Telemedicine in the diagnosis and treatment of sleep apnoea

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Using telemedicine in obstructive sleep apnoea patients under continuous positive airway pressure therapy leads to reductions in nursing workload, early identification of problematic patients, and at least similar treatment adherence. http://ow.ly/dfL830nuBzD

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ABSTRACT Telemedicine (TM) is a current tool in the landscape of medicine. It helps to address public health challenges such as increases in chronic disease in an ageing society and the associated burden in healthcare costs. Sleep TM refers to patient data exchange with the purpose of enhancing disease management. Obstructive sleep apnoea (OSA) syndrome is a chronic disorder associated with a significant morbidity, mainly cardiometabolic, and mortality. Obtaining adequate compliance to continuous positive airway pressure (CPAP) remains the greatest challenge related to OSA treatment, and the adoption of TM to support OSA management makes sense. In addition, the prevalence of OSA is growing and OSA is associated with increased healthcare costs that could be streamlined by the application of TM. In OSA, multiple modalities of TM are utilised, such as telediagnostics, teleconsultation, teletherapy and telemonitoring of patients being treated with CPAP. In the present article, I aim to provide an overview of current practice and the recent developments in TM for OSA management. Concerns related to TM use will also be addressed.

Introduction

The use of telemedicine (TM) is growing worldwide [1]. Miniaturisation and the ubiquitous use of smartphones have opened new communication pathways between patients and caregivers, but have also contributed to a climate of "apomediation" where patients are constantly seeking information on the internet, profoundly modifying the bond of trust between doctor and patient [2].

TM is defined as the practice of medicine using electronic communications, information technology or other means between a licensee in one location and a patient in another location, with or without an intervening healthcare provider [3]. The scope of TM is broad such that the terminology is complex, as summarised in table 1.

Sleep TM refers to the exchange of patient data with the purpose of enhancing disease management. Data are transmitted by telephone or *via* the internet, through video and smartphone applications. Feedback to the patient is provided using the same methods.

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TABLE 1 Terminology in telemedicine

Telemedicine	Distribution of healthcare by HCP using ICT technologies to exchange information useful to perform a distant diagnosis
Telediagnostic	Medical diagnosis made by means of telemedicine
Teleconsultation	Consultation between HCP or HCP and patients performed at a distance, *via* internet or video conferencing
Teletherapy	Remote initiation of a therapy
Telemonitoring	Wireless transmission of physiological or noninvasive data
Telematics	Use of ICT to allow computers to transfer data
Telecare	A combination of alarms, sensors and other equipment to help people live independently; in emergency situations the patients call for help
Telerehabilitation	Delivery of rehabilitation by HCP to patients at home *via* video conferencing
Telecoaching	Remote reinforcement to improve adherence
Telemetrics	Automatic measurement and transmission of data using ICT
Telexpertise	Enable a medical professional to solicit, remotely, the advice of medical professionals because of their particular expertise, for patient care

Note that this is a non-exhaustive list. HCP: healthcare providers; ICT: information and communication technologies.

In the field of sleep disorders, TM can potentially help improve access to healthcare, reduce waiting times for medical visits or investigations, and increase adherence to treatment [4]. TM overcomes the problems of distance, traffic congestion and absence from work for medical visits. A recent position paper from the American Academy of Sleep Medicine (AASM) related to the use of TM in sleep disorders stresses that, "the practice of telemedicine should aim to promote a care model in which sleep specialists, patients, primary care providers, and other members of the healthcare team aim to improve the value of healthcare delivery in a coordinated fashion" [5]. However, despite the fact that TM can be used easily in a large array of sleep disorders, the majority of TM research papers are focused on obstructive sleep apnoea (OSA) treatment.

OSA is a chronic disorder associated with significant morbidity, mainly cardiometabolic, and mortality. Excessive daytime sleepiness is responsible for impaired quality of life (QoL) and neurocognitive performance in these patients [6, 7]. Continuous positive airway pressure (CPAP) is the mainstay of treatment, improving QoL and reducing mortality [8]. Obtaining adequate compliance remains the greatest challenge related to OSA treatment, and TM makes sense in this setting. In addition, the prevalence of OSA is growing and is associated with increased healthcare costs that could be streamlined by the application of TM [9, 10]. As shown in table 2, TM can be utilised in all aspects of OSA patient management.

Although we have observed a constant increase in the routine use of telemonitoring by sleep centres [10], generalisation of the use of TM has been hampered by multiple barriers. In the present article, we aim to provide an overview of current practices and recent developments in the field of OSA management using TM.

Telediagnostics in OSA

Telemonitored sleep recording

The main goal of sleep TM is to obtain good quality sleep recordings outside the sleep lab. Home (or unattended) polygraphy or polysomnography (PSG) avoids the need for patients to face long waiting lists for an attended in-lab PSG [11]. PSG in the sleep lab is still the reference method for OSA diagnostics

TABLE 2 Potential use of telemedicine in obstructive sleep apnoea patient management

	Usual pathway	Telemedicine pathway
Diagnostic	Attended PSG and home PG	Remotely attended PSG/PG
Consultation	Face-to-face patient–physician consultation	Patient–physician teleconsultation
CPAP education	Face-to-face training	Video conferencing training
CPAP titration	Sleep lab attended CPAP titration and home APAP titration	Remotely attended CPAP titration
CPAP follow-up	Face-to-face patient–physician consultation	Telemonitoring, patient–physician teleconsultation, automated teledriven feedback, web-based supporting tools

CPAP: continuous positive airway pressure; APAP: automated CPAP; PSG: polysomnography; PG: polygraphy.

[12] but, due to the growing number of patients suffering from OSA, we have observed a shift to the use of easier and less expensive diagnostic tools, such as polygraphy, that offer limited sleep studies. Type III polygraphy devices [13] that can measure airflow, respiratory effort and oximetry, exhibit wide variability in sensitivity and specificity, from 64% to 100% and from 41% to 100%, respectively, depending on the brand and how it is used [14].

AASM has recently recommended the use of polygraphy, with a technically adequate device, for the diagnosis of OSA in uncomplicated adult patients presenting with signs and symptoms that indicate an increased risk of moderate-to-severe OSA [15].

There are still quality concerns regarding the use of home polygraphy devices, which have generally had a failure rate of ∼5–30% [16]. However, this has improved in more recent studies [17] and current failure rates for home PSG are generally <8% [18]. Effort should be made to avoid failures and the need to repeat recordings.

TM has been used in the context of sleep recording for two purposes. The first is to make home polygraphy recordings quickly available for analysis, using TM for data transmission. This has been studied by Borsini *et al.* [19] in Buenos Aires where polygraphy was performed at home, but fitted by non-expert technicians. Raw data were sent by e-mail the following day. In this classical population of patients highly likely to suffer from OSA the failure rate was 4%, and 12% needed an additional in-lab PSG. These positive results have allowed healthcare providers to enhance accessibility to sleep tests in a large country with few expert sleep centres [19].

The second context for the use of TM for sleep recording has been to ensure the quality of unattended polygraphy/PSG (performed at home or in a virtual hospital) by intermittent or continuous remote supervision of recording. The impact of real-time telematic transmission for unattended PSG was first tested by Gagnadoux *et al.* [20] in a prospective randomised crossover trial. 99 patients underwent one home PSG and one in-hospital unattended, but telemonitored, PSG (TM-PSG) on two consecutive nights. The TM-PSG was performed in the medical wards of two peripheral hospitals, with intermittent, real-time, remote control from the sleep technicians of the central sleep lab (every 30 min). In case of loss of signal, the technicians instructed the nursing staff at the two hospitals on how to replace the electrodes. A technical intervention was required for 13 TM-PSG, but nurses could only solve nine problems. Finally, the TM-PSG failure rate was 11% *versus* 23% for home PSG.

In our lab, we have conducted two studies to assess real-time remote supervision of home or unattended PSG [21, 22]. In the first pilot study, we assessed 21 patients likely to suffer from OSA at home. The Sleepbox tool (Sleepbox®, Medatec, Belgium) was added to the polysomnograph in order to transmit recordings to the technicians at the sleep lab in real time. They performed remote monitoring of the home PSG every hour. In case of sensor loss, the technician was able to call the patient through Skype or *via* the microphone of the Sleepbox to ask the patient to replace the sensors correctly. The results of this pilot study were interesting but highlighted several technical problems, especially with Skype. Overall, 90% of the recordings were graded excellent in terms of quality, but among the 10% of failed PSG recordings, one was due to the polysomnograph (battery failure), such that only one was attributable to a poor quality recording. Two Skype interventions were required for sensor losses, resulting in readjustment of defective probes. The second study was performed in a very different setting. In this study, we performed real-time monitoring of unattended PSG in an acute coronary care ward in 27 patients hospitalised for acute coronary syndrome, with the purpose of screening for OSA. Unattended PSG was remotely and continuously supervised from the sleep lab, which was located in another building of the same hospital. As in the study of Gagnadoux *et al.* [20], the sleep technicians instructed the nursing staff in the acute coronary care ward on how to replace the electrodes when faulty signals were detected. We obtained very good results with 100% interpretable sleep recordings and 89% graded as excellent. Once more, we had to deal with technical problems related to the 3G network connection, exhibiting why Sleepbox was only efficient in 78% of patients. However, the 10 successful interventions did effectively increase the global quality of the PSG recordings.

An additional study of TM sleep recording was conducted in Spain by Coma-del-Corral *et al.* [23]. A "Virtual Sleep Unit" was created at a distance of 80 km from the central sleep lab. Real-time continuously supervised telemonitored polygraphy was performed. Placement of polygraphy was done by the local nursing staff under remote supervision from the central sleep lab in patients likely to suffer from OSA. Supervision also included continuous video monitoring *via* a webcam. No telemonitored polygraphy failures were observed, but data transmission failed for 2.5% of the recordings.

These four pilot studies have confirmed the feasibility and the potential interest in telemonitored sleep recording, which is not routinely applied in current practice.

Teleconsultation following OSA diagnosis

TM can be used as a tool to facilitate consultations to explain diagnosis and therapy to recently diagnosed OSA patients. In this setting, TM can provide real-time clinician–patient interactions, often *via* the internet or video conferencing.

Teleconsultation

Coma-del-Corral *et al.* [23] applied teleconsultation in patients with confirmed OSA. After telemonitored polygraphy, patients were randomised to receive either a face-to-face consultation or a teleconsultation to receive the results of their sleep study. The teleconsultation was made *via* video conferencing. It was followed by a home trial with an automated positive airway pressure (APAP) device for the 16 patients requiring CPAP, and the data were telematically transmitted for 2 nights. At 6 months, in this very small group of patients, adherence was not different between the groups: 85% for the face-to-face consultation and 75% for the teleconsultation group.

CPAP education

In a study of CPAP education, Isetta *et al.* [24] included 40 OSA-naïve patients and scheduled them for CPAP training either by video conference (20 patients) or usual face-to-face practice (20 patients). After the training, patients answered questionnaires anonymously about what they had learned. The results showed that both knowledge and practical skills (*e.g.* mask and headgear placement and leak avoidance) related to OSA and CPAP therapy were equivalent between the groups (94% correct answers in the video conference group *versus* 92%) [24]. Thus, teleconsultation is feasible and leads to adequate knowledge when used for CPAP training.

Telemonitored remote CPAP treatment initiation

Home APAP titration, controlled by polygraphy, is a valuable alternative to in-lab attended titration and results in similar clinical outcomes in terms of adherence, sleepiness improvement and QoL [25–27]. Treatment adjustments are performed *a posteriori,* including the shift from APAP to fixed CPAP device and mask adaptations. However, in real-life settings, clinicians can be confronted with high failure rates for home APAP titration, up to 20% in one Canadian experience [17], leaving plenty of room for improvement.

Disappointingly, only one study has tested remote-attended CPAP titration at home. Dellaca *et al.* [28] studied 20 severe OSA patients exposed to CPAP for the first time. A telemetric unit was coupled to the CPAP device. Using GPRS mobile phone network, the technical team from the sleep lab was able to remotely control CPAP parameters (flow, pressure and leaks) and to adapt CPAP pressure. An attended CPAP titration PSG was performed 1 week later in the sleep lab, leading to the same pressure settings: 9.15 cmH_2O at home *versus* 9.2 cmH_2O in the sleep lab.

This interesting exploratory study, which allowed sleep technicians to avoid potential failures of APAP trials at home, has not yet been followed by larger scale trials.

Managing CPAP treated patients with TM

When treating OSA patients with CPAP, the challenge of obtaining adequate adherence is clearly an essential feature. Adherence is defined as use during at least 4 $h{\cdot}night^{-1}$ and for >70% of nights [29]. However, on an individual basis, greater adherence is required as the effects of CPAP grow with increased use. A linear relationship between CPAP use and subjective/objective sleepiness, functional outcomes assessed by sleep questionnaire, and improvement in memory has been demonstrated when CPAP was used for >6 $h{\cdot}night^{-1}$ in comparison with <2 $h{\cdot}night^{-1}$ [30]. Longer CPAP use also achieves greater reductions in blood pressure and sleepiness [31].

In a cohort of 3100 CPAP treated patients, Bouloukaki *et al.* [32] randomised patients to intensive *versus* standard interventions and confirmed the positive effects of greater CPAP use (6.9 *versus* 5.2 $h{\cdot}night^{-1}$) on cardiovascular outcomes, highlighting that regular use of 5–6 $h{\cdot}night^{-1}$ is required.

Predictive factors of low adherence have been identified in several studies. Low CPAP use at 1 month and side-effects at 1 month are predictors of low 12-month CPAP adherence [33]. Oro-nasal masks, depression and low effective pressure are also predictors of poor adherence [34]. Indeed, consistent and inconsistent users can be distinguished within the first week [35, 36], and adherence at 1 month is associated with adherence at 3–6 months [29, 37]. As intensive early intervention could improve long-term CPAP adherence; TM supporting strategies implemented early after CPAP initiation therapy could be a crucial element to improving patient care.

The first TM studies were designed using automated TM tools such as interactive websites [38], interactive telephone-based voice response systems [39], or daily internet-based informational support and feedback systems (a combination of branching questions, symptom management, health behaviour and knowledge) to support patients, independently of CPAP device reported data [40]. Since these first attempts, which reported conflicting results on CPAP adherence, CPAP devices have evolved and now offer, on a daily basis, accurate data on adherence, compliance, mask leaks, residual apnoeas and CPAP pressure. This technological progress has changed the landscape of TM intervention for CPAP users [41].

Telemonitoring of adherence, compliance, mask leaks, residual apnoeas and CPAP pressure

Currently, the majority of CPAP devices on the market have wireless built-in connectivity, such that they have the ability to transfer technical data on a daily basis *via* a central secured data centre (a cloud) to sleep labs or home care providers [41, 42]. It is also possible to remotely change the settings of the device [43]. The usefulness of telemonitoring for caregivers/patients has been reported in several randomised controlled trials (RCT), which are summarised in table 3.

Improved adherence has been shown in four out of seven studies [38, 44, 48, 49]. When assessed, patient acceptance of telemonitoring and satisfaction rates were also positive. Telemonitoring is often perceived as a means of reassurance for the patients [10]. The interest in telemonitoring has evolved from adherence focused purposes for other aims, such as nurse timesaving and amelioration of care for difficult-to treat patients.

Indeed, in an RCT from Hoet *et al.* [49], telemonitoring was applied to CPAP treated patients with the goal of assessing the impact of telemonitoring on the delay to the first technical intervention after CPAP initiation. 46 patients were randomised to usual care or telemonitoring. A total of 65% of patients in the usual care group and 78% in the telemonitoring group required treatment adaptation early in the course of CPAP therapy. Telemonitoring helped sleep technicians to act proactively soon after the beginning of the treatment, as interventions were triggered by the telemonitoring for 39% of patients. The authors were able to show a reduction in the delay to first intervention of 18 days in the telemonitoring group, and this closer follow-up led to better 3-month adherence (5.7 *versus* 4.2 h·night^{-1}).

After treatment initiation, telemonitoring can be used to rapidly identify two categories of patients: those who quickly adapted well and those with problems (*e.g.* acceptance, leaks, adherence, mask discomfort, nasal/mouth dryness) who need more support/intervention. For patients belonging to the first category,

TABLE 3 Results of the randomised studies comparing telemedicine (TM) follow-up *versus* usual care for continuous positive airway pressure (CPAP) patients

First author [ref.]	Patients n	AHI events·h^{-1}	TM application	Adherence TM *versus* usual care	Patient satisfaction
Stepnowsky [38]	45	>15	Interactive website with own CPAP data and guide for troubleshooting	2 months: 4.1 *versus* 3.4 h·night^{-1} (statistically significant)	No concerns of being remotely observed
Fox [44]	75	>15; mean: 42	Feedback by phone	3 months: 3.2 *versus* 1.7 h·night^{-1} (statistically significant)	NA
Isetta [45]	139	Mean: 49	Feedback by web tools	6 months: 4.4 *versus* 4.2 h·night^{-1} (NS)	Similar degree satisfaction
Anttalainen [46]#	111	Mean: 34	Nurse adjustment phone/visits	12 months: 6.4 *versus* 6.1 h·night^{-1} (NS)	NA
Munafo [47]	132	Mean: 34 (TM), 27 (usual care)	Multimedia approach to contact patient about their CPAP use	1 month: 5.1 *versus* 4.7 h·night^{-1} (NS)	Very good acceptance of the TM programme
Frasnelli [48]¶	223	Median: 37 (TM), 40 (usual care)	Pneumologist adjustment by phone	1 month: 5.3 *versus* 4.6 h·night^{-1} (statistically significant)	Overall satisfaction better in usual care group; privacy concerns
Hoet [49]	46	>20	Sleep technician adjustment phone/visits	3 months: 5.7 *versus* 4.2 h·night^{-1} (statistically significant)	NA
Turino [50]	100	>15	Pneumologist adjustment by phone	3 months: 5.1 *versus* 4.9 h·night^{-1} (NS)	Overall satisfaction better in usual care group; privacy concerns

AHI: apnoea/hypopnoea index; NS: not statistically significant; NA: not assessed. #: partially randomised; ¶: patients selected at random.

face-to-face consultations could be spaced, leaving more time for the nursing/technical staff to give care to the problematic patients. Anttalainen *et al.* [46] demonstrated a saving of 19 min in nursing time between telemonitoring patients and the usual care group, in 111 patients.

There is sufficient evidence to support the routine use of telemonitoring in sleep units including: the non-inferiority of telemonitoring compared to usual care for adherence; the decrease in nursing workload; the proactive aspects of technical interventions; and the early identification of problematic patients.

Teleconsultation for CPAP treated patients

The aim of teleconsultation is patient counselling with the purpose of reinforcing and supporting CPAP treatment goals. In a recent study from Isetta *et al.* [24], 50 patients with OSA were enrolled to attend a sleep laboratory for CPAP follow-up visits. These patients underwent a teleconsultation with the physician and were asked to evaluate the teleconsultation anonymously afterwards. More than 95% of the interviewed patients were satisfied with the teleconsultation, and 66% responded that teleconsultations could replace 50–100% of their CPAP follow-up visits.

Parikh *et al.* [51] compared teleconsultation delivered by video conferencing with face-to-face consultation for CPAP follow-up in 90 patients. The proportion of adherent patients and levels of patient satisfaction were not different between the two groups [51].

In a recent review from Murphie *et al.* [52], the authors performed a systematic review on the role of remote teleconsultation associated with telemonitoring for OSA patient follow-up. Four RCT studies and one controlled clinical trial (269 patients) were included in the analysis. Results regarding adherence were mixed, with two studies showing similar adherence to CPAP [23, 40] and three others, of smaller size, demonstrating slight improvements [44, 38, 53]. Patient satisfaction with teleconsultation was similar to that for face-to-face consultation. The author's conclusion was that these studies (including four with a moderate-to-high risk of bias) do not provide definitive evidence of the effectiveness (in terms of adherence and symptom control) of teleconsultation/telemonitoring in CPAP users; however, there was no suggestion of any harm. They stressed the need for adequately powered trials at low risk of bias to establish whether the combination of remote consultation and real-time telemonitoring is a clinically viable, acceptable and cost-effective option for OSA patients using CPAP therapy.

Automated teledriven feedback for CPAP treated patients

In the area of automated feedback, one study has assessed the impact of direct access to daily CPAP device parameters for patients. Kuna *et al.* [25] randomised 138 recently diagnosed OSA patients requiring CPAP to usual care, usual care with access to CPAP usage, or usual care with access to CPAP usage and a financial incentive. After 3 months, mean adherence was 4.8 and 5 $h \cdot night^{-1}$ in the intervention groups *versus* 3.8 $h \cdot night^{-1}$ for usual care ($p<0.0001$). Web access and direct daily feedback seems to act positively on adherence. Interestingly, patients frequently consulted their own data during the first week of treatment but then interest in their own data decreased rapidly. More CPAP data consultation was associated with better CPAP adherence.

More recently, in the Tele-OSA trial, Hwang *et al.* [54] assessed the use of TM web-based OSA education (Tel-Ed) and CPAP telemonitoring with automated patient feedback (Tel-TM) on adherence. A total of 1455 patients were randomised to four arms to receive usual care, usual care+Tel-Ed, usual care+Tel-TM or usual care+Tel-Ed+Tel-TM (Tel-both). The use of CPAP telemonitoring with automated patient feedback messaging improved 90-day adherence in patients with OSA. However, a 1-year follow-up analysis was performed and showed that adherence decreased 3 months after the end of the feedback messaging, matching the rate in the usual care arm but not in patients where messaging continued, suggesting the need for continuous support in these patients. TM web-based education added to usual care did not significantly improve CPAP adherence but did increase clinic attendance for OSA evaluation by 10%.

Using automated feedback seems interesting, at least in the beginning of treatment, but it is clear that a certain degree of weariness can be induced by the system.

Patient support tools

Several support tools, in the form of websites and/or apps, have been developed to help patients with CPAP therapy. Stepnowsky *et al.* [55] randomised CPAP users to usual care or MyCPAP (an interactive website that includes CPAP data, graphs and a troubleshooting guide) to measure the impact on adherence, internet use and satisfaction. Adherence was improved at 2 months in the MyCPAP group (3.4 *versus* 2.3 $h \cdot night^{-1}$), and internet use to seek OSA information also increased from 38% to 62% at 4 months. Skills obtained from MyCPAP were considered to be good for 88–94% of the patients. The majority were not concerned with privacy issues.

At the 2018 European Respiratory Society International Congress, Engelman *et al.* [56] presented a retrospective study (data from Philips) comparing CPAP use in an "old fashioned" OSA cohort *versus* a "new feature" OSA cohort, including remote monitoring, device display and a patient support phone app. In the 817 included patients, the implementation of multiple telemedicine supporting tools resulted in an increase in daily CPAP use of 1.1 h·night^{-1} during the first 12 weeks of CPAP therapy.

A retrospective study assessed the impact of using a telemonitoring tool (pro-active care, AirView; Resmed Inc, San Diego, CA, USA) *versus* telemonitoring plus a patient engagement tool (AirView+myAir; Resmed) on termination rates. Use was ⩾4 h·night^{-1} in 77% of the AirView group *versus* 63% in the proactive care group (p<0.001). Therapy termination rates were also lower in the patient engagement group [57]. These results were confirmed in a much larger cohort (128 037 patients) where adherence was 5.9 h·night^{-1} in the AirView+myAir group *versus* 4.9 h·night^{-1} in the matched usual care group (p<0.0001) [58].

In a RCT, Mendelson *et al.* [59] studied the use of an app to provide lifestyle counselling (diet/physical activity) and CPAP use support in 107 patients. Disappointingly, compared to the usual care arm, the app did not positively influence CPAP adherence, blood pressure measurements or physical activity.

The use of supporting tools generally results in better adherence. However, it is not sufficient to change lifestyle and behaviours.

Discussion

As we have discussed in this article, despite a lack of high-quality large randomised data, interest in the use of TM in OSA is clearly established, with the most evidence available for the use of telemonitoring, teleconsultation for treatment follow-up, and web tool support. As with any technological evolution, TM offers hope for improvement of patient care that is tempered by concerns about the potentially worrying aspects of this technique, including ethics, data ownership, privacy, billing, storage, and misuse of large databases [60]. In addition, the media often reports medical data breaches related to cybercriminal hacking [61]. How can physicians manage their patient–physician virtual relationships? How will physicians deal with this additional arrival of data from patient's homes?

Issues regarding the security and privacy of TM must be addressed by parties providing healthcare, *e.g.* governments, scientific organisations, hospitals and homecare provider companies [10]. Work in this area is in progress. For example, France has recently adopted a ministerial decree for the 2018 social security financing law approving the deployment of telemedicine both for doctor–patient consultations (teleconsultation) and "telexpertise" (between health professionals) [62].

Implementation of TM in sleep units requires important resources and a lot of time. On a regular basis sleep lab teams have to schedule a review of telemonitoring pre-established alarms in all CPAP treated patients. This implies profound changes in management for physicians and caregivers. Apart from planning adaptation and modification of patient–physician relationships, the question of responsibility is important. Usually, patients are reviewed at the consultation soon after CPAP initiation and then regularly, in order to assess/adapt treatment and solve problems. In the case of telemonitoring routine use, physicians can be technically aware of lack of compliance before the scheduled visit. What about a physician's responsibility if the patient has a car accident between the moment of detection of non-compliance and the visit? Or if the crash occurs between two moments of virtual review because of CPAP use interruption? Do we have to alert the patient immediately if non-compliance is detected? In sleep labs treating an important number of patients it seems unrealistic to check alerts and contact patients on a daily basis, but in case of a problem we could be blamed because we had to be theoretically informed of the situation.

The issue of cost-effectiveness related to TM use also remains crucial, despite decreases in the cost of information and communication technologies. The first cost analysis was performed in 2001, when the costs of information and communication technologies were higher. In a study that compared the costs of TM-PSG and home PSG for OSA diagnosis, the authors concluded that although TM was more effective (half the number of failures) it was also very expensive ($244 *versus* $153 for home PSG) [63].

More recently, two research teams have assessed the cost-effectiveness of TM follow-up in CPAP treated patients. In the first study, 139 CPAP patients were randomised to TM follow-up (telemonitoring and teleconsultation) or usual care for 6 months. TM was more cost-effective: despite more visits costs were lower and no significant differences in effectiveness were observed [45]. In the second study [50], in 100 CPAP patients randomised to telemonitoring or usual care for 3 months, the authors observed that telemonitoring was less expensive than standard management (€124 *versus* €171; p=0.022) and was cost-effective, but was associated with lower patient satisfaction. These two studies support the cost-effectiveness of TM for CPAP treated patients but need to be confirmed in larger series.

Another concern is related to patients' perceptions of telemonitoring. In a recent study from TURINO *et al.* [50], patients were not worried about being remotely observed through telemonitoring systems, but in another study of patient acceptance of telemonitoring, despite the fact that the majority (78%) of the 160 studied patients expressed a favourable attitude toward telemonitoring, 40% consider this device intrusive [64].

Dehumanisation and depersonalisation of care can be poorly perceived by patients (*e.g.* telephone-based programmes and automatic e-mails) [65]. Specific communication skills that apply to the use of TM technologies should be learned by nurses and physicians.

The question of the qualifications of the caregiver giving patient feedback has also been debated. As the capacity of sleep centres is limited, a lot of studies have assessed OSA management, from diagnosis to CPAP treatment follow-up, by nurses and primary care physicians resulting in similar clinical outcomes [66]. However, in my opinion, even if the majority of OSA patient management could be shifted into the hands of non-sleep specialists, careful step-by-step algorithms should be implemented, provided by the sleep lab to avoid dangerous drifts in care such as lowering the quality of care, missing an OSA diagnosis in some patients, missing associated sleep disorders, and forgetting to offer other treatments besides CPAP for OSA. We have to keep in mind the study of PARTHASARATHY *et al.* [67] that demonstrated better global OSA patient management from accredited sleep centres and certified physicians. In practice, routine telemonitoring use has the potential to mask some aspects of care by relying excessively on technical parameters, forgetting the clinical picture. This could result in a decrease in medical quality, missing the fact, for example, that monitoring CPAP use, leak levels, and residual apnoeas can be satisfying, but in a patient still complaining of residual excessive sleepiness or comorbid insomnia it is not the whole picture [68, 69].

Conclusion

Telemedicine is a current tool in the landscape of medicine. It helps to address public health challenges such as increases in chronic disease in an ageing society and the associated burden in healthcare costs.

Healthcare organisation is undergoing many changes through the implementation of telemedicine and technology-based care. TM is going to change the patient–physician relationship and can simplify some aspects of diagnosis and care. However, TM carries an inherent risk of over reliance on technology and dehumanisation of care.

Based on the current literature, the use of TM in sleep medicine for OSA patient management seems to make sense. Recent studies have confirmed the cost-effectiveness of TM but this important issue should be addressed in future large-scale trials.

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