors.

2. Methods

An online survey was used to investigate the prevalence of work-related musculoskeletal disorders (WRMSDs) with distribution via the Royal College of Obstetrics and Gynaecology (O&G) and the Midlands Obstetrics and Gynaecology Trainees' Research Collaborative personal networks (MTReC). Eighteen questions collected data about: exposure to MAS-associated risks, including number and duration of cases; physical stature; WRMSD symptoms; contributory factors e.g. availability of equipment and assistance, time pressures, type and complexity of surgery, patient shape and size; sickness absence and WRMSD treatment; and coping strategies. The coping strategy options included: managing/reducing workload,

limiting additional operating lists; increasing/decreasing the number of MAS cases; reducing complexity, including plus-size patients; and stopping the performance of elective surgery in major/minor cases and emergency surgery.

A pilot study was carried out with 11 surgeons using purposive and snowball sampling, to: investigate working posture (REBA; Hignett and McAtamney, 2000); and to explore coping strategies using interviews) Participants were asked to set up a simulated working environment (Figure 1) to indicate their preferred working posture using 1 or 2 laparoscopic monitors. The lead surgeons then adopted their preferred working postures for unilateral /midline /bilateral access port placements (Figure 2) on 50th percentile (%ile) and 99th %ile simulation abdomens. Data were recorded for the most frequent posture and most extreme posture. Three port placements were used: bilateral, midline, and unilateral (Moss, 2016, personal communication). The postures were recorded for the 50th %ile and the 99th %ile abdomen for surgeon port choice (the most frequent and most extreme postures) and port placement for bilateral, midline and unilateral access, and analysed with REBA.

Figure 1: Monitor and access port (unilateral) for 50%ile abdomen simulator

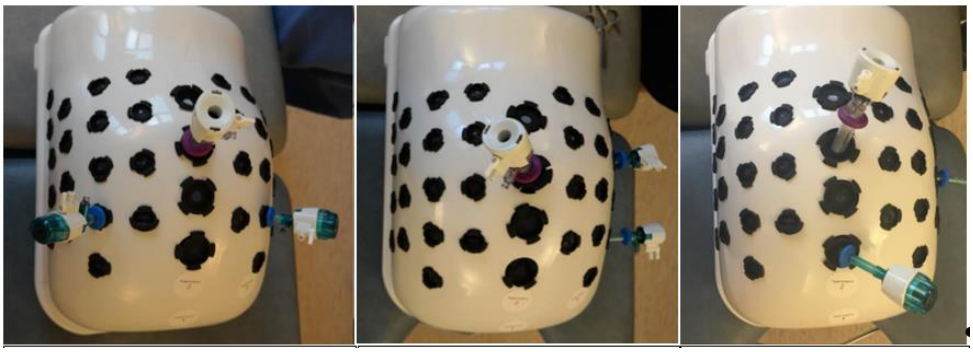

Figure 2: Port placements: bilateral, unilateral, midline

The interview schedule was developed from the survey with additional questions from the observational data. Coping strategies such as aspirations and opportunities to

adjust working equipment and environment were explored for the three port options and plus-size patients. The interview data were audio-recorded and imported into NVivo for content analysis.

This research was approved by Loughborough University Ethics committee as an NHS Service Evaluation.

3. Results

The survey participants (n=42) included 18 males (38%) and 29 females (62%). Over 70% were under 40 years of age with a range of experience in O&G between 1 and 40 years. Females were significantly shorter in stature (more than 60% were shorter than 170cm) than males (80% were taller than 170cm). Of the 42 respondents 89% reported WRMSD within the last 12 months, especially for the lower back, shoulders, neck and wrist/hands. Although 62% had sought treatment including physiotherapy, analgesia and steroid injections, only 6% reported taking time off work. Contributory factors for WRMSD were suggested to be: patient shape and size (85%); and the duration (72%) and complexity of surgery (62%). Only 9% of respondents reporting making changes to manage their pain/discomfort by reducing their workload including the number of operations and refusing additional operating lists.

In the pilot study, the 11 participants (4 males and 7 females) were slightly older than the survey respondents (n=4, 30-39 years; n=5, 40-49 years; n=1, 50-59 years). The stature distribution was similar with most females under 170cm (n=7; median 62nd %ile) and all males over 170cm (n=4; median 63rd %ile; Pheasant and Haslegrave, 2006).

The postural analysis results found that unilateral port option had the lowest level of risk exposure compared with midline, and the bilateral port postures had the highest REBA scores. However patient shape and size (99th%ile) resulted in a change of port choice (Figure 3) with more participants using the unilateral port compared with the 50th%ile patient. Lowering the operating table and using steps moderated the excessive working postures (lowered the REBA scores).

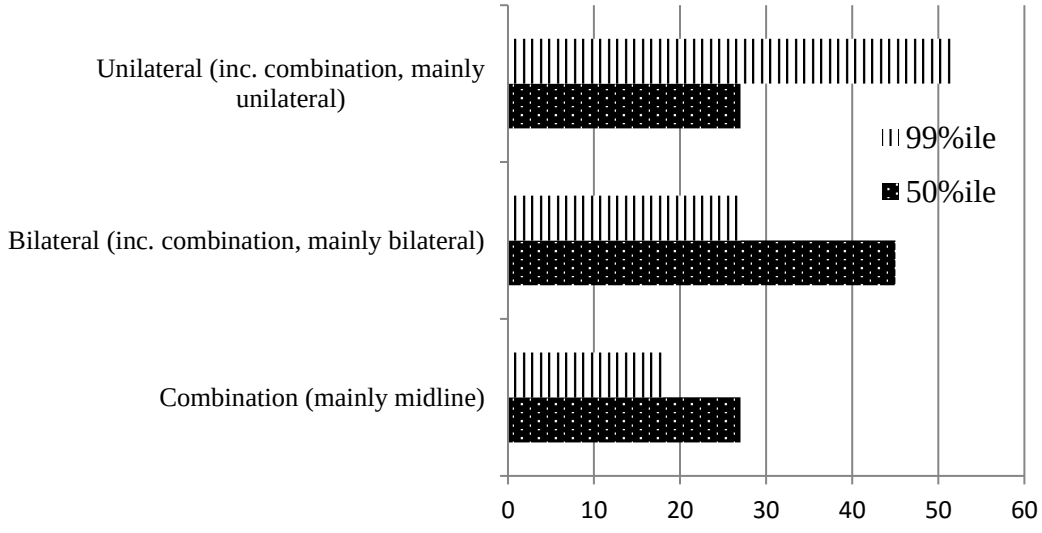

Figure 3: Port (access) choices for 50%ile and 99%ile

In the interviews 9 participants (82%) reported experiencing WRMSD. Discomfort in shoulders was often attributed to awkward and sustained postures '*sometimes if I'm holding an instrument out like this* [right arm over the patient], *so sometimes your grip is not strong enough while your arm is over there or your arm is not long enough, so then it will start aching my shoulders*' (P4). Difficulties with reach could also contribute to lower limb pain e.g. standing on tip toes to reach across the patient '*you tend to hyperextend your knees … your knees end up locking, you're sort of, like, leaning forward and trying to do something and your knees will ache afterwards*' (P7).

The surgeons all had coping strategies to reduce their discomfort during laparoscopic hysterectomy procedures e.g. tilting the patient head-down (Trendelenburg) to allow more internal abdominal/pelvic space. The design of operating tables could facilitate or limit this option, '*sometimes you can't actually bring them* [table] *down as far as you want to... Some theatre tables can go almost down to the floor, but some can't, so it's also the quality of the theatre tables is also quite important'* (P1). This could then lead to a second coping strategy using steps, which could introduce additional hazards.

The selection of port access for a 50%ile patient depended on a number of factors including: personal factors e.g. reach; surgical assistance e.g. availability and experience; pathology; and patient size; *'ports are not just dependent on the patient size, it is dependent on the pathology … if somebody has got a left side massive ovarian cyst (…) it is easier to … have one port definitely on the right side so you are coming at an angle, so if you are working from the same side that the pathology is on sometimes it is difficult to do the movements, so you are better coming at it from the opposite side*' (P10).

The workplace layout (monitor placement; Figure 4) could contribute to awkward postures, '*the fact that you often only have one screen for all of you is, it's not great, so you're obviously having to go and look side-on so your head is looking in the other direction'* (P7). However technology solutions are available, '*I have seen loads of places that have integrated theatres, so you don't have this business of moving the stacks and rotating it's all coming down through the ceiling, through the walls, control the height, you can bright the screen right in front of you if you want. So obviously there are better things available'* (P10).

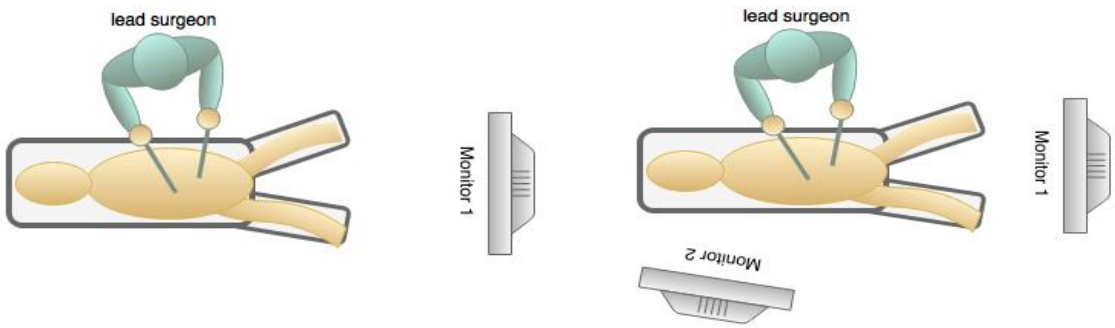

Figure 4: Examples of monitor placement for 1 and 2 monitors

Participants were aware of the possibility that their discomfort might affect the task

(and patient), '*when I'm suturing, it's probably only for 5 or 10 minutes, I'm in a very difficult position. The rest of the times, I think I kind of make sure the task is not affected, but you do so reflexively that you're not aware of your positions, only after the procedure you realise - 'Oh God, what have I done to my back' – but while you are doing the procedure, I don't think as a surgeon I'm compromising the task as such'* (P2). This challenge was reported to have been discussed during both experiential training, *'people always say try and keep your shoulders relaxed, don't stretch your arms and you know eye level etc.'* (P10) and formal training *'as part of my fellowship that was one full session of the ergonomics'* (P9).

4. Discussion

For many surgeons discomfort from performing laparoscopic procedures appears to be part of the job. The lack of purposely designed equipment can make it very difficult to work comfortably without risking their own physical health (Szeto et al, 2009). The survey and interviews indicated very similar areas of discomfort, in particular for the lower back and shoulders. Upper body discomfort was often attributed to awkward postures associated with using laparoscopic tools.

Age and experience have previously been discussed with increased WRMSD for both older and younger surgeons (Franasiak et al, 2012; Park et al,2010; Adams, et al, 2013). We could not draw conclusions from this survey, but did find that older survey participants reported knee and foot discomfort from extended procedures and standing. The level of WRMSD is of concern, at over 80% for both the survey and interview participants. In other clinical professions e.g. nursing, this has been associated with: psychosocial factors, including workload and error; and turnover, including leaving the profession (Lövgren et al, 2014; Estryn-Behar et al, 2010).

Unilateral ports seem to encourage more comfortable postures, but may not always be selected due to: experience and the working environment, including team preferences; or patient factors e.g. pathology, size, shape. The younger surgeons (with less than 5 years' experience) tended to use the uncomfortable bilateral port position more frequently. Participants reported coping strategies but options could be limited due to local working circumstances, including team support (availability and experience) and equipment. These challenges are exacerbated for plus-size patients (99^{th}%ile) due to the lack of inclusive design in many operating theatres.

Laparoscopic surgery poses many challenges but the effects of these on surgeons could be reduced by implementing interventions and adjustments to the environment and equipment as well as continuing to raise awareness through training. There has been a tendency to address surgical patient safety problems with training and communication interventions (Hignett et al, 2013), however it is becoming increasingly recognized that engineering solutions (working with safety scientists, including Human Factors/Ergonomics practitioners) are needed (Makary and Daniel, 2016).

5. Conclusion

This project was initiated due to concerns raised by a female surgeon. The survey and observation data indicate that there is a real problem in this population, with a very high level of WRMSD. The analysis uses a traditional WRMSD ergonomics approach

e.g. using anthropometry and postural analysis, and there will be many previously known solutions which can also be transferred. However, some of the challenges need new engineering solutions to allow flexibility to support surgeon choice of operating approach (open, laparscopic or robotic) in a workplace which supports adaptation to the task, surgeon and patient.

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