

# Chapter 30

## Physical and Morphological Characterization of an Innovative System Control for the Accurate Execution of Lung Surgery

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**Abstract** Pulmonary ventilation is an important and indispensable method used in lung surgery. Generally, during the operation it is necessary to exclude one of the two lungs from ventilation. To this purpose the characteristics of the actual bronchial blockers don't let to exclude easily the lung during the surgical maneuvers. The difficulties evidenced during the anesthesia procedures by using a common blocker, have highlighted the need to find a new solution with alternative characteristics, such as to create an exclusion of the lung and at the same time to optimize the position of the blocker throughout the surgical maneuver.

### 30.1 Introduction

In recent years, commercial blockers have been made available for providing lung isolation. The one-lung ventilation creates differences, even on blood circulation, which undergoes a shunt effect, doubling the volume of blood on the ventilated lung. Any medical prosthesis, if introduced into a bronchus, creates a foreign body that must be managed to avoid the creation of mechanical problems to the patient.

The blocker inserted into the lumen has in the final position a balloon that, once inflated, avoid inflation of the air/oxygen in the lung and at the same time guarantee the residual air contained in the lung to go-out trough the channel inside the blocker [1, 2]. Blockers currently on the market have dimensions that sometime

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are not suitable to follow some anatomical variants, preventing its correct position and, consequently, the failure of deflation lung lobes. Sometime, the large footprint of the cuff on the mucosa causes ischemia in surgery and, in very long situation, can be cause even of irreversible damage. The experience demonstrates that, the characteristics of the actual bronchial blockers don't let to exclude easily the lung during the surgical maneuvers. Moreover, in some cases, there are anatomic variations in which the right upper lobar bronchus is located at a few centimeters from the tracheal bifurcation. The difficulties evidenced during the anesthesia procedures by using a common blocker, has highlighted the need of finding a new solution with alternative characteristics, such as to create an exclusion of the lung and at the same time to optimize the position of the blocker throughout the surgical maneuver.

In this paper a new solution has been reported by a suitable redesign of the blocker. This new solution (called fuggiano-blocker) has been designed with a shape similar to a "life jacket" that is very broad in order to occlude the bronchus, and small in order to be used in these anatomic variants. The shape of the cap, checked frequently with the fiberscope, has demonstrated an excellent stability, with no deformation, which allows keeping the blocker in vertical position.

## 30.2 Experimental Setup

A glass tube of dimensions close to those of a real bronchial channel has been used as a model for the determination of physical parameters involved in the real problem. Obviously the model is not a real situation but we can extract physical parameters such as the pressure inside the balloon and pressure for unit of surface generated to the internal surface of the tube by using image analysis software. A CCD camera give us information about the contact surface between the balloon and the internal surface of the model.

A comparison between the performances of a standard blocker and the novel solution as been performed in term of suitable internal pressure to obtain a correct seal. Analysis of the shape and morphological modification of the balloon as a function of the internal pressure for both cases has been performed. Moreover a control of the seal of the novel device has been performed by using oxygen pressure sensor in order to determine the minimum pressure suitable for a correct seal during the surgery. Finally, Japan's Fuji Company has agreed to produce some prototypes acquiring the CE mark, which allowed us to use this prototype as medical product.

## 30.3 Results and Discussions

Figure 30.1a, b report the shape of the two analyzed balloon, (a) new and (b) commercial device respectively, inserted in a simulator of lung. As one can see the dimension of the new blocker is smaller respect to the commercial device,

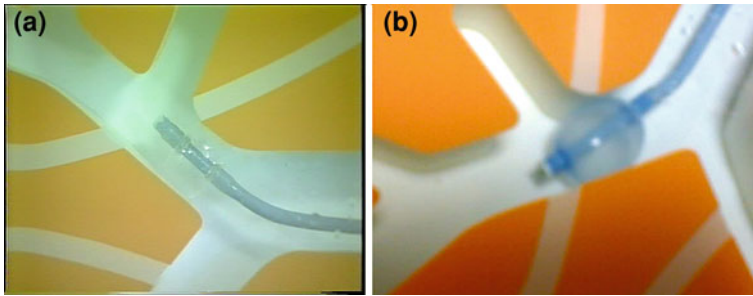


Fig. 30.1 a New Fuggiano-blocker, b commercial blocker

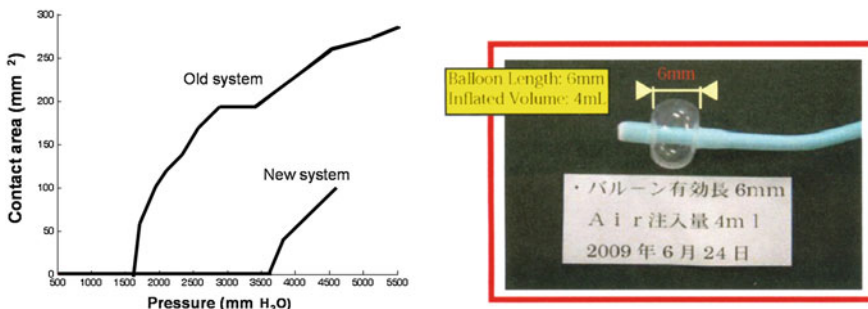


Fig. 30.2 Contact area onto the internal model surface vs inflating pressure

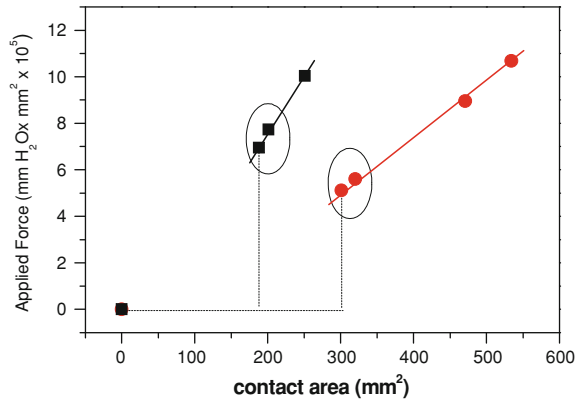
moreover, checked frequently with the fiberscope, has demonstrated an excellent stability, with no deformation. It is able to keep the blocker in vertical position to avoid any changing in the direction of the final point of the tube.

Analysis of the pressure suitable to obtain a good seal in the glass tube model has been evaluated by using specific experimental set-up consisting of two pressure gauges. By a CCD camera, the contact area inside the model tube as a function of the internal pressure has been monitored. Figure 30.2 shows the behavior of the seal cap during the inflation at different pressure for both system, old and new device respectively. Whereas a higher pressure it is need to expand the balloon of the new device until seal condition, a minor contact area it is necessary to guarantee seal in the case of new cap.

Figure 30.3 reports the intensity of the force applied to the internal contact surface of the model as a function of contact area for the new system (black line) and old system (red line) respectively.

The circles evidenced in the Fig. 30.3 put in evidence the optimal seal condition needed to avoid the air flow through the contact region between the two surfaces of interest, the balloon and the model. To do this a suitable control of the seal of the novel device has been performed by an oxygen pressure sensor in order to determine the minimum pressure suitable for a correct seal during the surgery. Notwithstanding an higher inflating pressure in the case of the new device, the seal

**Fig. 30.3** Applied force to the internal contact surface of the model as a function of contact area for the new system (*black line*). The circles indicate the optimum seal condition and old system (*red line*)



is guarantee, when the contact's surface is about 188 mm<sup>2</sup>, on the contrary, in the case of the commercial device, this surface must be of about 330 mm<sup>2</sup>.

### 30.4 Conclusions

A novel modified blocker has been developed to be used during the lung-surgery. Comparison between the new system and the commercial one give us interesting results as concerns the reduced invasiveness demonstrated from the new system during the surgery. Moreover a less damage of the mucous membrane of the bronchus has been evidenced. The shape of the blocker provides a supporting surface of the mucosa very least to allow the seal without creating ischemia. Given its its small footprint, also avoids possible desaturation of oxygen, related to compression of arteries in the thickness of the bronchus. The shape of the balloon makes the blocker more stable during all surgical procedures without having to frequently reposition the blocker. The oval shape of the old model displaced the tip, obliterating and preventing air leakage. The fuggiano-blocker keeps the tip at the centre of the bronchus, facilitating the deflation of the lung lobes. Also the material component of the balloon has demonstrated to be suitable for the aim, because it is transparent and allows observation of the bronchus below, bringing together the bronchoscope, thereby ensuring a direct view of the operative field.

### References

1. Cohen E (2002) MD-New trends in thoracic anesthesia. *ASA Refresher Courses in Anesthesiology* 30(1):69–85
2. Allen MS (1996) Video assisted thoracoscopic surgical procedures: the Mayo experience. *Mayo Clin Proc* 71:351