Historical survey of ergonomic improvements in medical engineering for endoscopic surgery

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Development of medical devices for endoscopic surgery



In order to improve the safety of endoscopic surgery and reduce the burden on surgeons, various research and developments have been carried out, ranging from active forceps to surgical support robots. The surgical robot system da Vinci ™ dominated the global market over 20 years after its release. Now, many other surgical robots such as hinotori™ were also released in Japan.

Results & Conclusion

Improved quality of the endoscopic imaging, simulation & navigation system using 3D & Augmented Reality Image has been put to practical use. These advances had contributed to the safety and speed of surgery & ergonomic improvement for surgeon.

However, the issue of eye strain caused by 3-D imaging & head mounted display remains to be resolved. Development and progress of energy devices and stapling devices for endoscopic surgery has eliminated the need for manual ligation and hemostasis, contributing to reduce the burden on surgeons. On the other hand, ergonomic strain remains with conventional small caliber forceps and scissors. So muscle fatigue of surgeons remains.

The surgical robot expanded the intuitive freedom of surgical operation. Also, surgical robot has made it easier for surgeons to operate from the chair. These improvements had greatly reduced surgeon's fatigue. Ergonomic issues to be resolved are the complicated preparation procedures, docking and undocking of robotic system, and the human workload associated with cleaning and sterilizing of reusable devices.

Thirty-five years have passed since the start of endoscopic surgery, and the burden on surgeons has been steadily reduced through the development of various surgical technology. However, further ergonomic improvement are needed in the design of conventional forceps and workload of OR staffs.

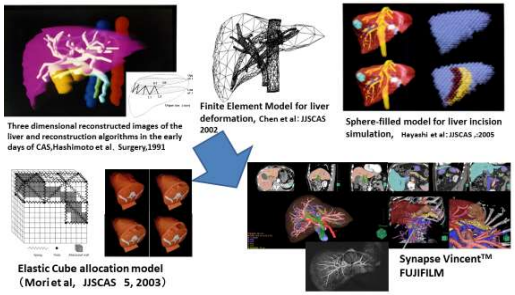
Background and Objectives

Endoscopic surgery, which requires surgical procedure under two-dimensional imaging in a small working space, put a lot of strain on the surgeon in early days. To solve these problems, advances have been made in the medical engineering. Ergonomic progress and challenges of equipment since the inception of endoscopic surgery were investigated in this study.

Materials and Methods

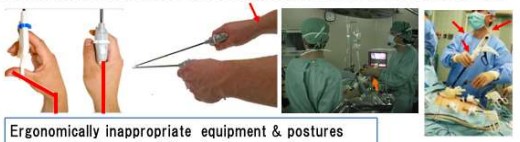
This study conducted a historical survey of products and published literature regarding ergonomic issues of medical technology and equipment in endoscopic surgery, and analyzed the achievements and problems of medical equipment from ergonomic perspective.

Advances in computer aided imaging for endoscopic surgery



In the early 2000s,the calculation function of residual liver volume & vascular perfusion area were put into surgical practice. Now, more advanced surgical navigation and virtual simulation during the operation are used .

Ergonomic problem of endoscopic surgery in the early days①

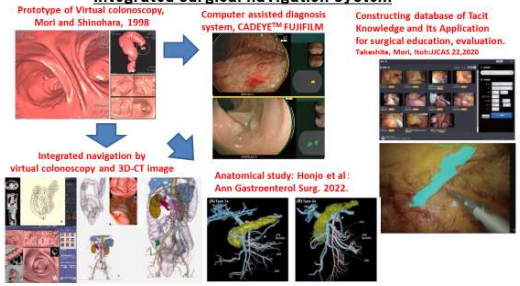


Ergonomically inappropriate equipment & postures
⇒Neuralgia &muscle fatigue in the upper limbs



Dim room lighting, improperly placed display, limited endoscopic view
⇒Eye strain, Neck &Back pain, Difficulty in surgical procedures

Advances of Computer Aided Surgery in virtual endoscopy and integrated surgical navigation system



Developments of Computer Aided Surgery(CAS) targets not only surgical support systems but also virtual endoscopy, computer-assisted diagnosis & navigation . Also, Research is underway to evaluate surgeon's technique using AI. CAS is also expected to be applied to anatomical research, medical device development by using a large amount of surgical information data in the Big Data.

Ergonomic problem of endoscopic surgery in the early days ②



Too many tubes & wires ,complicated preparation procedures of instruments⇒Increased workload & risk of human errors

Limited view & information under 2D-view
Remote procedure under limited working space & freedom of operation

⇒

Visual aid ⇒development of advanced endoscopy, navigation system with AR/VR & AI tech.
Motion aid ⇒development of active forceps, surgical robotics

Ergonomic Challenges and prospects

- Surgical robots enable intuitive surgical operations inside the patient's body. However human resources required for preparation, tidying-up and sterilization of surgical robots remains unresolved. Also, the problem of sudden computer freezes during surgery remains unresolved.
- It is also important to take further ergonomic considerations to prevent eye strain and neck-shoulder fatigue when using displays, HMDs and holograms. Until now, navigation system development efforts have been made only to accurate superimpose and display of a large amount of information. However , AI can select and present essential information for surgeons that is truly necessary to reduce the burden on surgeons.
- Furthermore, the integrated control system of various medical equipment in the operating room, such as imaging equipment, energy devices and electronic medical record system has not yet been completed. Information and Computer Technology is also important for improving the ergonomics of the total surgical system.



Time-consuming preparation&irrigation/eye strain/neck&shoulder fatigue‥