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Review Article

Brief overview in the field of laryngeal rehabilitation

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Abstract

The larynx is an important organ in humans. When it is removed, most often following cancer, the patient's life is seriously damaged. They undergo a major mutilation with significant physical and psychological sequelae, leading to a serious deterioration of their social life. For more than a century, researchers have focused on the rehabilitation of the voice, which is now acquired by different solutions [1]. All these devices have been erroneously called artificial larynx, even though they did not rehabilitate all the functions of the larynx, but only the voice. In particular, the tracheostomy which is performed after the removal of the larynx remains in place. This is unfortunately the most disabling part for the patient when he found his voice. This article presents the main solutions to avoid tracheostomy, and in particular the possibility of an active implantable artificial larynx.

Keywords: Total laryngectomy; Airway reconstruction; Artificial larynx; Active implantable artificial larynx

Introduction

The larynx is an organ located in the neck; it is a central part of the respiratory system. It is an organ used to speak, breathe, and eat. The larynx is a complex assembly made up of cartilage, ligaments, and muscles. This organ is well detailed in all anatomy books.

When a patient undergoes a total laryngectomy (the larynx is removed), patients are then tracheostomized, i.e., they have two separate circuits, one for food, and one for breathing. Speech disappears, as well as nasal functions (humidification, heating, filtration, olfaction, and air acceleration) and the possibility of performing an effort with a closed glottis (such as lifting a load for example). To rehabilitate the larynx, the solutions proposed, stay in the field of research, for several decades now. The different way explored can be grouped into three categories: (1) larynx transplantation, (2) replacement of the larynx by a biologic natural element, (3) replacement of the larynx by an artificial device. The progress of these three categories is briefly presented below.

Laryngeal transplantation

The time and space devoted recently in the mass media to the transplantation of non-vital organs, such as the hands or the face, have raised questions regarding the possibility of transplanting the larynx. The main barriers to larynx transplantation are tissue viability of the transplanted organ, immunological tolerance, and functional restoration [2-4]. The first successful transplant was performed in the United States in 1998 and, three years later, the

patient had regained a normal life. Yet, the graft was eventually removed 14 years later because of chronic rejection. Two other transplants followed and showed promising results in 2012 and 2015. Yet, despite the success of these operation, little is done to generalize the laryngeal transplantation. Indeed, the absence of its functionalities does not put the patient's life at risk, but the need of post-transplant immunosuppressants considerably increases the risk to develop a malignancy. Even though research is conducted to reduce their impact on the body's defenses, the risk has not yet been considered worth it.

Replacement of the larynx by a natural element

The field of tissue engineering have enabled great progress in airway reconstruction techniques, making it possible to envisage the replacement of long segments of trachea in the future. These reconstructions associated with the development of biomaterials could also facilitate the design and insertion of a laryngeal prosthesis [5]. In particular, recent aortic transplantation is encouraging and allows to avoid immunosuppressants [6]. However, well tolerated laryngeal substitutes are still a great challenge and various method have been developed [7] but, despite promising results, no available solution exists today.

Replacement of the larynx by an artificial device

To keep the trachea in place and avoid the tracheostomy, Debry et al [8-10] developed an artificial larynx as a replacement device. Implanted in 2012 on six patients, it consists in a titanium prosthesis with a double valve system allowing the patient to breathe via the upper respiratory airways, while avoiding the aspiration of food. Unfortunately, no permanent use outside the hospital could be authorized because of the imperfect sealing of the valve. Moreover, the irremovable part of the prosthesis was not completely integrated, and there was a risk of obstruction in the long term. Tests with this model were therefore stopped.

The active implantable artificial larynx

The past decades have provided new possibilities in the fields of airway reconstruction and artificial larynx. On that basis, an innovative approach is emerging by means of an active implantable artificial larynx [11]. It intends to detect a swallowing in real-time through the measurement of physiological signals, which most often consists in myoelectric signals from a dedicated muscle. The trachea could then be closed temporarily, to protect the airway from aspiration, and reopened once the bolus has passed to allow the patient to breathe. At present, research is conduced to acquire ElectroMyoGraphic (EMG) signals on healthy subjects within the framework of a clinical research protocol. Dedicated signal processing and early detection strategy are developed in order to close the trachea sufficiently early, before the passage of the food bolus. The ultimate goal is to use this principle to control a valve on an artificial larynx which would then become active.

Conclusion

Among all the solutions presented, transplantation seems the least promising since it still presents unresolved complex problems. Among the other potential solutions, allograft seems to be an interesting possibility, which will nevertheless not be sufficient on its own. It will be able to reconstruct the trachea in a natural way, which is already a great promise. The development of a plug and play device to replace the larynx has not yet seen the light today. The association of different research approaches can give hope for the creation of a hybrid larynx by combining tissue engineering, allograft, biomaterials and artificial devices.

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Conflict of interest

No conflict of interest.

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