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Surgeons Beware: The Ergonomics of Robotic & Laparoscopic Hernia Repair

***Brian Wca Tian*[1]*; *Graziano Ceccarelli*[2]**

[1]*Department of General Surgery, Singapore General Hospital, Singapore, Singapore.*

[2]*General Surgery, San Giovanni Battista Hospital, USL Umbria 2, Via Massimo Arcamone, 1, 06034, Foligno, PG, Italy.*

***Corresponding Author(s): Brian WCA Tian**
Department of General Surgery, Singapore General Hospital, Singapore, Singapore.
Email: briananthonytian@gmail.com

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Introduction

Minimally invasive techniques are gaining traction in the discipline of hernia repair. However, there still remains a significant learning curve, especially when repairing complicated hernias laparoscopically. At times, many surgeons find themselves contorting their hands and bodies in abnormal postures to perform certain segments of the operation.

The development of robotic platforms have enabled surgeons to overcome many of these technical limitations [1,2]. Although the robotic platform enables easier suturing and manoeuvring, surgeons should still pay heed to the ergonomics when working these machines. Poor ergonomics can cause significant physical and mental stress.

Despite the intuitiveness of this topic, many surgeons of tenignore these ergonomic principles. In fact, many surgeons are unfamiliar with existing guidelines or recommendations [3]. This is however, a potentially huge problem. Any work-related injuries to surgeons can ultimately transalate into long periods of absence from work, chronic disabilities and need for rehabilitation. At the end of the day, it will be the patients who will pay the price – financially or in terms of outcomes [4,5].

Current Ergonomic Land scape in Laparoscopic and Robotic Hernia Repair

During conventional open surgery, surgeons typically stand up and look directly into the operating field. Surgical tools such as self-retaining retractors have been introduced to improve ergonomics [6-10]. However, surgeons still experience prolonged neck flexion and strain. Standing long hours ultimately also leads to lower back pain [11].

The introduction of laparoscopic surgery have brought immense benefits to patients: Reduced pain and wound trauma, and shorter hospital stays. However, laparoscopic surgery is still

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limited by two-dimensional vision and by the loss of direct contact with tissues [12]. The adoption of long instruments and a camera system also means many surgeons and their assistants tend to awkwardly contort their hands and bodies [especially when attempting difficults uturing]. The surgical team also has to fix their gaze on a monitor which can cause eye strain.

In most laparoscopic hernia surgeries, the surgeon tends to abduct and internally rotate the arms. Depending on size of patient and the surgeon, the surgeon might need to cross his body over the midline of the patient. When added onto a prolonged static posture; all these effects will cause long-term back pain. It is estimated that more than 80% of surgeons performing laparoscopic surgery during their working life suffer from work related symptoms, particularly cervical and lumbar musculoskeletal disorders. [9,13-15].

The laparoscopic assistant is also not spared from this physical strain. This is because the assistant is required to hold a heavy camera, and sometimes a retractor in the other hand as well. The assistant still has to make way for the main surgeon, and has to adopt un-natural postures [16,17].

There have been previously published ergonomics guidelines for laparoscopy. However many surgeons continue to perform laparoscopic procedures, without taking them into account [18,19].

The advent of robotic surgery promises a complete revolution. In the realm of hernia surgery, several robotic techniques have been described.

These include:

- Intra Peritoneal On Lay Of Mesh (rIPOM)

- Trans Abdominal Preperitoneal Repair (rTAPP),

- Retromuscular Repair With Or Without Transverses Abdominis Release (rRVHR or rTAR)

- Extended Extra Peritoneal (eTEP)

A key feature of robotic surgery plat forms is the improved ergonomics and surgical function for surgeons. The primary surgeon works sitting at a console station, with a high-definition 3D vision. This reduces ocular strain and physical fatigue. The robotic system also confers improved dexterity without needing the surgeon to contort himself or herself. This allows for safer and more effective procedures especially for complex hernias [28].

Compared to laparoscopy, the robotic platform decreases strain on the surgeon's arms, forearms and wrists. A previous study reported that a robotic platform's ergonomics and features help to significantly reduce mental and physical stress on the surgeon [20]. Despite the reported and intuitive benefits, robot surgeons may still experience neck strain and discomfort to the upper torso due to prolonged console posturing [21].

However, there are no studies on the robotic assistant. The assistant typically maintains a prolonged and upright posture, whilst physically interacting with the robotic arms (with a risk of injury).

How can we improve ergonomics?

There are many aspects to improving ergonomics during surgery. It could involve optimal patient positioning, better operating theater setup, etc. In this editorial, we will focus most only some key pointers.

Positioning

During hernia surgery, the patients' arms are preferably placed along their sides, with the surgeon and assistant working at the patient's head. In laparoscopy, the table's height should be set at the surgeon's elbow (between 90 and 120 degrees) [14]; considering that higher heights may cause fatigue and pain in the wrist and shoulders [22]. For robotic surgery, there was been development of an integrated table motion technology which offers synchronous movements of the table with the cart. Although for robotic hernia surgery, this may not be necessary.

Equipment set up

In laparoscopy, the placement of monitor in front of the surgeon and below his line of vision is considered the ideal option [23,24]. The optimal monitor height, that provides for a neutral position of the cervical muscles, is considered to be at 10 to 25 degrees below the horizontal plane of the eye [23,25]. The distance of the screen from the surgeon depends on the screen size, but overall should be between about 1 and 3 m [26]. Multiple screens allow for better visualization for assistants and scrub nurses, especially if they have a different direction of view from the surgeon [12,16,27].

When operating laparoscopically, if one considers that the handle of the instruments at the level of the operator's elbow as the "zero" point; then the ideal height has been shown to be between 0 and-10 cm; therefore, the operating bed should be normally placed at a height from the ground between 64 and 77 cm. Studies to determine the correct height of the table and laparoscopic instrument handles were performed using box trainer devices [25,28].

Proper trocar placement allows surgeons to adopt and maintain a correct posture, facilitates instrument handling, and helps avoid collisions. This proves to be true especially when attempting to perform technically difficult suturing. To easily perform a laparoscopic suture, instruments should reach the field of action with an angle large enough to pass the stitch perpendicularly to the suture line (ideal angle of 80°-100°). Overall, performing a vertical suture is simpler than a horizontal one.

For the robotic platform, the surgeon's knees should be site data 90-degree angle or greater; the arms should be perpendicular to the floor and the elbows should be at 90 degrees resting on the armrest. Studies demonstrated that the preferred viewing angle for video display positioning is between 10° to 25° below the line of sight, with any larger angulation being associated with neck and back pain [29,30]. The Rapid Upper Limb Assessment (RULA) score establishes that the optimal ergonomic position for the surgeon at the console is achieved when the joint angles are within the following ranges: Between 90° and 110° for knees and between 90° and 100° for hips, respectively [31].

A very unique feature of the robotic system is the image inversion artifice (INV) for ventral hernia repair. To set this up, the robotic 30°endoscope is first inverted in a 180° rotation. Next, the robotic instruments must be reassigned to the opposite hands. An image inversion can thus be achieved, this leads to more intuitive and effective surgery, especially robotic TAR [29].

Conclusion

The attention to the well-being and health of workers has grown over time in every working environment. The surgeon job is not an "assembly line," but rather a craftsmanship. To achieve better outcomes in terms of patient health, the well-being of

surgical staff is crucial. At the same time, a well-trained team is mandatory to maximize the use of time and achieve efficiency. Frequently stressful working conditions may increase the fatigue of the surgical team. Surgeon disabilities related to in correct ergonomics and operative posture are rarely recognized until they occur. However their impact on productivity, job satisfaction, and on surgical outcomes, are not studied enough.

The future of hernia repair is in the direction of minimally invasive technology. But the steep learning curve necessary to perform complex procedures has caused delays in implementation and slow global adoption. Robot-assisted surgery has demonstrated the ability to overcome many limits of laparoscopy and provide better ergonomics, especially for challenging minimally invasive procedures.

With regards to abdominal hernia repair, the robotic platform makes it easier to access the different layers of the abdominal wall compared to conventional laparoscopy, allowing to perform complex tasks. The enhanced instrument articulation, the image stability and the immersive view, the "lift effect" of the robotic arms, which keeps the abdominal wall elevated, are the main advantages of this technology. However, this platform presents new ergonomics challenges which need to be studied and improved. Recent studies reported several physical complaints during robot-assisted surgery too.

New robotic platforms should take into account these ergonomic aspects, not only for the surgeon comfort but also for the whole surgical team. The improved high-definition view (4 K or 8 K) and the 3D devices should be accessible to every staff member. Potentially, a new operating room concept and design is required, in order to manage a large number of devices, technologies and cables or connections. This new vision can only be realized by developing in-depth knowledge and awareness of the problem, and increasing formal education and proper training, aimed at improving the existing guidelines for the prevention of occupational injuries.

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