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Robotic Surgery in Obstructive Sleep Apnea-Hypopnoea Syndrome

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Summary

Obstructive sleep apnoea-hypopnoea (OSAH) syndrome is a sleep disorder characterised by pauses in breathing (apnoea) or periods of reduced breathing (hypopnoea) during sleep. It results in cerebral hypoxia and a disturbed sleep pattern. The gold standard treatment for OSA is continuous positive airway pressure (CPAP). However, significant number of patients are not able to tolerate this device and approximately 50% of patients report inability to achieve long term usage to CPAP.

Robotic surgery is an emerging technique for sleep surgery. TORS is an alternative treatment for OSA for patients who have failed CPAP treatment or conventional non-robotic sleep surgery. This technology is assisted by remote-controlled miniaturized surgical instruments and magnified visualization with a high-definition three-dimensional camera. Tongue base reduction (TBR) refers to the primary focus of this targeted surgery for obstructive sleep apnea (OSA).

TORS approach for OSA may include 2 different surgical steps frequently combined in the same procedures according to the patient's features: tongue base reduction and supraglottoplasty (SGP).

In the light of the present results and of the literature, TORS tongue-base reduction appears to be effective. With the improved visualization and precise tissue removal provided by robotic surgery, TORS may become more widespread in the treatment of OSA in the coming years. There was an improvement in objective and subjective sleep measures. The comparison among pre-operative and post-operative parameters showed a significant decreasing in post-operative AHI, ESS and an increasing of the lowest SpO_2 value.

Key words

robotic surgery; obstructive sleep apnoea; da Vinci system; obesity

Introduction

Transoral robotic surgery (TORS) is one of the fastest growing areas of head and neck surgery. This technology is assisted by remote-controlled miniaturized surgical instruments and magnified visualization with a high-definition three-dimensional camera. It was initially introduced as a surgical technique in the treatment of head and neck cancer. The Food and Drug Administration (FDA) approval of the da Vinci Surgical System (Intuitive Surgical Inc., Sunnyvale, CA) for the use in TORS in 2009 [1]. Since then, there has been a rapid development in the field of transoral robotic surgery (TORS) and robotic surgery in otolaryngology. Thanks to its advantages in accuracy and vision, interest in TORS has been increasing for benign pathologies where aesthetic and functional impacts are relevant, avoiding more invasive procedures [1].

Obstructive sleep apnoea-hypopnoea (OSAH) syndrome is a sleep disorder characterised by pauses in breathing (apnoea) or periods of reduced breathing (hypopnoea) during sleep. It results in cerebral hypoxia and a disturbed sleep pattern. Depending on the frequency of these pauses, OSA is defined by an Apnoea-Hypopnoea Index (AHI) of greater than 5 events per hour (AHI: >5/h) and graded as mild (AHI: 5–15/h), moderate (AHI: 15–30 h/h), and severe (AHI >30 h/h) [2].

The incidence of OSAH is increasing with increasing numbers of obesity cases around the world [3]. Due to this, OSAH constitutes a major public health problem affecting over 10% of the world's population with significant implications on quality of life [4].

Patients with Obstructive sleep apnea (OSA) are at increased risk of metabolic, neurocognitive and cardiovascular diseases due to the oxidative stress and inflammation triggered by intermittent hypoxemia[5]. OSA is an important risk factor for hypertension, myocardial infarction, stroke and impair the life quality of the patient [6].The presence of OSAH is also associated with significant mental health problems and road traffic accidents [2]. OSAH is caused by multilevel collapse of the upper airway, with the tongue base being a common site of obstruction (found in up to 17% to 33% of patients)[7].

The gold standard treatment for OSA is continuous positive airway pressure (CPAP). It has been shown to be highly effective in reducing daytime somnolence [7]. However, significant number of patients are not able to tolerate this device and approximately 50% of patients report inability to achieve long term usage to CPAP. These patients require an alternative treatment [1,8].

Surgery might be an alternative for the treatment of OSA, which can ease symptoms, reduce the risk of long-term after-effects, and improve the quality of life [5]. However, the tongue base has been recognized as one of the anatomic regions that may be challenging to surgeons due to difficult access, critical neurovascular structures and limited surgical techniques [9].

A variety of procedures have been described to target this region with the goal of improving surgical success rates: tissue debulking procedures (midline glossectomy, radiofrequency ablation) and tissue repositioning (tongue suspension, genioglossal advancement, maxillomandibular advancement) each with varying results [7,10]. The most commonly reported surgical procedure is uvulopalatopharyngoplasty (UPPP). Tracheostomy, hypoglossal nerve stimulation, and tongue base reduction (TBR) are also surgical options for select patients with OSA [3]. However, considering the frequent multilevel obstruction seen in patients with OSAHS, the base of tongue represents an anatomic target of interest, as oropharyngeal and retroglossal airway obstructions are commonly identified in patients with OSA [3,8].

Robotic surgery is an emerging technique for sleep surgery. TORS is an alternative treatment for OSA for patients who have failed CPAP treatment or conventional non-robotic sleep surgery [1]. The feasibility and safety of using robotics in the treatment of OSA was first reported by Vicini et al in 2010 [11]. It is now preferred by many sleep surgeons after its first use for OSA treatment. TORS provides a lot of benefits for the surgeon: superior exposure and three-dimensional visualization of the target anatomy inside the pharynx, more precise dissection and improved preservation of intralingual vessels and nerves, shorter learning curve, faster operative time, and a more reproducible approach as compared with traditional open as well as endoscopic techniques [9,12]. These advantages increase the surgeon's dissecting ability within the narrow surgical field and are partly responsible for the interest in this technique [2]. Data from the Literature describe TORS for tongue base resection alone, as well as in connection with other upper airway procedures [7]. This type of treatment for obstructive sleep apnoea syndrome (OSAS) appears to be widespread and well documented, with several meta-analyses proving its effectiveness.

Purpose to evaluate the usage of TORS on sleep-related outcomes in the treatment of OSA.

Description of the state of knowledge

Tongue base reduction (TBR) refers to the primary focus of this targeted surgery for obstructive sleep apnea (OSA). TBR can include removal of lingual tonsillar tissue, tongue base musculature, or both. The amount of resection is based on the patient's anatomy and degree of prolapse during sleep and can vary from several milliliter to greater than 50 mL [12]. Data from literature show that surgeons favor using transoral robotic surgery base of tongue (TORS BOT) reduction in patients with macroglossia or lingual tonsillar hypertrophy which cause retroglossal airway obstruction. However, many have focused on recognizing additional patient prognostic factors to further improve success rates [10].

Determining the anatomical and physiological site of obstruction is crucial for matching a patient to the appropriate surgical intervention. Multilevel obstructions are commonly identified in up to 54% of patients [13]. During physical examination, special attention should be paid to mouth opening, dentition, Mallampati score and biometric measures including neck circumference. Clinical examination should form part of the standard assessment process including fibreoptic pharyngolaryngoscopy (to visualize the tongue base and perform the Mueller manoeuvre looking for retropalatal-hypopharyngeal collapse) , polysomnography and drug-induced sleep endoscopy (DISE) (which allows more precisely detection of base of tongue collapses in patients affected by OSA) [14]. Other specialised investigations, such as volumetric MRI, should be conducted depending on institutional expertise and availability[vauterin2018]. All of this is needed to ensure patient suitability for TORS and minimise the risk of subsequent exposure-related injuries [2].

Patients should also fulfill all of the following criteria for TORS to be considered as a treatment for OSA: (1) moderate-to-severe OSA confirmed by polysomnography (defined as AHI ≥15 /h), (2) failure to comply or refusal of all other treatment modalities including CPAP, and mandibular advancement device, (3) BMI < 35 kg/m^2, and (4) predominant base of tongue collapse with or without epiglottic collapse evaluated by drug-induced sleep endoscopy (DISE).[vauterin2018]. TORS seems to be a good treatment option for non-morbidly obese patients (BMI ≤35 kg/m^2) failing to tolerate CPAP [2].

1. The procedure

TORS is conducted with the DaVinci robotic system (Intuitive Surgical, Sunnyvale CA). The surgical robotic cart is positioned at 30° to the surgical bed on the right-hand side of the patient. Following trocar insertion, 3 robotic arms are used: one central 12 mm for the 0° (for palate) and 30° up (for tongue base and epiglottis) endoscope, and two 5 mm ones on either side for the instruments, the Maryland dissector forceps and Bovie monopoly diathermy (15J, blended mode)[2,12]. Additional hemostasis can be provided by using an insulated coagulation-suction tube. An insulated bipolar forceps are of paramount importance for safe coagulation in the peripheral aspects of the surgical field. The forceps must be insulated from the tip to the handle in order to avoid burns of the oral commissure[2].

The patient is positioned supine (neck flexed and head extended) in order to achieve the best exposure. Tongue base exposure is achieved in the standard TORS approach with a combination of tongue tip traction and tongue body displacement by mouth gag under direct visualization with a head light. A combination of tongue base traction and properly selected mouth-gag blade length is the key for excellent exposure. After the insertion of a mouth gag, the da Vinci robotic arms are placed in the oral cavity. Surgery begins with the visualization of the epiglottis to orientate the surgeon [2,12].

TORS approach for OSA may include 2 different surgical steps frequently combined in the same procedures according to the patient's features: tongue base reduction and supraglottoplasty (SGP).

The goal of TBR is to enlarge the oropharyngeal space by removing tissue from the anterior wall. The end point of TBR may be achieved when the surgical view changes from a Cormack & Lehane Grade IV or III to a Grade II or I [2,12]. Lymphoid tissue as well as tongue base muscle must be removed in order to clear the retrolingual space or posterior airway space. The robot is used to perform lingual tonsillectomy, midline glossectomy, epiglottoplasty and palatine tonsillectomy, with the aim of establishing proper air flow [15]. The mean volume of tissue removed is typically 10 mL, but in some cases the overall volume may be up to 50 mL [2].

The procedure starts with right-side lingual tonsillectomy. After completing right lingual tonsillectomy, left lingual tonsillectomy is completed in the same way after side inversion of the robotic arms and tools. The surgical field is now inspected in order to evaluate the residual degree of obstruction. If Cormack & Lehane Grade is greater than 2, additional resection in the muscle layer is required. In order to open the posterior airway space it may be necessary to remove muscle in addition to lymphoid tissue. It is important to avoid injury to the neurovascular structures, including the dorsal branches of the lingual arteries and hypoglossal nerve. Depending on the levels of airway collapse identified preoperatively, tongue base reduction can be followed by epiglottoplasty [2,12].

Supraglottoplasty may be carried out concurrent with TBR in patient with primary and, in some cases, secondary epiglottic collapse. The role of SGP is to prevent the inward collapse of the floppy epiglottis and/or redundant supraglottic tissue. The upper third of the suprahyoid epiglottis can be removed but epiglottic resection should stop at above the pharyngoepiglottic folds to minimise the chances of aspiration and also prevent bleeding from inadvertent injury to branches of the superior laryngeal artery [2,12].

Tracheostomy is not performed routinely for patients undergoing TORS. It is performed only in certain circumstances including patients who were found to have a difficult intubation and during situations where emergent reintubation is anticipated to be difficult [2,7].

Patients are usually discharged within 24–48 h after surgery when their pain is controlled [2].

The average surgical time for tongue base resection using TORS is 30 min. The additional time required for SPG is usually less than 15 minutes [9,12].

2. Outcomes

In the light of the present results and of the literature, TORS tongue-base reduction appears to be effective. There was an improvement in objective and subjective sleep measures. The comparison among pre-operative and post-operative parameters showed a significant decreasing in post-operative AHI, ESS and an increasing of the lowest SpO_2 value [15].

In selected patients, TORS has been shown to be a promising and effective option for the treatment of OSA, allowing the resection of the base of the tongue.[14]. The improvement in sleep outcomes and notable success rate in TORS is most likely due to improved visualization, instrument access, and more precise tissue resection which results in larger volumes of tissue removal [10].

In analyzed literature, mean age was 47 years, men to women ratio was 5:3 respectively, initial body-mass index ranged from 18 to 35 kg/m2(mean, 29). Mean Epworth Sleepiness Scale score was 12. Mean preoperative AHI was 47 (range, 36–67) [16].

The rate of success, defined as 50% reduction of pre-operative AHI and an overall AHI<20, is achieved in up to 76.6% of patients with a range between 53.8% and 83.3% [4,14,17].

Data from literature show significant mean postoperative reduction in AHI and epworth sleepiness scale (ESS).

Lin et al. demonstrated reduction in AHI from 43.9/h to 17.6/h and ESS from 13.7 to 6.4 [2,9]. The lowest O_2 saturation increased from mean 79.8% to 85.0% in the TORS group [9].

Several factors seem to influence the surgical outcome in patients undergoing TORS for OSA. In particular, patients presenting with BMI < 30 kg/m2, AHI < 60 events/h, Friedman stage II-III and absence of lateral pharyngeal wall collapse generally benefit more from TORS than other phenotypes [14]. Success rates drops with increasing BMI. The risk of TORS failure rate was reported to be significantly higher in patients with BMI>30kg/m2. [14]. Beyond a BMI of 40kg/m^2, TORS has no role in the treatment of OSA with surgical response rates dropping to below 20% [4] .

Therefore, reliable predictors of the surgical response remains an area of active research.

Some articles looked at predictive factors for surgical success with BMI ≤30 kg/m2, AHI ≤60/h, absence of lateral pharyngeal wall collapse and amount of tissue resected between 10 and 20 mm^3 These factors were reported to be the most clinically relevant predictors in TORS [2].

An average complication rate of 22.3% in TORS for OSAH syndrome is reported in the Literature [2]. The most common complications of TORS are postoperative pain, swallowing problems, and haemorrhage [2,12].

Transient dysphagia as one of the potential complication does compromise the quality of life and must be discussed with patients preoperatively [15].

Persistent gustative disorder seems to be the most frequent minor complication, in work conducted by Debonecaze, progressively diminishing from 55% at 1 month to 7% at 1 year[16].

Although, robotic surgery provides benefits for the patient: excellent cosmetic outcomes, no neck scars (except for tracheostomy, if necessary), reduced likelihood of iatrogenic injury to vessels and nerves, better and faster functional recovery compared with the transcervical approach, reduced operating room time, and shortened length of hospital stay [12,17].

Summary

Robotic-assisted surgery for the treatment of OSAHS appears to be a promising and safe procedure for patients seeking an alternative to traditional therapy with CPAP. There is meaningful evidence that TORS reduces AHI and daytime sleepiness in the current published studies. With the improved visualization and precise tissue removal provided by robotic surgery, TORS may become more widespread in the treatment of OSA in the coming years. Appropriate patient selection and deeper understanding of the OSA pathogenesis is needed to implement an individual treatment strategy, that could lead to a more successful implementation of this novel surgical approach.

Nowadays, the major limitation of robotic surgical systems is their prohibitive cost. This is likely to change in the near future as patents expire and newer robotic systems emerge. This might create market competition, drive down costs and make TORS more pervasive affordable.

Although, more randomized trials are needed to prove the effectiveness of TORS in the treatment of Obstructive Sleep Apnea.

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