New organisation for follow-up and assessment of treatment efficacy in sleep apnoea

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Telemedicine could improve the management of sleep apnoea and other breathing disorders during sleep. http://bit.ly/2XPoPW1

Cite this article as: Suarez-Giron M, Bonsignore MR, Montserrat JM. New organisation for follow-up and assessment of treatment efficacy in sleep apnoea. *Eur Respir Rev* 2019; 28: 190059 [https://doi.org/10.1183/16000617.0059-2019].

ABSTRACT Obstructive sleep apnoea (OSA) is a highly prevalent disease, and there is an increased demand for OSA diagnosis and treatment. However, resources are limited compared with the growing needs for OSA diagnosis and management, and alternative strategies need to be developed to optimise the OSA clinical pathway. In this review, we propose a management strategy for OSA, and in general for sleep-disordered breathing, to be implemented from diagnosis to follow-up. For this purpose, the best current options seem to be: 1) networking at different levels of care, from primary physicians to specialised sleep laboratories; and 2) use of telemedicine. Telemedicine can contribute to the improved cost-effectiveness of OSA management during both the diagnostic and therapeutic phases. However, although the technology is already in place and different commercial platforms are in use, it is still unclear how to use telemedicine effectively in the sleep field. Application of telemedicine for titration of positive airway pressure treatment, follow-up to improve compliance to treatment through early identification and solution of problems, and teleconsultation all appear to be promising areas for improved OSA management.

Introduction

Obstructive sleep apnoea (OSA) together with insomnia are the most common sleep disorders [1, 2]. OSA is secondary to complete or partial airway obstruction caused by recurrent pharyngeal collapse during sleep, producing loud snoring or choking and frequent awakenings [3–5]. OSA may markedly affect quality of life and can be a risk factor for cardiovascular, metabolic and neurologic diseases, among others [6, 7]. General measures, such as the treatment of obesity, exercise, avoidance of alcohol and sedatives, and sufficient amount of habitual sleep are important in OSA treatment but are often insufficient, and continuous positive airway pressure (CPAP) remains the optimal treatment option [8]. Increased knowledge of OSA by general practitioners and the general population has heightened the demand for consultations with a specialist. Over the past two decades, with the increasing prevalence of obesity, the number of patients diagnosed as suffering from OSA has increased drastically and will probably further increase over the coming years [2]. However, this increase in demand has not been accompanied by

Received: 25 May 2019 | Accepted after revision: 16 July 2019

Provenance: Commissioned article, peer reviewed

strategic changes to make cost-efficient diagnosis, treatment or follow-up of patients with OSA. Therefore, there is a pressing need to improve OSA management.

All the problems listed above highlight the need for a change. To deal with these difficulties, and in view of the speed of current global change, continuous linear improvement needs to be developed in a short time [9]. Probably, the most important factors to be considered are the different medical levels involved in the clinical management of OSA, and the increasing availability of information and communications technologies.

In this review, we propose tentative management strategies for sleep-disordered breathing to be implemented from diagnosis to follow-up. As mentioned previously, a network of functioning and telemedicine techniques seem to be the best options, possibly generating a cost-effective personalised form of care provision [10–16]. There are a few points to be considered. 1) When a disease is common, all medical levels must be involved, from primary care, physicians and nurses, to reference (fully equipped, multidisciplinary teams or sleep specialists) and nonreference hospitals (able to perform simplified studies). 2) Sleep breathing disorders are not restricted to OSA. While uncomplicated OSA can be controlled by primary care medicine, other breathing disorders such as hypoventilation syndromes requiring noninvasive mechanical ventilation will likely become highly relevant in respiratory medicine in the near future. 3) The concept of patient-centred medicine has to be considered in all the different steps or procedures regarding sleep-disordered breathing. However, other sleep disorders, such as insomnia or restless leg syndrome, or nonsleep-related diseases such as obesity or depression are often associated with sleep-disordered breathing and require comprehensive patient management [17, 18]. 4) At present, technology has and will have even more importance in the management of sleep-disordered breathing in both diagnosis and follow-up. However, the technology should be simple, easy to use, reliable and, above all, transparent; it should not be a "black box". The better a technology is understood, the better it will be used [19, 20]. 5) Other important aspects are the relationship with the administration, industry and other professionals. There is also a changing perspective regarding sleep, as it is currently considered at least as important as exercise or diet in general health. Therefore, healthy sleep is an important aspect to consider in the management of patients with OSA [21].

The network system, as its name implies, requires a close interrelationship between its medical components at each of the different clinical levels, with each piece knowing its hierarchy, influence area, communication channels, and common action guidelines and channelling systems. The keys to the successful operation of the network are autonomy, information, training and communication. This model allows optimisation of existing resources, making them available to the entire network and optimises priorities based on preference and complexity. Different groups have considered a greater role for primary care physicians, nurses and other healthcare professionals in the management of OSA. Ideally, this uses a hub-and-spoke model, in which OSA is predominantly managed in the community, with support for patients with more complicated or treatment-resistant symptoms provided in a sleep medicine centre [22–27].

Telemedicine offers the tools necessary to reach patients located in rural areas with health professional shortages. The use of telemedicine technologies that combine direct point-to-point sleep tests, data transmission, automatic CPAP systems and videoconference can help to establish diagnostic and therapeutic strategies for OSA from remote locations. These can be managed by a central sleep unit, maintaining an appropriate cost-effectiveness ratio, providing the possibility of avoiding travelling by the patients [28] and a reduction in lost productivity from work absenteeism [29]. Nonetheless, healthcare professionals providing telemedicine services should have the necessary education, training and orientation to ensure they possess the necessary competencies for the safe provision of quality health services, as well as a systematic quality improvement and performance management process that complies with organisational, regulatory or accrediting requirements for outcome management [30].

In addition, simplified devices are very useful in a large number of patients [31–37]; however, not all procedures can be applied universally because of problems in some healthcare environments or for other reasons. Other procedures currently applied are: 1) telemedicine management of sleep; and 2) studies performed over several days [37, 38]. Until procedures are fully standardised in clinical care pathways and shown to be the most appropriate, it seems reasonable to follow different rules based on healthcare levels and severity of disease. The following basic steps are proposed (figure 1). 1) Primary medicine: if after the differential diagnosis, OSA is suspected, basic general measures for treatment should be initiated. 2) If symptoms are severe and the patients do not respond to the basic measures recommended, or other sleep-related diseases are suspected, the patient should be referred for diagnosis and treatment initiation in the sleep centre, fully equipped and with a multidisciplinary team, or able to manage simple devices and noncomplicated cases. 3) After diagnosis in the sleep centre and a therapeutic recommendation made, patients require follow-up. If the patient care goes well (with or without CPAP), the patient should return

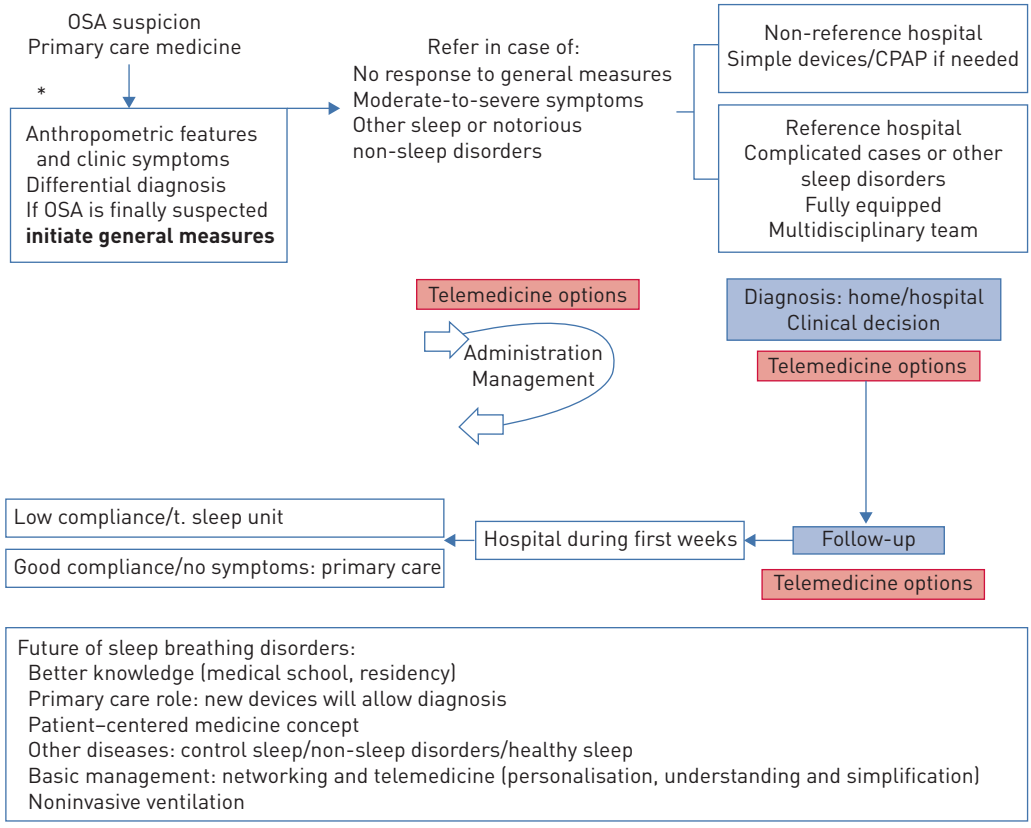

FIGURE 1 Overview of obstructive sleep apnoea (OSA) management. For OSA suspicion in primary care consider the following conditions: overweight, maxillo-mandibular abnormalities, heavy snoring and breathing pauses, nocturnal asphyxias and daytime somnolence. General measurements refer to: weight loss, exercise, sufficiently long sleep and avoidance of sedatives and alcohol. Differential diagnosis includes: inadequate sleep habits, depression with snoring, narcolepsy, hypoventilation syndromes, central sleep apnoea, restless leg syndrome, insomnia and substance abuse. CPAP: continuous positive airway pressure.

to the primary care physician with a clear indication of identifiable alert signs that may require referral back to the sleep centre. If CPAP is prescribed and compliance to treatment is good, lifestyle recommendations should be reinforced by the primary care physician. In case of poor compliance to treatment, patients should be reassessed and followed up by the sleep centre.

Telemedicine can have an important role in OSA management in the different steps as shown in figure 1, particularly during follow-up, as discussed later. Finally, two major points have to be considered and markedly improved: the role of primary care medicine and the implication of nursing staff, because in the near future with appropriate devices both of them can potentially contribute not only in the follow-up but also in the diagnosis with the implementation of simple devices. As already noted, adequate coordination between the different medical levels (networking) is imperative. To properly manage patients, personalised treatment, according to the entire spectrum of OSA phenotypes and associated comorbidities is a key point.

As far as sleep studies are concerned, there are two major types: full polysomnography (PSG; type 1 attended and type 2 non-attended) and home respiratory polygraphy (HRP; type 3 with at least four respiratory variables (flow, oximetry, band and position) and type 4 (just two respiratory variables) [39, 40]. PSG is considered to be the diagnostic gold standard; however, access to this procedure is limited because it requires special institutions with trained technicians and is relatively expensive overall. Organisations such as the American Academy of Sleep Medicine and the Australian Sleep Association recommend the management of OSA by HRP in patients with a high pre-istest OSA probability. A very short summary of the Australian Sleep Association recommendations follows: 1) A sleep study is only one component of the diagnosis. Clinical history and examination are as important and are complementary to the sleep study. The reference study is PSG at the sleep laboratory (type 1). 2) Type 2 studies have good diagnostic accuracy (to both "rule in" and "rule out" OSA) in selected patients and are an alternative to a type 1 study. 3) Home-based type 3 and 4 type sleep studies are useful to rule-in (but not rule out) OSA

in patients with a high suspicion of OSA, or when combined with a validated sleep questionnaire. However, supervision by an accredited physician is recommended.

In general, a type 1 sleep study is recommended to diagnose sleep disorders, including sleep-disordered breathing; however, the diagnostic methodology will probably radically change in the near future due to the changes in the type of devices and information and communication technologies [41, 42] or development and use of new sensors [41]. New smartphones with sensors for ambient light, respiratory effort by built-in microphone, movement by built-in accelerometer and phone usage provide enough data to accurately estimate sleep and wake patterns. Moreover, the development of sleep medicine applications for sleep apnoea recognition with a continuous oximetry curve using an external sensor has been validated for screening children and adults providing an improved portable at-home screening tool, allowing multiple nights of monitoring. Furthermore, smart watches can carry sensors that pick up body signals directly without additional sensors being attached. However, evidence is scarce and although this could be considered easy, such new hardware and software systems require adequate validation [43]. Table 1 summarises the old and new diagnostic and titration procedures [41–43].

CPAP follow-up

Spanish guidelines for optimal CPAP follow-up recommend monitoring at 1–2 weeks, 1 month and 3 months after CPAP [44]. The next visits depend on the patient's characteristics, comorbidities, side-effects, residual symptoms, events detected and compliance. Since the early detection and treatment of side-effects is one of the most important points to control during the first weeks to ensure better compliance, the application of telemonitoring strategies seems a promising tool to achieve this goal [45]. The factors that predict successful long-term CPAP adherence identified in a recent trial in patients with moderate-to-severe OSA and cardiovascular disease (SAVE study) treated with CPAP were that the average hours of nightly CPAP use and side-effects at 1 month following the initiation of therapy [46] were consistent with results from previous studies in the OSA population [47, 48]. Other factors identifiable prior to commencing treatment such as initial problems (reported at auto-titration), recent life events and living alone have also been associated with lower CPAP use. Moreover, reporting problems after the first night of CPAP seems to be an important predictor of compliance [49].

Telemonitoring CPAP and troubleshooting

The telemonitoring of CPAP therapy has been used to improve compliance using different approaches of telemedicine but results have been inconsistent. Numerous providers have developed CPAP modems that enable the use of wired Ethernet cables, home Wi-Fi networks and Bluetooth connections to transfer data to a Cloud database. Technology continues to move forward by using cellular connection as the standard, with remote access to CPAP data by both providers and patients [50]. Access to this information likely benefits both parties. Kuna *et al.* [51] reported that when patients accessed their own data, CPAP adherence improved.

Moreover, randomised trials comparing telemonitoring follow-up *versus* usual care for CPAP therapy have shown a statistically significant improvement in CPAP use when CPAP data telemonitoring (compliance, leaks and apnoea–hypopnoea index) are used for clinician intervention management [52], associating with feedback *via* phone [53, 54]. Hoet *et al.* [55] showed that telemonitoring significantly reduced the delay to the first intervention for CPAP treatment (29±25 *versus* 47±30 days), associated with the detection of problems by the telemonitoring system (39% of patients). Additionally, compliance at 3 months was significantly better in the telemonitoring group (5.7±1.6 *versus* 4.2±1.9 h·night^{-1}) [55]. Moreover, in a

TABLE 1 Different diagnostic procedures

At present diagnosis	Near future	Diagnosis in the future
In-hospital or home PSG	Home PSG/HRP remote transmission	Han *et al.* [41]
HRP	Smartphone with different sensors	Alshaer *et al.* [42]
	Devices collecting data during several days	Penzel Schöbel *et al.* [43]
	Contactless devices with data transmission	
Titration		
PSG hospital	Remote titration	
Home titration	Automatic devices with data transmission	
Auto-CPAP treatment	Improvement of auto-CPAP devices with oximetry	

PSG: polysomnography; HRP: home respiratory polygraph; CPAP: continuous positive airway pressure.

recent trial conducted by Hwang *et al.* [56] that incorporated automated responses to the patient and education through a web platform (Tele-OSA), telemonitoring was useful in improving short-term compliance (3 months); however, at 1 year of follow-up it was observed that 3 months after the end of telemonitoring interventions compliance to CPAP was similar to that of patients who followed usual management, suggesting that the application of these strategies requires continuous application.

There are certain barriers when it comes to incorporating the use of CPAP telemonitoring into routine clinical practice, such as the use of different CPAP brands, the lack of standardisation of parameters used by different providers, preventing interoperability for healthcare professionals and the management of data within the existing electronic patient records. When using telecommunication systems, there is also the potential for network complications which should be adequately prevented and managed by a competent and fully available support service [57, 58].

Teleconsultation

Teleconsultation to support the clinical review of CPAP users is potentially useful and can be effective with regard to therapy compliance and user satisfaction, in addition to saving time taken from employment to attend specialistic visits at a sleep centre [59, 60]. Isetta and co-workers have performed two important studies [45, 59]. In the first, 50 consecutive patients with OSA received a teleconsultation with a physician. Most patients were satisfied and 66% agreed that the teleconsultation could replace more than half of their CPAP follow-up visits [45]. In a second randomised study, 40 patients with OSA were divided into standard face-to-face training (n=20) or training *via* videoconference (n=20); subsequently they were blindly evaluated on what they had learned about OSA and mask placement [59]. Knowledge was comparable between groups, as was the performance of practical skills (mask and headgear placement, and leak avoidance) between groups [59].

Some concerns may be raised because of the limitation to perform a physical examination during teleconsultations. Despite that, patients with OSA could be adequately assessed without performing a physical examination that required the physician to be in the same room with the patient. Some elements of the examination, such as weight or blood pressure can be easily obtained by the nurse or primary care physicians [58].

Research is scarce regarding teleconsultation and telemonitoring; however, in a recent review by Murphie *et al.* [61], no safety concerns were raised. Two randomised trials showed improved CPAP compliance (n=19 and n=75); while two others (n=114 and n=75) reported no differences between groups. Satisfaction was generally positively reported; one trial reported teleconsultation and telemonitoring as cost-effective. Therefore, well-designed and adequately powered trials are needed to establish whether this approach is a clinically effective and cost-effective option for CPAP users [61].

Self-management and automated solutions

With the continuous evolution of telemedicine applications, CPAP companies are also moving forward integrating features with expansion to follow-up with the aim of providing comprehensive management of

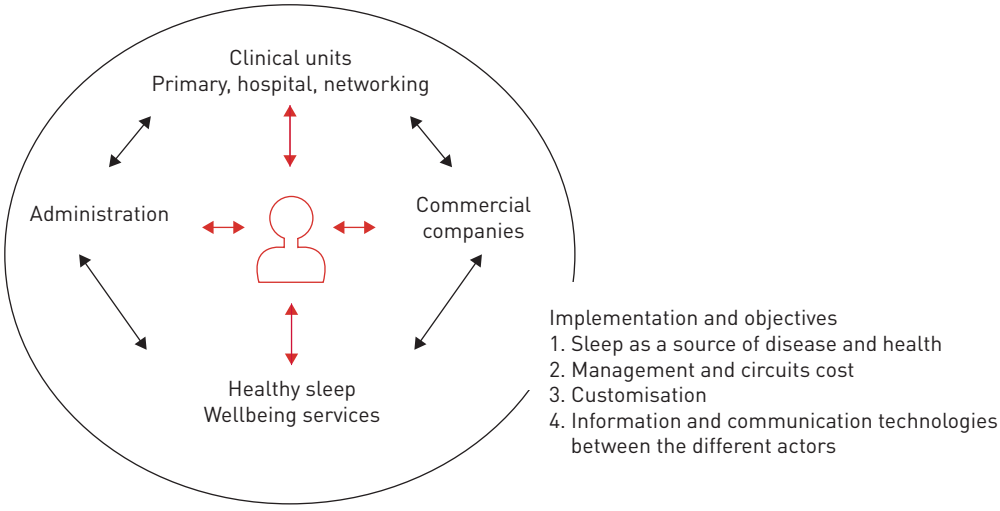

FIGURE 2 Strategies as a means of advancing patients health by improving patient care organisation, data management, diagnostic tools and follow-up support.

OSA. Self-management platforms operate through mobile device applications (DreamMapper; Respironics, The Netherands, MyAir: ResMed, Australia), providing personal CPAP data in simple graphs to each patient, and also incorporating CPAP troubleshooting material. The data are transferred from the patients' CPAP to an online database, the same platform used by sleep professionals to access a comprehensive report of CPAP therapy data to monitor patients; and virtually all these patients have access to their CPAP data *via* an Internet browser (web portal) or a mobile device application. A retrospective review of 15 000 patients in a database showed 78% of those who used SleepMapper were compliant at 90 days and used CPAP; however, it should be noted that a potential issue with this kind of retrospective uncontrolled data analysis is the possibility of confounding factors [50]. Moreover, for patients with comorbid insomnia, telemedicine also provides opportunities to exchange and automatically process sleep diaries and sleep–wake data using smartphone applications, and to follow online programmes related to cognitive behaviour therapy [58, 62, 63]. Evidence also highlights the potential of mobile apps in improving symptom management and health outcomes through self-management interventions among those living with chronic diseases like OSA [64, 65]. Mobile apps also represent an opportunity to reach patients routinely, and promote lifestyle modifications, such as nutrition and exercise [66], which can be of great use in OSA management.

Summary

The implementation of telemedicine in general practice is continuously growing, and both OSA and noninvasive mechanical ventilation belong to an area where much effort has been made to develop new strategies as a means of advancing patient health by improving patient care organisation, data management, diagnostic tools and follow-up support (figure 2). The American Academy of Sleep Medicine Task Force on sleep medicine supports telemedicine, while insisting on the importance of a clear understanding of its application and maintaining the clinical standards of care including all aspects of diagnosis and treatment [30]. Telemedicine applications can be useful to monitor and motivate patients with OSA treated with CPAP, by means of new mechanisms for supporting virtual visits and remote monitoring; however, further research into the impact, cost-effectiveness and outcomes is still needed for broad telemedicine enforcement. Basic concepts are simplification, understanding and personalisation of the processes. In addition, good coordination with companies, as well as appropriate training for both patients and professionals is imperative.

Conflict of interest: None declared.

Support statement: Funding was received from the Spanish Ministry of Economy and Competitiveness (PI14/00416 and PI17/01068). Funding information for this article has been deposited with the Crossref Funder Registry.

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