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Case report

Improving surgical results in complex nerve anatomy during implantation of selective upper airway stimulation

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ABSTRACT

The following report presents a case of two late embedded hypoglossus branches during implantation of an upper airway stimulation device that caused a mixed activation of the tongue when included in the stimulation cuff. In the end, correct cuff placement could be achieved by careful examination of the hypoglossal nerve anatomy, precise nerve dissection, tongue motion analysis and intraoperative nerve monitoring.

1. Introduction

The majority of patients with obstructive sleep apnea (OSA) are treated with continuous positive airway pressure (CPAP) [1]. But despite its efficacy, there is a high rate of non-adherence due to CPAP-intolerance. Only 68% of the patients after 5 years are adherent to CPAP therapy [2]. Selective upper airway stimulation (sUAS) has proven to be an effective therapy in the treatment of OSA [3]. Criteria for surgical indication included an apnea–hypopnea index (AHI) <50, a body mass index (BMI) $\leq 32\ kg/m^2$ and the absence of palatal complete concentric collapse during drug-induced sleep endoscopy (DISE). Clinical examination was performed to rule out any anatomical abnormalities preventing the effective use of assessment of the sUAS, e.g. patients with enlarged tonsils or nasal pathologies were excluded [3]. Opening different levels of the upper pharyngeal airway with a breathing-dependent stimulation is a promising treatment option. A detailed step-by-step guide for the surgical implantation has been described [4]. Furthermore, a new classification system of the hypoglossal nerve (HN) and its individual anatomy of the terminating branches was developed to help surgeons to identify the optimal location for the cuff placement in sUAS [4]. The main target fibers of the HN are the medial branches, which innervate the horizontal and oblique compartments of the genioglossus muscle (GGh, GGo) to protrude the tongue and the transversal and vertical intrinsic tongue muscles (T/V) to stiffen the tongue body during stimulation. The first cervical nerve (C1), which innervates the geniohyoid muscle should be placed in the cuff to open the hypopharyngeal airway by moving the hyoid bone anteriorly. In most cases it runs inferior to the hypoglossal nerve fibers but individual varieties have also been observed [5].

The lateral fibers of the HN innervate the retractor muscles, namely the styloglossus (SG) and hyoglossus (HG) muscle. These fibers should be excluded when placing the cuff [4]. Therefore, precise separation of the lateral branches from the medial branches is essential for sUAS.

2. Case report

A 59-year-old man (BMI of 28.9 kg/m^2) presented with a two-year history of OSA and non-adherence to CPAP. He is a

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non-smoker and non-drinker with a medical history of arterial hypertension and right carotid artery stenosis. The in-laboratory polysomnography (PSG) revealed a baseline AHI of 54.4 events per hour and a baseline oxygen saturation nadir of 81%. The baseline Epworth Sleepiness Scale (ESS) was 13. DISE was performed using a propofol target controlled infusion (Alaris Asena PK MkIII targetcontrolled infusion pump; Alaris; Becton, Dickinson, and Company Franklin Lakes, NJ) and entropy (GE Healthcare) to measure the depth of sedation. As shown in previous studies propofol target concentrations between 2.5–3.2 $\mu g\ ml^{-1}$ are best suited to evaluate the obstruction levels and patterns by using the VOTE (Velum, Oropharynx lateral walls, Tongue base, Epiglottis) classification [6,7]. It is important to exclude a complete concentric collapse at velum level for selective upper airway stimulation. In this case the patient showed complete obstructions of the velopharynx and the tongue base. Both occurred in an anteroposterior direction. Thus, indication for sUAS was given and an implantation (Inspire II, Inspire Medical Systems Inc., Maple Grove, MN, USA) was performed.

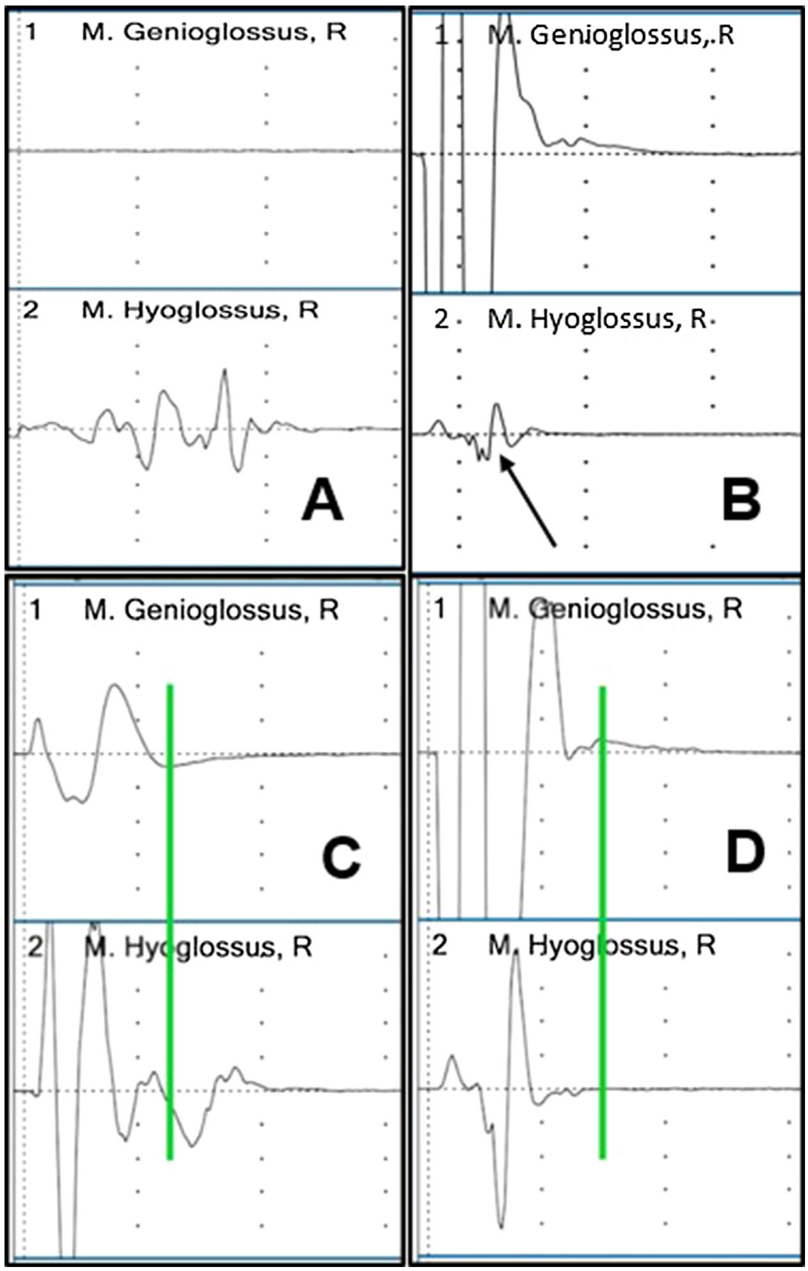

Fig. 1. The different intraoperative EMG signals of the two NIM channels are presented. (A) shows the EMG signal of stimulating a HG branch. A choppy and fractioned signal in the HG channel can be typically seen. (B) shows the EMG signal during testing the system after the first cuff placement with 0.3 V. The arrow marks choppy pieces in the HG channel, which could be associated with another hidden HG branch in the stimulation cuff. (C) shows again an EMG signal during testing after second cuff placement. Notice again the EMG response in both channels. The vertical green line indicates the end of the signal in the GG channel and shows the choppy, fractionated signal in the HG channel after the GG channel had calmed down; this is another hint of a HG branch in the stimulation cuff. (D) shows an EMG signal after finally exclusion of all HG fibers. Now, with all branches out, the HG signal says clear inclusion as it is quite smooth and returns to baseline along with the GG signal, and even a little bit sooner. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

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