A New Operative Telesurgical System: Telelap Alf-X - Experimental Study on Animal Model

Valentina Larocca[1,*], Francesco Marino[1], Antonio De Filippis[1], Stefano Gidaro[2] and Achille Lococo[1]

[1]Department of Thoracic Surgery, "Spirito Santo" Hospital, Pescara, Italy

[2]Department of Biomedical and Experimental Science, University of Chieti, Chieti, Italy

Abstract: *Objective*: To report the first surgical thoracic major procedure performed using a new robotic telesurgical device (TELE-LAP ALF-X) in the ovine model.

Materials: The new operative-system has two innovative peculiarities: tactile perception (similar to tactile feedback of thoracoscopy) and eye tracking (the immediate and perfect synchronization between the surgeon eyes and the Robot-camera).

Results: After a careful setting of the robotic device, we have performed a lower-right lobectomy under complete robotic-assistance. The operative time was similar to the traditional thoracoscopy. In particular after the resection of inferior pulmonary ligament, we have isolated and closed firstly the lower pulmonary vein, then the bronchus followed by the arterial branches. The vascular and bronchial resections as well as the completion of the fissure were performed with standard endoscopic staplers introduced through an utility 4cm-sized incision. The specimen was placed in an endoscopic retrieval-bag and removed through the minithoracotomy. Finally, albeit the limitations due to different anatomical landmarks, a mediastinal lymph nodal dissection was also completed. Overall operation time was 180 minutes (with estimated blood loss of 100ml). The cooperation between the "first-operator" (placed at computer-console) and the "second-operator" (placed at the surgical-theatre) was optimal and no technical difficulties occurred.

Conclusions: According to this first experimental experience, we may assume that robotic thoracic procedures, using Tele-Lap Alf-X system, could be technical feasible in the ovine model. Although more "*in vivo*" experimental data are needed, we believe that robot-assisted telesurgery approach could be reasonable an innovative contribution in the near future also in human model.

Keywords: Thoracic surgery, robotic surgery, Telelap Alf-X, experimental study, animal model.

INTRODUCTION

Robotic surgery in its current form has established itself as a viable treatment option for several indications and the gold standard for a few indications; future possible additions to the technological armamentarium might significantly improve the ways how surgeons perform robotic surgery [1]. The future of robotic surgery will take this current platform forward by improving haptic feedback, vision and robot accessibility [1]. Haptic describes touch feedback, which includes both kinesthetic (forces and positions of muscles/joints) and cutaneous (tactile) feedback encompassing distributed pressure, temperature, vibration and texture [2]. The disadvantages of existing telesurgical systems are the lack of haptic sensation and, therefore, the dependence on visual force feedback [3, 4]. The haptic sensation seems to be a key factor concerning quality and improvement [5]. Since February 2010 we have been testing, the first as thoracic surgeons, a new telesurgical system, called Telelap Alf-X, also characterized by haptic feedback, on animal model.

MATERIALS AND METHODS

Telelap Alf-X is a new robotic device, initiated by the EU Commission and CE certified, that consists of an innovative console and three/four independent manipulator arms which can adapt their position in relation to the need of surgeon and the type of surgical procedure. This offers a large and safe space for the surgeon assistant and an easy access to the patient (for example in case of need to convert) (Figure **1**). Each arm has six freedom degrees and it is very easy and fast to move. Most instruments are attached to the arms with magnets, therefore, the change of instruments after their insertion to the patient is very quick. The unit detects instantly the pivot point at the fascia level. Low-cost disposable or reusable instruments are available; it offers a reduction of costs per intervention. Any instrument can be adapted to the system. The console incorporates the following main components: an ergonomic seat, the laparoscopic tele-operation master (LTM) with haptic handles, a 3D-HD monitor, an eye-tracking system (ETS), a keyboard and touchpad, and one foot pedal; the ETS and LTM are

*Address correspondence to this author at the Department of Thoracic Surgery, "Spirito Santo" Hospital, Pescara, Italy; Tel: 0039 3494737375; Fax: 00390854252973; E-mail: drsvalentinalarocca@libero.it

E-ISSN: 2311-1755/14

integrated by a software application called the Remote Human Machine Interface (RHMI) whose interface is on the screen as a toolbar beneath the operative view. This offers an open view of the operative room and thanks to a comfortable seat it enables effortless sitting throughout long operations, unconstrained posture for the surgeon and a less tiring surgery (Figure **2**). But the two innovative features of Telelap Alf-X are ETS and haptic feedback. The ETS is an infrared-based eye-tracking system that detects which point the surgeon is looking at. Before using the ETS, the device has to be calibrated interactively with the user following a procedure displayed on the RHMI and that takes one minute. The calibration procedure identifies physiological parameters of the user. Then the surgeon can move the camera without releasing the handles because the watched image is enlarged or reduced by moving the head to or from the screen and any point looked at on the screen moves to the monitor center (it offers a faster and easier control of bleeding or other problems); moreover it's possible to assign tools to the handles without releasing them. The ETS is a safe function because the robot stops if the surgeon gaze is not on the monitor. The haptic sensation can be used for palpation (for example to find hidden intraparenchymal lesions), pushing or pulling to estimate elasticity and consistency of tissues (very useful to avoid damage to delicate anatomical structures as blood vessels) and controlling the tensility of the sutures when tying. Moreover it offers a good perception when instruments touch each other avoiding collision between robotic arms.

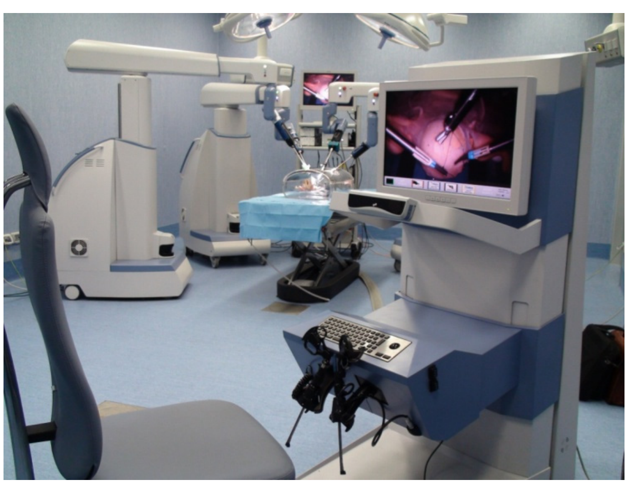

Figure 1: Extreme flexibility and adaptability of robotic arms with a large and safe space for the surgeon at the operating table; open view of the operating room with an easy access to the patient.

Telelap Alf-X is a new concept of telesurgery because, if up to now all robotic devices have been designed and constructed to replace the surgeon's hands, it has a thoracoscopy-like mindset: in fact the handles are similar to thoracoscopic instruments and the movements of handle at the console and of instruments on robotic arms moving in chest wall are specular, so the surgeon performs his robotic procedure like he would have done as a thoracoscopic procedure. Performing surgery in a familiar way results in a short learning-curve.

Figure 2: An ergonomic and confortable seat of the surgeon at the console; a thoracoscopy-like way to perform surgery.

Since 2010 our surgical team has been testing this new telesurgical system in an experimental operative unit at the Veterinary University of Lodi, Italy. The first part of our work consisted of short dry lab test to study and to improve some skills such as hand-eye coordination, manual dexterity, depth of field and ability of making endoscopic sutures and knots. Following we have performed the main thoracic surgical procedures on animal model. At the beginning we have chosen the swine model for its similarity with human anatomy: female pigs, two or three months old, weighing between 40 and 50 kilograms, Large White/Landrace cross race. But during our surgical procedures we met many problems because the haptic feedback system was set with a maximum load of two kilograms, instead pig chest wall's thickness and consistency created a bigger resistance to robotic arms movement, resulting in machine's block. So we switched our experimental study on a different animal model, less similar to human pulmonary anatomy but with a suitable chest wall: the ship (both gender, four or five months old, weighing about 40 kilograms, Bergamo race). The animals underwent to the main surgical procedures in lung and mediastinum.

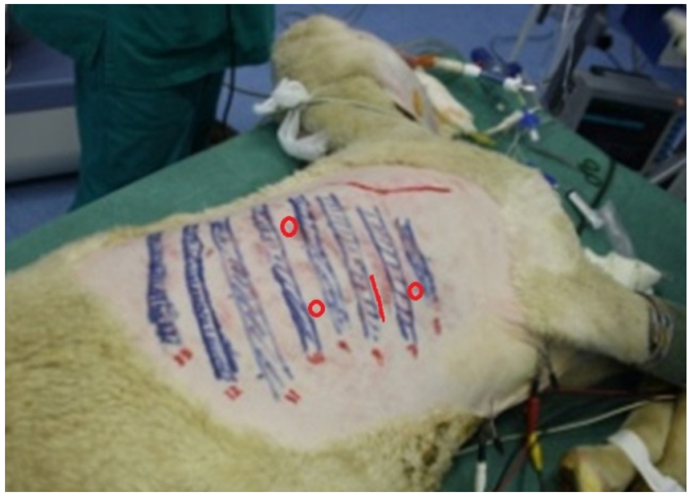

Figure 3: Accesses for pulmonary righ lower lobectomy in the ship.

	SWINE 1	SWINE 2	OVINE 1	OVINE 2	OVINE 3	OVINE 4
LIGAMENTUM	50’	38’	35’	38’	30’	25’
VEIN	50’	42’	30’	42’	30’	30’
ARTERY	50’	40’	30’	20’	30’	25’
BRONCHUS	60’	45’	45’	40’	35’	30’

Figure 4: Times of pulmonary lower lobectomies in animal models.

RESULTS

We performed two complete left lower pulmonary lobectomies on swine models, four complete right lower lobectomies on ovine models (Figure **3**) and some lymphadenectomies, some pleuropericardial fenestrations, one esophagus isolation and suture, one tracheal isolation and suture, two thymectomies. Regarding pulmonary lobectomies, the operative times in pig was longer than in ship and dividing the overall time of each procedure into the different steps (pulmonary ligamentum, pulmonary vein, artery and bronchus) the times were similar in the two different animal models because the difference was due to the problems with the haptic feedback system and pig's chest wall features. Focusing on pulmonary lobectomies on ovine, average operative time was 180 minutes (similar to the traditional thoracoscopy) (Figure **4**). In particular after resection of the inferior pulmonary ligament, we isolated and closed firstly the lower pulmonary vein, then the bronchus and afterwards the arterial branches. The vascular and bronchial resections as well as the completion of the fissures were performed with standard endoscopic staplers introduced through an utility 4cm-sized incision. The specimen was placed in an endoscopic retrieval-bag and removed through the minithoracotomy. Finally, albeit the limitations due to different anatomical landmarks, a mediastinal lymph nodal dissection was also completed.

DISCUSSION

Our 2-years long experimental study on animal model has demonstrated feasibility and safety of a new telesurgical system, Telelap Alf-X. The ovine model was the suitable one to test a robotic device provided with haptic feedback system. Telelap Alf-X is an evolving platform which offers innovative and exclusive features (haptic feedback, eye-tracking system, thoracoscopy-like mind-set with a short learning-curve) and a good cost-benefit ratio (lower costs per operation thanks to the reusable instruments). Both these aspects make it a surgical device simple to use and universally usable. Our short-term future prospects are to test the Telelap Alf-X system on humans.

REFERENCES

[1] Wedmid A, Llukani E, Lee DI. Future perspectives in robotic surgery. BJU Int 2011; 108: 1028-36. http://dx.doi.org/10.1111/j.1464-410X.2011.10458.x

[2] Okamura AM. Haptic feedback in robot-assisted minimally invasive surgery. Curr Opin Urol 2009; 19: 102-7. http://dx.doi.org/10.1097/MOU.0b013e32831a478c

[3] Reiley CE, Akinbiyi T, Burschka D, Chang DC, Okamura AM, Yuh DD. Effects of visual force feedback on robot-assisted surgical task performance. J Thorac Cardiovasc Surg 2008; 135: 196-202. http://dx.doi.org/10.1016/j.jtcvs.2007.08.043

[4] D'Amico. Robotics in thoracic surgery: Applications and outcomes. J Thorac Cardiovasc Surg 2006; 131: 19-20. http://dx.doi.org/10.1016/j.jtcvs.2005.09.007

[5] Stark M, Morales ER, Gidaro S. Telesurgery is promising but still need proof through prospective comparative studies. J Gynecol Oncol 2012; 23: 134-5. http://dx.doi.org/10.3802/jgo.2012.23.2.134

Received on 06-02-2014 Accepted on 19-03-2014 Published on 11-04-2014

DOI: http://dx.doi.org/10.12970/2311-1755.2014.02.01.2