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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Laparoscopic surgery and ergonomics

It's time to think of ourselves as well

Laparoscopic surgery has brought many benefits to patients. The reduction of pain, the shorter recovery time and hospital stay, and the earlier restitution of normal physiological markers have been proven objectively in many well-designed clinical studies. It has also been clear from the beginning, and has been investigated thoroughly ever since that time, that minimally invasive techniques can also cause harm to patients if they are applied indiscriminately [6]. However, the fact that laparoscopic surgery can also harm laparoscopic surgeons was only recognized somewhat later, and this phenomenon is now being investigated worldwide.

The disadvantages of laparoscopic procedures are mainly due to the nonergonomic design of the surgical instruments and the out dated environment of the operating theater. As laparoscopic surgery became more advanced and complex, the duration of the procedures expanded and, in proportion, so did the levels of mental and physical stress imposed on the surgical team. Yet so far, no significant changes have been made to the operating room, which was originally designed for conventional operations.

Ergonomics, a relatively new science, first gained wide popularity in the field of industrial engineering. Experts began to notice that when workers do their jobs under nonergonomical circumstances they become stressed and fatigued, which leads to a drop in quality and productivity. As the advertising industry began to tout the "ergonomic design" of various cars and household utensils, ergonomics was viewed as a serious factor influencing the sales of such products. Today, enormous sums of money are earmarked for ergonomical research into industrial design. In turn, new industrial software tools have been developed to assess the ergonomic features of new products. These tools are designed to measure the posture and movement of the human body very accurately, without using any markers [17].

Unfortunately, medicine did not get in on the ground floor of these ergonomic developments, because productivity and quality in this area cannot be connected as directly to ergonomics as they can in industry, and the profit gained from ergonomic reorganization is difficult to quantify in financial terms. Thus, it has been reported that the main reason for choosing a particular instrument is its cost–quality ratio and not its ergonomic design [18].

However, thanks to the concerted efforts of surgeons and medical staff, the assessment of the ergonomic aspects of laparoscopic surgery is now under way. We already have many objective data on the problems that arise in the course of everyday practice, and some attempts have been made to alter the operating environment accordingly [10].

During laparoscopic operations, surgeons suffer from high levels of mental and physical stress. After a certain time—~4 h—the so-called surgical fatigue syndrome sets in. This syndrome is characterized by mental exhaustion, reduced dexterity, and a reduced capacity for good judgment [6].

Mental stress is caused by numerous factors. The view of the operative situation is displayed on a monitor that is widely separated from the field of action [9], so the surgeon has to overcome the natural instinct to direct the eyes to the activity of the hands. The two-dimensional viewing of a three-dimensional field has to be interpreted and synchronized to instrument movement. The surgeon also has to adapt to the fact that the tip of the instrument is moving in a direction opposite to the handle—the so-called fulcrum effect [5, 8]. In addition to performing the operation, the surgeon has to constantly monitor the different devices used during the procedure. Although it is not easy to measure mental stress, there are some data on skin conductance level and electro-oculogram monitoring as they relate to increased mental concentration [3]. It has been shown that mental stress can be compensated for with mental effort [5, 8], but such efforts surely lead to earlier fatigue, which can be a significant handicap during operations that last for hours.

Physical stress, on the other hand, can be measured very well with objective devices. Standing in a fixed position determined by the placement of the trocars and the site of the screen(s) causes static strain to the eyes, head, neck, and spine, which translates into eye strain, neck and shoulder pain, and stiffness [2, 12]. This type of stress can be measured by the duration of the stressful postures and the rotation of the joints as compared to the characteristics of a comfortable posture, or by the force plate measurement of the feet, which indicates the characteristic position of the trunk [1]. In order to pivot the instruments around the trocars, which are fixed to the abdominal wall, increased muscle activity and

awkward movements of the upper limb are necessary [12]. The force needed to control laparoscopic instruments can be six times greater than that needed in open surgery, and the problem is magnified further by the nonergonomic design of the handle. The effort needed to control the instruments translates into premature fatigue, pain, and the degradation of performance, and it can be demonstrated on electromyograms (EMG) and motion analysis studies [2]. Badly designed hand instruments, which also produce long-term strain, can even damage the nerves of the thumb and thenar, causing the so-called laparoscopist's thumb [11].

To measure physical strain precisely, a wide array of sophisticated devices has to be used. The movements, or the posture, of the surgeon must be recorded on standard or special (infrared) video cameras for evaluation; in most cases, the individual being measured has to wear a special outfit, with reflective markers, motion sensors, electrodes, etc. [3, 7, 15]. This is not easily accomplished during operations on humans. Markers attached to surgeons dress may drift, and the view of the marker is often obscured during manipulation. It is also uncertain to what degree the wires and attached sensors may influence the surgeon's movements. For this reason, ergonomic studies are mainly done during laboratory experiments and not real operations.

Another problem is that currently no method or software is available to simultaneously measure both the movements of the upper limbs and the static posture of the trunk under real operative circumstances. The industrial programs were not developed to accommodate the special requirements of the operating theater, such as the clothing covering the torsos of the personnel, the need for sterility, the obstruction of the view due to crowding in a very small area, etc. Furthermore, most studies have concentrated on the individual doing the operation, when it is well known that other members of the staff (assistants, scrub nurses) suffer from the same strain. New software and tracking systems have to be developed so that ergonomical studies can be done on a routine basis in operating theaters.

What tools do we now have to make ergonomic improvements to laparoscopic operations? First of all, the surgeon has certain means, such as using more monitors and positioning them at the places most comfortable for the whole team, finding the most comfortable and advantageous place to do the operation, adjusting the height of the operating table to the proper level, avoiding the offset placement of trocars, or using ergonomically designed hand instruments [4, 7, 9]. The cumulative ergonomic stress is also reduced if the number of surgeons involved is smaller. For this purpose, robotic camera holders can be substituted for human assistants. These robots can be directed remotely by wire or voice control. Indeed, self-guided systems are even now under development [13, 14].

At the same time, the companies that produce laparoscopic equipment have to realize that their products are possible sources of damage to the surgeon. They have to be persuaded to redesign devices that respect the ergonomic aspects of the operating theater and accommodote the needs of the operating team. New devices, such as special chairs for laparoscopic surgeons that incorporate integrated pedal switches and body support, would make prolonged operations more comfortable, thus reducing fatigue [16]. Self-guided camera and instrument holders, which would be directed by the head or eyeball movement of the surgeon, could reduce the number of participating surgeons; and the thorny problem of automated lens cleaning has to be solved as well. Image display systems, such as lightweight head-mounted three-dimensional displays, or head-up displays (projecting the image near the field of operation onto collimating glass) with an integrated check field (to control abdominal pressure, gas flow, settings of the coagulating equipment, etc.), would reduce both mental and physical strain [6, 9]. Last, but not least, the handles of all surgical instruments have to be constructed ergonomically.

To enhance these efforts, surgeons have to continue performing ergonomic studies, using the latest software developments available to, acquire objective, reliable, and reproducible data. This should lead to the availability of properly designed products, so there would be no more need to search for ways to force hospital management to buy not the cheapest products but the ones with the best ergonomic design.

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