Integration of devices in operation room (OR) for reduction in cognitive load during surgical procedures

Efficient management of device parameters for improved clinical outcomes

Arpita Banerjee, Sandesh Gavade
Health Care & Life Sciences, Medical Devices Unit,
Wipro Technologies,
Sarjapur Road, Doddakannelli, Pin Code 560035,
Bangalore, India.

***Abstract*—Minimally invasive surgeries have reduced the post-operative recuperation period and improved clinical outcomes. At the same time, it has increased complexity of the operating room since most of such procedures need support of technology. These technologies, however, entered surgical practice in tandem and they all operated on different platforms. In addition to the surgical procedure itself, surgeons now need to focus on parameters of these devices that are assisting surgery. This position paper highlights a device integration platform proposed to bring together most parameters on a common platform so that their interplay may be better visualized and controlled to help reduction of cognitive load on the surgeon. A gateway controller is used to integrate the devices and an unified OR application helps to display the relevant information throughout the procedure.**

Type of Submission: Position Paper (CSCI-ISHI)

Keywords— Minimally invasive surgeries, cognitive load, Laparoscopic cholecystectomy, unified OR (Operation Room)

I. INTRODUCTION

The use of technology in surgical procedures is on the rise. Surgical technology will be valued at $11 billion by 2016. Its main growth drivers are: the rise of health care spending in emerging markets like India and China, the increasing incidence of lifestyle induced diseases and the increased demand for technological innovations by surgeons, physicians and nurses. The medical technology is mostly around minimally invasive procedures.

Even with the rise of modern medical equipment, there is always an abundance of surgeons, physicians and nurses in an operation theater (Fig. 1.). This defeats the purpose of technology designed to make their lives easier. Medical equipment, which are haphazardly introduced into an existing process of a surgical procedure, only increase the cognitive load on surgeons and make the procedures very complex. This leaves surgeons often battling the demand for minimally invasive surgeries with a large medical armamentarium [1].

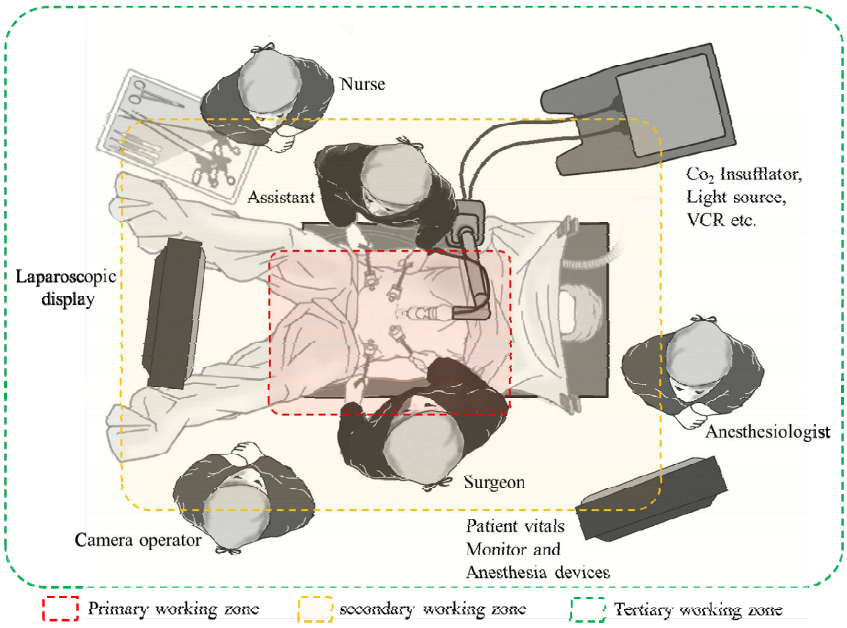

Fig. 1. Multiple work zones of various actors and devices for a minimally invasive Laparoscopy procedure as a case in point

978-1-4673-9795-7/15 $31.00 © 2015 IEEE
DOI 10.1109/CSCI.2015.111

Minimally invasive surgeries have been on the rise to reduce morbidity associated with procedures, the duration of stay in the hospital and the time to recovery. Most of them are aided by medical equipment that provides ease of visualization for small or no incision to skin. And more often than not, the current set up requires the surgeon to tread the procedure through a complex interplay of various medical devices and supporting physicians and staff.

Hence, there is an immense need to relieve the surgeons from some of the less essential processes of the procedure. This will help them have better control to handle the complexities of the surgery more efficiently for better clinical outcomes.

II. Discovering Unmet Needs Of A Surgical Procedure Taking Laparoscopic Hysterectomy As Case In Point

Laparoscopically assisted vaginal hysterectomy (LAVH) is a surgical procedure using a laparoscope to guide the removal of the uterus and/or Fallopian tubes and ovaries through the vagina. Laparoscopic hysterectomy needs a huge armamentarium of different types of equipment like imaging devices (laparoscopic display monitor & Patient Vitals), CO_2 insufflator to create a working space within the abdomen, electrocautery to achieve hemostasis, the optical system including a laparoscope, a high-intensity light source, a miniature video camera and camera box, a high-resolution video monitor, infusion pump, syringe pump, anesthesia and patient monitoring equipment and other surgical equipment's like trocars, graspers, dissectors, clip applicators, scissors, a dissecting electrocautery hook, probes, reducers, endoloops, a Veress needle, needle holders, etc. [2]. It is only when all of these are in the right order, will the surgeon be able to locate and remove the uterus with ease without any post-operative complications.

Surgeon faces following problems during such complex minimally invasive procedures [3], [5].

- High cognitive load due to repetitive steps that lead to increased procedure time, device handling complexity that affect clinical outcome, fragmented information that the surgeon has to refer to from multiple sources that prevent easy clinical decision making.

- Multiple actors in the OR to perform related tasks (handle fluid mgmt. & imaging systems, track patient vitals, operate laser device etc.) that increase surgeon's dependency on others.

- Devices in the OR today are not integrated or interoperable. Monitoring devices, surgical & therapeutic devices, and information systems are all disjointed and disconnected. There is a need to integrate these for better clinical outcomes.

This brings in the aforementioned complexity due to the interplay of all the equipment and resources in a single room. An intelligent "automation" of some of the less essential processes, based on feedback from ongoing procedure and other equipment will help making the procedure simpler. But creating that seamless interoperability requires a deep understanding of the procedure and its associated equipment.

Building an intelligent interface through capital devices integration will help the surgeon deliver better clinical outcomes by reducing the dependency on other actors in the OR. It will help

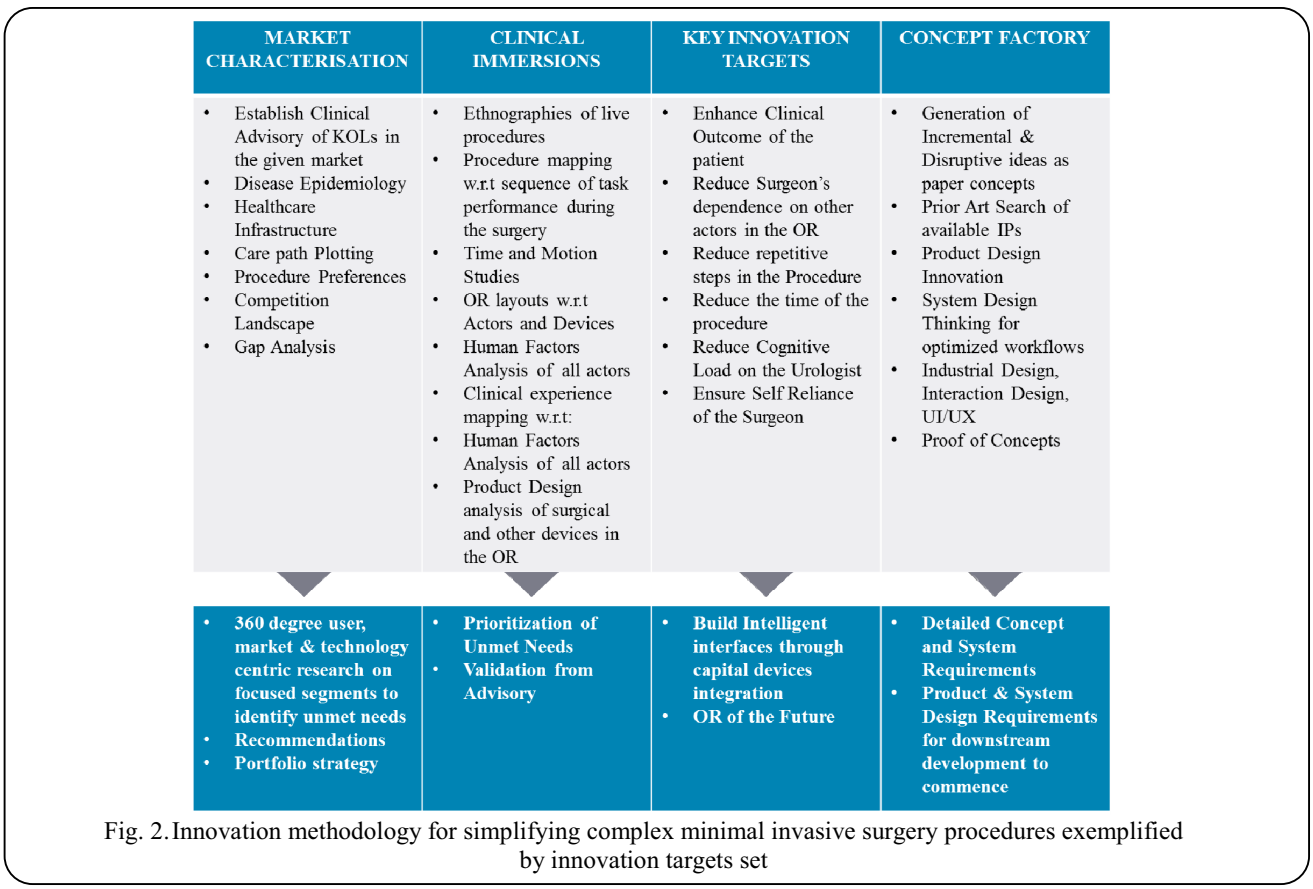

Fig. 2. Innovation methodology for simplifying complex minimal invasive surgery procedures exemplified by innovation targets set

reduce the repetitive steps in the procedure and the time taken to complete the procedure.

An integrated approach to create a new surgical environment begins with the convergence of research, design and product development (Fig. 2). It has to be led by a team that can visualize the complexities of the existing procedure, design a new approach without changing a surgeon's perspective, and work on technology required to transform the procedure.

The comprehensive approach involves a qualitative and quantitative assessment of the disease market and deep dive clinical immersions through ethnographies. Only then can the use case scenarios of unmet needs, at each step of the surgical procedure be identified, leading us to innovation goals.

III. Building An Or Of The Future

The outcome of this approach is the unified OR of the future. It allows a seamless ecosystem of multiple devices on a single workstation (Fig 3). This workstation will have the capability to manage all the devices which is easily accessible to the surgeon. And this allows the review of various parameters in real time while doing the procedure. The processes aiding the surgery continue to run in the background, guiding the surgeon through the essential steps of the procedure. The ancillary equipment may be manipulated whenever necessary. This will allow the reduction of manpower assisting the procedure and is well designed to help improve surgical outcomes in multiple ways.

Innovation in creating architecture by design that can accommodate a seamless interplay of various devices will become the key approach in new product development. And such innovations will have far reaching consequences including better performance by less trained surgeons. This is essential to obviate the ever increasing demand supply gap in healthcare today. The insight generated through "digitization" of data used in the procedure will generate quick evidence for standardization of procedures delivering better clinical outcomes.

The solution overview in (Fig 4) gives different systems and devices that are connected to a gateway controller and sending/exchanging information. The Unified OR platform application running on an iPad is connected to a gateway controller and receives live images/video feed and patient information. This information displayed on the unified OR platform enables the surgeon to,

- Make faster & smarter decisions during the Laparoscopy procedure to enhance clinical outcome
- Reduces procedure time & cognitive load on the surgeon.
- Gives easy access to the critical decision making information such as patient vitals & history, CO2 pressure and flow rate through the insufflator, anesthesia parameters, approximate size and volume of the uterus and/or Fallopian tubes and ovaries to be removed

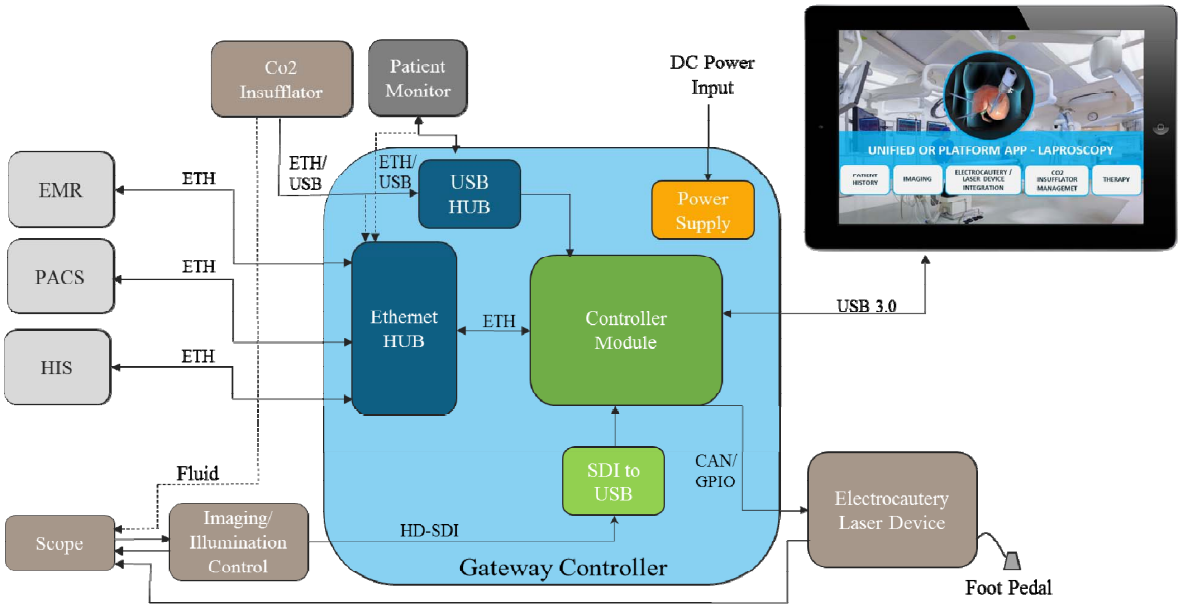

Fig. 3. Visualizing the OR of the Future where the surgeon has control on all devices in the on a central control panel

Such a workstation is a result of seamless integration of equipment and electronic medical records for real time exchange of information during the procedure. A gateway controller needs to be created that interacts with various devices in the OR and EMR/PACS of the hospital. Performance of the procedure, proper documentation of the clinical procedures, evidence based data for future optimizations and innovations are some of the additional benefits.

The unified OR platform includes the following solution components:

- The Gateway controller which receives data from different devices in an OR such as a Patient vitals monitor, CO2 insufflator, electrocautery, laparoscope, high-intensity light source etc. and converts this information to be compatible for display on the iPad.

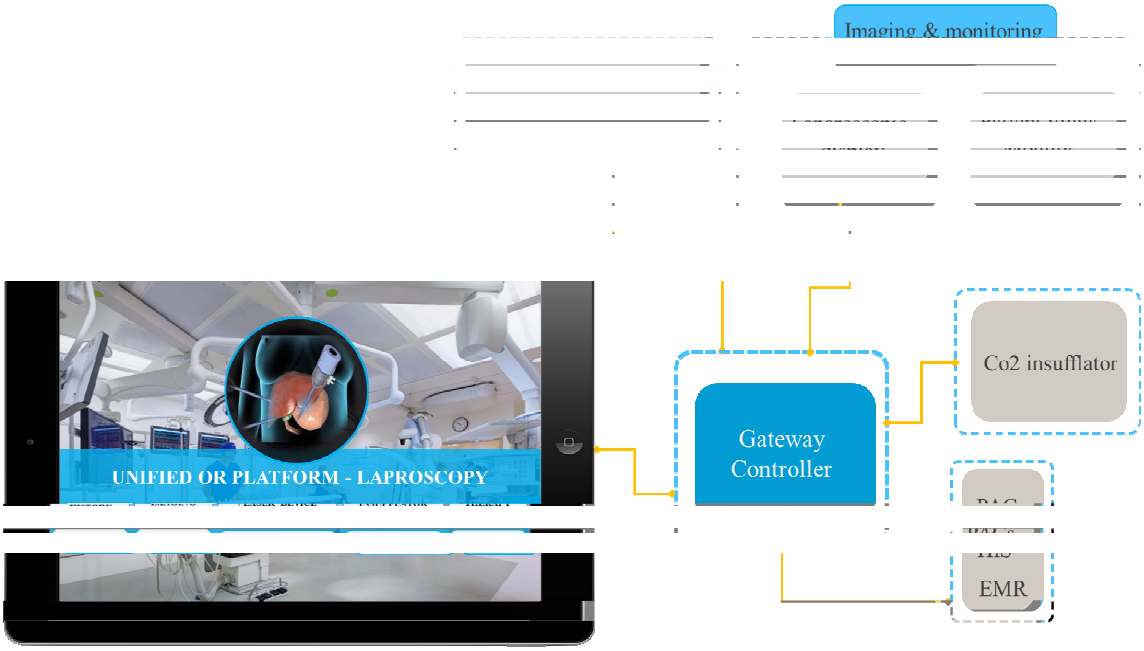

Fig. 4. High level technical architecture of Gateway controller

- The Unified OR Application displays essential information to the surgeon such as patient clinical history, critical patient vitals, pressure values of CO2 insufflator and the Laparoscopic live feed along with smart graphical features mapped over to enable the surgeon with better decision making abilities during the procedure.

A Gateway Controller is an external hardware unit which has intelligence to connect to multiple devices and applications. It uses an intelligent controller module that is linked to the connector hubs to take the data feed from devices inside an OR including devices using an Ethernet/USB connection. It also has the Serial Digital interface to USB converter which is used for connecting with the digital scope. A CANBUS interface is used for connecting a Laser Device/ electrocautery. The intelligent controller collects and displays the data on a tablet device to assist the surgeon.

IV. Discussion

Minimally invasive surgeries will continue to grow for their obvious benefits to patients. Such an approach to unify all the OR equipment is a major need of the hour, both for reduction of cognitive load and for the assistance of surgeons with lesser exposure to different technologies. While some parameters are independent, there are others that have dependency.

For example, adequate carbon dioxide insufflation is important for operative field visualization but can rapidly alter patient monitoring parameters. Similarly, patient positioning impacts physiological parameters and it also needs to be altered for better operative field by adjusting insufflation and suction in the dependent area. There are many such adjustments required for different surgeries and therefore integration of devices on a common platform is expected to ease out some of these complex interdependencies. When such integration is widely practiced, it will help to data mine various parameters to discover correlations and automate some of the adjustments for optimal physiological control. It will help with standardization of the procedural steps and give way for further innovation.

Acknowledgment

The authors acknowledge help of Dr. Chetan Mittal and Mr. Nishant Dayal for their help with the solution edits of this publication.

References

[1] Kaplan MB, Rogers R. Laparoscopic Surgery: A View From the Head of the Table. Seminars in Laparoscopic Surgery. 1994 Dec; 1(4):207-210.

[2] Maria F. Martín-Cancho, Diego Celdrán, Juan R. Lima, Maria S. Carrasco-Jimenez, Francisco M. Sánchez- Margallo and Jesús Usón-Gargallo. Anaesthetic Considerations during Laparoscopic Surgery, Advanced Gynecologic Endoscopy, Dr. Atef Darwish (Ed.), ISBN: 978-953-307-348-4, InTech, 2011.

[3] K. A.O'Hanlan, S. L. Dibble, A. C. Garnier, andM. L. Reuland, "Total laparoscopic hysterectomy: technique and complications of 830 cases," *Journal of the Society of Laparoendoscopic Surgeons*, vol. 11, no. 1, pp. 45–53, 2007.

[4] W. S. Melvin, J. A. Johnson, and E. C. Ellison, "Laparoscopic skills enhancement," *The American Journal of Surgery*, vol. 172, no. 4, pp. 377–379, 1996.

[5] Complications of Laparoscopic Surgery by MAGRINA, JAVIER F. MD