Home-Based Care Evolution in Chronic Respiratory Failure between 2001 and 2015 (Antadir Federation Observatory)

Boris Melloni^{a, b} Line Mounier^a Jean-Pierre Laaban^c Arnaud Chambellan^d
Didier Foret^a Jean-François Muir^{a, e}

^aANTADIR Federation, Paris, France; ^bDepartment of Pulmonology, Limoges University Hospital, Limoges, France;

^cDepartment of Pulmonology, AP-HP Cochin, Paris, France; ^dChest Institute, Nantes University Hospital, "Movement, Interactions, Performance" Laboratory (EA 4334), Faculty of Sport Sciences, Nantes University, Nantes, France;

^eDepartment of Pulmonology and Respiratory Intensive Care, Rouen University Hospital, Rouen, France

Keywords

Chronic respiratory failure · Non-invasive ventilation · Long-term oxygen therapy · Chronic obstructive pulmonary disease · Obesity-hypoventilation syndrome

Abstract

Background: The aetiologies of chronic respiratory failure (CRF) are moving in many western countries. Obesity-Hypoventilation syndrome (OHS) has become one of the most common indications of non-invasive ventilation (NIV) with Chronic Obstructive Pulmonary Diseases (COPD). Long-Term Oxygen Therapy (LTOT) technology is the treatment plan for CRF patients in the new era. **Objectives:** This study aimed to assess home-based care evolution in CRF patients on LTOT (LTOT) and/or NIV from the ANTADIR observatory. **Methods:** A computerized database from 14 regional facilities was analysed (30% of French home-treated patients). Patient age, sex, aetiology, home respiratory devices were recorded between 2001 and 2015. **Results:** By the end of

2015, 12,147 CRF patients received LTOT (40%), NIV (24%), LTOT + NIV (23%), continuous positive airway pressure (CPAP; 11%) or LTOT + CPAP (3%). Between 2001 and 2015, we observed a decrease of LTOT (63–40%) in the benefit of NIV ± LTOT (25–47%). Regarding the aetiology, we note a slight decrease in obstructive disease and a significant increase in restrictive disease, mainly due to OHS. The 10-year survival was better on NIV ± LTOT than on LTOT, for overall patients and for both obstructive and restrictive patients. The 10-year survival was better on NIV ± LTOT than on LTOT (35 vs. 10%, $p < 0.05$). In COPD patients on LTOT, a switch from conventional to new home devices was observed. Stationary LTOT systems were less prescribed, while portable/transportable system, liquid oxygen and self-filling oxygen were increasingly prescribed. **Conclusion:** Our study confirmed changes in CRF aetiologies and home devices. OHS is now an important indication of NIV. Using new LTOT technologies changed home prescriptions in COPD patients.

© 2018 S. Karger AG, Basel

Introduction

The ANTADIR patient observatory was created in 1983. This observatory has previously allowed characterizing the population of patients receiving long-term oxygen therapy (LTOT) [1, 2]. Other studies on these data have shown that the nutritional status and haematocrit were prognostic factors for survival [3, 4]. The importance of cardiovascular risk factors in the population of patients treated for sleep apnoea syndrome has been shown by collecting data from the observatory as part of a specific study [5, 6]. Regarding Chronic respiratory failure (CRF), major technological advances have been made in the field of oxygen therapy and non-invasive ventilation (NIV). In this work based on the data of the observatory, the population of CRF patients aged 20 years or over treated with LTOT combined or not with NIV or continuous positive airway pressure (CPAP) was analysed yearly on December 31 over the 2001–2015 period. The aim of this study was to analyse home-based care evolution over 15 years.

Materials and Methods

Data Collection

The organization of the ANTADIR Federation has already been described and detailed in previous studies [1, 2]. Patient information was derived from the initial French social security healthcare costs form and the computerized patient monitoring system of 14 Federation member regional facilities. French social security healthcare form includes demographic data such as sex, age, height and weight and clinical data such as diagnosis and initial room air arterial blood gaze. In the annual national computerised database issue of data of 14 regional facilities, the following data were available: device type (LTOT and/or NIV), treatment changes and discontinuations, and treatment reference codes (LPPR codes) that allowed very specifically identifying the sources of oxygen (Appendix 1). The date of death was recorded but not the cause and patient's associated comorbidities were not available.

Each year, the ANTADIR centralizes anonymously these data to prepare an annual report. The French authorities, National Commission on Computer Technology and Freedom (CNIL) approved this observatory.

Patient Selection

Patients aged 20 years or over included by 14 home-based healthcare providers of the ANTADIR Federation, located in metropolitan France, over the 2001–2015 period were included in this study, taking into account their presence or not on December 31 each year. The following treatments were studied: LTOT, NIV and CPAP. All further analyses are focused only on CRF patients.

Data Analysis

For each patient, the age, sex, date of first management, prescribed treatment and all treatment changes and possible discontinuation were taken into account. Patients were classified into

4 groups according to CRF aetiology: obstructive patients (chronic obstructive pulmonary disease [COPD], bronchiectasis, panlobular emphysema), restrictive patients (neuromuscular disease, Kyphoscoliosis, diffuse interstitial pneumonia), mixed patients if 2 aetiologies were associated and patients with another aetiology, not listed in the initial French social security healthcare costs form implemented in 1982 and that became mandatory in 1985 for any device prescription in France. Among these other diseases, obesity hypoventilation syndrome (OHS) is currently the dominant cause and not listed in the French social security healthcare costs form. We decided to analyse our database in each regional association to identify OHS patients combining body mass index ($\text{BMI} \geq 30 \text{ kg/m}^3$), air arterial carbon dioxide pressure (stable $\text{PaCO}_2 \geq 45 \text{ mm Hg}$) and type of NIV.

For COPD patients, prescription changes over the 15-year period have been analysed for LTOT and/or NIV.

Patient survival from restrictive or obstructive aetiologies was studied for over 10 years by including CRF patients who were on machine-assisted treatment in 2006.

Analysis

Means were compared using the Student *t* test and percentages using the Pearson χ^2 test, at the minimum significance threshold of 0.95. Survival was analysed according to the actuarial method based on unique information on a set date. Univariate comparisons of survival rates were performed using the log rank test.

Results

Patient Characteristics

Among the patients who were treated on December 31, 2015, that is, over a 15-year period, 97,256 individuals aged 20 years or over were treated with LTOT, NIV or CPAP for their respiratory disease or obstructive sleep apnoea syndrome (OSAS). In this population, 84,839 individuals had OSAS and 12,147 had CRF. Figure 1 shows the evolution of the number of patients with OSAS versus CRF in the ANTADIR database. The management of OSAS patients increased constantly over time, whereas that of CRF patients showed a slow progression, stagnation and then a decrease in 2015. Table 1 summarizes over 3 time points, the distribution between women and men in the CRF population receiving home-based care and, for each group, the mean age and distribution according to age groups. For all patients, the mean age of women was significantly higher than that of men ($p < 0.001$), regardless of the year.

Aetiologies of Home-Treated Respiratory Diseases

According to the selected groupings described above, there was a progressive decrease in the number of obstructive patients, a virtual stability of restrictive patients and an increase in “other” diseases (Fig. 2). End 2015, OHS

Fig. 1. Evolution of the number of home-treated patients between 2001 and 2015 (LTOT alone, NIV $\pm$ LTOT, CPAP $\pm$ LTOT): total population, CRF patients, OSAS patients. OSAS, obstructive sleep apnoea syndrome; CRF, chronic respiratory failure.

accounted for 56% of the other aetiologies. The remaining 44% were divided as follows: Cheyne-Stokes respiration in heart failure (17%), pulmonary hypertension (9%), amyotrophic lateral sclerosis (4%), lung cancer (4%), nocturnal and/or exercise-induced desaturation (4%), alveolar hypoventilation (3%) and orphan diseases (3%).

Evolution of Prescribed Devices in CRF Patients

Figure 3 shows the evolution of devices prescribed during the study period in CRF patients: LTOT alone, NIV alone, NIV and LTOT, CPAP alone, CPAP and LTOT. The decrease in LTOT prescriptions, regardless of the aetiology, was associated with an increase in prescriptions of NIV alone or combined with LTOT. The prescriptions of CPAP alone increased very moderately in our population, reflecting overlap syndromes. Table 2 shows this evolution according to the sex. In 2015, there were a significantly higher number of men on CPAP compared to women, since LTOT prescriptions were preferred in women while NIV prescriptions were identical in both groups. For COPD patients, the type of prescribed devices was studied by comparing the use of stationary oxygen concentrators, liquid oxygen therapy, portable or transportable oxygen concentrators, filling systems, NIV $\pm$ LTOT and CPAP $\pm$ LTOT (Table 3). The use of stationary oxygen concentrators decreased while that of portable or transportable oxygen concentrators increased. The use of liquid oxygen remained stable after a peak in 2008; the filling systems remained underused. For 15 years, the use of NIV continued to increase in the treatment of COPD, mostly combined with LTOT.

Table 1. Distribution according to gender and age of patients

Total number of patients	2001, % (n = 10,738)	2008, % (n = 12,894)	2015, % (n = 12,417)
Men	64.7	58.7	54.9
Age, years, (mean $\pm$ SD)	68.0 $\pm$ 12.6	68.8 $\pm$ 13.1	68.5 $\pm$ 13.8
20–44	4.9	4.4	5.8
45–54	9.6	8.4	7.2
55–64	17.4	21.2	21.0
65–74	34.5	26.9	29.4
75–84	28.4	31.1	25.9
≥ 85	5.2	8.0	10.7
Women	35.3	41.3	45.1
Age, years, (mean $\pm$ SD)	71.0 $\pm$ 13.8	72.1 $\pm$ 14.7	72.6 $\pm$ 15.0
20–44	5.0	4.9	4.4
45–54	8.2	7.7	7.1
55–64	11.8	15.3	16.7
65–74	28.8	18.8	22.1
75–84	32.1	33.2	24.7
≥ 85	14.1	20.1	25.0

Patients treated with LTOT alone, NIV $\pm$ LTOT, CPAP $\pm$ LTOT.

Survival Curves of the CRF Population

In 2006, a treatment with LTOT alone or NIV $\pm$ LTOT or CPAP $\pm$ LTOT was initiated in 3,063 patients with CRF. The 183 patients who received CPAP $\pm$ LTOT were excluded from the analysis given their small number. Figure 4 shows annual survival rates according to

Fig. 2. Aetiologies of CRF patients treated: LTOT alone, NIV ± LTOT, CPAP ± LTOT.

Fig. 3. Evolution of prescribed devices in the CRF population aged 20 years or over. LTOT, long-term oxygen therapy; NIV, non-invasive ventilation; CPAP, continuous positive airway pressure.

the treatment (LTOT ± NIV) and restrictive or obstructive pattern. The 5-year survival rate of restrictive patients on LTOT was 21.4%, while it was 32.2% for obstructive patients on LTOT. For NIV ± LTOT, the 5-year survival rate of restrictive patients was $52.9 \pm 8.4\%$, while it was $59.4 \pm 6.3\%$ for obstructive patients, significantly lower. At 10 years, the survival rate was better for the restrictive versus the obstructive, but the difference was not significant ($35.1 \pm 8.2\%$ and $32.3 \pm 6.1\%$ respective-

ly). In the population treated with LTOT alone, the survival of COPD patients was studied according to the PaO_2 value at the time of initial prescription (Fig. 5). No significant difference in the 10-year survival was observed between patients whose initial PaO_2 in ambient air was less than 55 mm Hg or ranged between 55 and 60 mm Hg. However, the survival of patients with a PaO_2 greater than or equal to 60 mm Hg was significantly better ($p < 0.02$).

Discussion

The data from the observatory showed a marked increase in the number of patients treated for OSAS, as previously reported in Europe [7]. Regarding CRF, the proportions are less well known because various aetiologies, which do not have the same prognosis, are grouped. The most common disorder was COPD, for which the most prescribed treatment at the CRF stage was LTOT followed by NIV. A recent analysis carried out in France of the data from the healthcare system has shown that LTOT accounts for 70% of home-based treatments for CRF [8]. In this work, the increase in LTOT prevalence and incidence was higher in women, in connection with COPD. This study, based on the data from the healthcare system, does not allow determining the reason for prescribing LTOT, the precise aetiology or the initial PaO₂.

In Europe, the indications and use of home-based NIV have been studied in COPD [9]. NIV is proposed in stable patients with severe COPD, and leads to a reduced number of hospitalizations, with a great variability in practices from one country to another. In our observatory, there was a discrete decrease in the number of CRF patients home-treated with LTOT and/or NIV.

In the overall population managed within the ANTA-DIR Federation (with OSAS and CRF), the increase was greater in women. The mean age was also significantly higher in women. This result is consistent with the prevalence of COPD and OSAS reported in women in France and in Europe. Regarding the type of treatment, the prescription of LTOT decreased while that of NIV increased. This could be explained by a change in practices in COPD, but mainly by changes in CRF aetiologies. The prevalence of OHS is estimated at 0.3–0.4% in the general population of developed countries [10]. Most of these patients often have associated OSAS and/or COPD. In addition, the prevalence of COPD in the general population is of about 10%, like that of OSAS. The overlap of both disorders is frequent and thus changes the management [11]. This finding could partly explain the increased use of NIV in our population. This population is also subject to multiple comorbidities associated with these disorders: OHS + OSAS, OHS + COPD, COPD + OSAS.

CRF aetiologies change over time. For oxygen therapy, COPD is the main indication in CRF with a slight decrease over time, explained by a lower prevalence in men in France and Sweden [8, 12]. For NIV, a study conducted in 2003 in Switzerland has shown a change in indications over a 7-year period [13]. A significant increase in the use of NIV in COPD and OHS was observed, and the

Table 2. Evolution of prescribed devices in CRF patients

	2001, %	2008, %	2015, %
Men	<i>n</i> = 6,942	<i>n</i> = 7,570	<i>n</i> = 6,812
LTOT alone	60.6	4.4	5.8
NIV alone	9.9	8.4	7.2
NIV + LTOT	12.9	21.2	21.0
CPAP alone	13.4	26.9	29.4
CPAP + LTOT	3.1	31.1	25.9
Women	<i>n</i> = 3,786	<i>n</i> = 5,324	<i>n</i> = 5,605
LTOT alone	66.9	57.3	45.8
NIV alone	10.4	14.7	21.7
NIV + LTOT	17.0	21.4	24.7
CPAP alone	4.3	4.8	5.9
CPAP + LTOT	1.5	1.8	2.0

Table 3. COPD patients – type of devices prescribed

Total	2001, % (<i>n</i> = 1,558)	2008, % (<i>n</i> = 1,534)	2015, % (<i>n</i> = 867)
LTOT alone	76.9	71.7	60.2
Stationary concentrator	65.0	46.9	31.5
Liquid O ₂	11.9	21.4	12.9
Bottle filler	0.0	0.1	3.1
Portable/transportable concentrator	0.0	3.3	12.7
NIV	11.9	22.0	33.1
NIV alone	4.0	5.9	13.6
NIV + LTOT	7.9	16.1	19.5
CPAP	11.2	6.3	6.7
CPAP alone	8.7	3.2	3.9
CPAP + LTOT	2.5	3.1	2.8

survival was poorer in COPD patients in this study. In Europe, the proportion of patients on NIV varies from one country to another depending on aetiologies: lung diseases, chest deformities or neuromuscular diseases [14]. In France, among lung diseases, COPD and OHS are currently the first indications of home-based NIV.

LTOT prescriptions regularly decreased, while the prescriptions of NIV alone or combined with LTOT increased. The NIV and LTOT combination represented a significant part of treatments. This could be explained by a new distribution of aetiologies over time, with the appearance of OHS alone or associated with COPD, and the recent increase in the indication of NIV in COPD [9, 15]. Medical devices proposed for home-based LTOT vary in COPD patients and, by extension, in the other indications [16, 17]. In the COPD population, there was a clear change in prescriptions with an increased use of new portable and

Fig. 4. Survival for obstructive and restrictive patients according to treatment: LTOT alone or NIV ± LTOT. LTOT, long-term oxygen therapy; NIV, non-invasive ventilation.

Fig. 5. Survival of COPD patients treated with LTOT alone according to PaO₂ class.

transportable devices. The use of liquid oxygen remained stable, as a direct result of a commitment of the French public authorities not to increase healthcare costs for the last 10 years. To date, filling devices are still barely used.

Survival was significantly higher in CRF patients treated with NIV ± LTOT versus LTOT alone, which could be partly explained by patient age at the time of treatment initiation, respectively, 73.6 ± 12.8 years for LTOT and 63.9 ± 12.9 years for NIV ± LTOT. Five-year survival was

also significantly higher in obstructive patients compared to restrictive CRF patients, but this result is different at 10-year survival. The French study has shown that the median survival of patients on oxygen therapy was 27 months for COPD, with a 2-year survival rate of 54% [8]. We observed the same rate for LTOT at 2 years, but a higher rate for NIV; patients were younger at the time of NIV initiation compared to LTOT initiation and COPD was not the predominant aetiology.

Regarding LTOT indications, specific guidelines have been proposed to permit the prescription of LTOT in stable patients with 2 consecutive PaO₂ measurements in ambient air <55 mm Hg or ranging between 55 and 60 mm Hg in the presence of right heart failure or polycythemia. In our study, we noted that COPD patients with an initial PaO₂ greater than 60 mm Hg received LTOT. The survival was significantly different between patients with usual prescription criteria and patients with less severe hypoxemia. Although the observatory strengths are its sample size and its longitudinal follow-up, there are some limitations. For this group of COPD patients, the data on comorbidities and associated secondary pulmonary hypertension were missing. In a recent prospective randomized study, it has been shown that, in patients with moderate desaturation, LTOT did not improve survival or the number of first hospitalizations [18], which is inconsistent with our findings. In this study conducted in 2 groups of more than 350 patients, the inclusion criterion was having an oxygen saturation (SpO₂) ranging between 88 and 93% at rest, associated with significant desaturations in the 6-minute walking test (SpO₂ ≥80% for ≥5 min and <90% for ≥10 s). This inclusion criterion is not exactly the same as that used in our COPD population in which the arterial blood gas test was taken into account at rest, without considering nocturnal and/or exercise-induced desaturations. Similarly, in COPD patients with hypoxemia, the mortality is comparable between a daily LTOT treatment duration of 15 or 24 h [19]. In our study, confirmed data on prescription duration were missing so that we could not perform the same analysis. Patient compliance was a detrimental missing data in all these studies. In a recent paper, it has been demonstrated that home-

based NIV following COPD exacerbation with hypercapnia reduces the time to readmission or death [20]. Home-based NIV in COPD patients should be discussed in this situation and could also explain the increased indication of NIV in COPD observed in France.

In conclusion, the ANTADIR patient observatory showed that in France, CRF prevalence is increasing in women, in connection with COPD. A significant increase in OHS management should also be stressed in both sexes. NIV took an important place among prescriptions, both in restrictive patients and in COPD. The types of prescribed LTOT devices changed with an increased use of portable or transportable devices. Survival of CRF patients appeared to be stable but was better in NIV-treated patients with however a bias related to the age at the time of prescription and to the increased number of ventilated OHS patients. We aim to continue this observatory on LTOT, by taking into account the detailed aetiologies, comorbidities and patient observance, based on the model of observatory on home-based NIV implemented in April 2015 by the ANTADIR Federation and the Ventilatory Support Group of the French Language Pneumology Society (*Société de Pneumologie de langue Française: SPLF*).

Acknowledgements

The authors thank all the ANTADIR member facilities that have transmitted their data: Don Du Souffle Assistance (Besançon), A.I.R. Partenaire Santé (Caen), AGEvie (Dijon), AGIR à dom. (Grenoble), Santelys Association (Lille), ALAIR and AVD (Limoges), AIR à domicile (Mulhouse), AGEvie (Nancy), Aliséo (Nantes), Airairchar (Reims), AADAIRC (Rocheffort), ADIR Assistance (Rouen), ADIRAL Assistance (Strasbourg) and SADIR Assistance (Toulouse).

Appendix 1

List of LPPR codes used to define the package of oxygen therapy and/or NIV and/or CPAP over the 2001–2015 period.

1184315	Ambulatory long-term oxygen therapy PHILIPS ULTRAFILL
1120338	Ambulatory long-term oxygen therapy VENTURE HOMEFILL II
1148130	Concentrator for long-term oxygen therapy + INVACARE PLATINUM 9
1130220	Liquid oxygen for intensive or ambulatory long-term oxygen therapy
1136581	Stationary long-term oxygen therapy
1191568	Ambulatory long-term oxygen therapy INVACARE SOLO2
1143983	Ambulatory long-term oxygen therapy INVACARE XPO2
1118324	Ambulatory long-term oxygen therapy PHILIPS SIMPLYGO
1125100	Ambulatory long-term oxygen therapy SCALEO INOGEN ONE G2
1133430	Ambulatory long-term oxygen therapy DEWILBISS HEALTHCARE IFILL
1116680	Transportable long-term oxygen therapy CHART SEQUAL ECLIPSE 3
1138315	Ambulatory long-term oxygen therapy SCALEO INOGEN ONE G3

1163030	Assisted ventilation ≥12 h package 5
1107763	Assisted ventilation ≥12 h + ULTRAFILL
1151190	Assisted ventilation ≥12 h + VENTURE HOMEFILL II
1175380	Assisted ventilation ≥12 h + Stationary device for long-term oxygen therapy
1122053	Assisted ventilation ≥12 h + Liquid oxygen for long-term oxygen therapy
1125287	Assisted ventilation ≥12 h package 5 + INVACARE PLATINUM 9
1178540	Assisted ventilation ≥12 h + INVACARE SOLO2
1177663	Assisted ventilation ≥12 h + INVACARE XPO2
1145404	Assisted ventilation ≥12 h + PHILIPS SIMPLYGO
1100614	Assisted ventilation ≥12 h + SCALEO INOGEN ONE G2
1108917	Assisted ventilation ≥12 h + SCALEO INOGEN ONE G3
1127607	Assisted ventilation ≥12 h + CHART SEQUAL ECLIPSE 3
1144103	Assisted ventilation ≥12 h + DEWILBISS HEALTHCARE IFILL
1196270	Assisted ventilation <12 h package 6
1100229	Assisted ventilation <12 h package 6 + INVACARE PLATINUM 9
1130236	Assisted ventilation <12 h + VENTURE HOMEFILL II
1103720	Assisted ventilation <12 h + ULTRAFILL
1107579	Assisted ventilation <12 h + Stationary device for long-term oxygen therapy
1162437	Assisted ventilation <12 h + Liquid oxygen for long-term oxygen therapy
1125790	Assisted ventilation <12 h + INVACARE SOLO2
1169304	Assisted ventilation <12 h + INVACARE XPO2
1172967	Assisted ventilation <12 h + PHILIPS SIMPLYGO
1167890	Assisted ventilation <12 h + SCALEO INOGEN ONE G2
1132442	Assisted ventilation <12 h + SCALEO INOGEN ONE G3
1119134	Assisted ventilation <12 h + CHART SEQUAL ECLIPSE 3
1126708	Assisted ventilation <12 h + DEWILBISS HEALTHCARE IFILL
1103720	Assisted ventilation <12 h + ULTRAFILL
1188684	Continuous positive airway pressure package 9
1166688	Continuous positive airway pressure package 9 + INVACARE PLATINUM 9
1162093	Continuous positive airway pressure + VENTURE HOMEFILL II
1103156	Continuous positive airway pressure + ULTRAFILL
1130897	Continuous positive airway pressure + Stationary device for long-term oxygen therapy
1189991	Continuous positive airway pressure + Liquid oxygen for long-term oxygen therapy
1188767	Continuous positive airway pressure + INVACARE
1124460	Continuous positive airway pressure + INVACARE XPO2
1118904	Continuous positive airway pressure + PHILIPS SIMPLYGO
1118614	Continuous positive airway pressure + SCALEO INOGEN ONE G2
1172513	Continuous positive airway pressure + SCALEO INOGEN ONE G3
1133163	Continuous positive airway pressure + CHART SEQUAL ECLIPSE 3
1141197	Continuous positive airway pressure + DEWILBISS HEALTHCARE IFILL

References

- Chailleux E, Fauroux B, Binet F, Dautzenberg B, Polu JM: Predictors of survival in patients receiving domiciliary oxygen therapy or mechanical ventilation. A 10-year analysis of ANTADIR Observatory. *Chest* 1996;109:741–749.
- Veale D, Chailleux E, Taytard A, Cardinaud JP: Characteristics and survival of patients prescribed long-term oxygen therapy outside prescription guidelines. *Eur Respir J* 1998;12:780–784.
- Chailleux E, Laaban JP, Veale D: Prognostic value of nutritional depletion in patients with COPD treated by long-term oxygen therapy: data from the ANTADIR observatory. *Chest* 2003;123:1460–1466.
- Chambellan A, Chailleux E, Similowski T: Prognostic value of the hematocrit in patients with severe COPD receiving long-term oxygen therapy. *Chest* 2006;128:1201–1208.
- Laaban JP, Chailleux E: Daytime hypercapnia in adult patients with obstructive sleep apnea syndrome in France, before initiating nocturnal nasal continuous positive airway pressure therapy. *Chest* 2005;127:710–715.
- Laaban JP, Mounier L, Roque d'Orbcastel O, Veale D, Blacher J, Melloni B, Cornette A, Muir JF, Chailleux E: Cardiovascular risk factors in men and women with obstructive sleep apnoea syndrome. *Respir Med* 2010;104:1063–1068.
- Jennum P, Riha RL: Epidemiology of sleep apnoea/hypopnoea syndrome and sleep-disordered breathing. *Eur Respir J* 2009;33:907–914.
- Fuhrman C, Boussac-Zarebska M, Roche N, Delmas MC: Long-term oxygen therapy in France, 2006–2011. *Rev Mal Respir* 2014;31:421–429.
- Crimi C, Noto A, Princi P, et al: Domiciliary non-invasive ventilation in COPD: an international survey of indications and practices. *COPD* 2016;13:483–490.
- Mokhlesi B: Obesity hypoventilation syndrome: a state-of-the-art. *Respir Care* 2010;55:1347–1362.
- McNicholas WT: Chronic obstructive pulmonary disease and obstructive sleep apnoea-the overlap syndrom. *J Thorac Dis* 2016;8:236–242.

- 12 Franklin KA, Gustafson T, Ranstam J, et al: Survival and future need of long-term oxygen therapy for chronic obstructive pulmonary disease – gender differences. *Respir Med* 2007;101:1506–1511.
- 13 Janssens JP, Derivaz S, Breitenstein E, et al: Changing patterns in long-term noninvasive ventilation: a 7-year prospective study in the Geneva Lake area. *Chest* 2003;123:67–79.
- 14 Lloyd-Owen SJ, Donaldson GC, Ambrosino N, et al: Patterns of home mechanical ventilation use in Europe: results from the Eurovent survey. *Eur Respir J* 2005;25:1025–1031.
- 15 Böing S, Randerath WJ: Chronic hypoventilation syndromes and sleep-related hypoventilation. *J Thorac Dis* 2015;7:1273–1285.
- 16 Dunne PJ: The clinical impact of new long-term oxygen therapy technology. *Respir Care* 2009;54:1100–1111.
- 17 McCoy RW: Options for home oxygen therapy equipment: storage and metering of oxygen in the home. *Respir Care* 2013;58:65–85.
- 18 Long-Term Oxygen Treatment Trial Research Group, Albert RK, Au DH, Blackford AL, Casaburi R, Cooper JA Jr, Criner GJ, Diaz P, Fuhlbrigge AL, Gay SE, Kanner RE, MacIntyre N, Martinez FJ, Panos RJ, Piantadosi S, Sciurba F, Shade D, Stibolt T, Stoller JK, Wise R, Yusef RD, Tonascia J, Sternberg AL, Bailey W: A randomized trial of long-term oxygen for COPD with moderate desaturation. *N Engl J Med* 2016;375:1617–1627.
- 19 Ahmadi Z, Sundh J, Bornefalk-Hermansson A, Ekström M: Long-term oxygen therapy 24 vs 15 h/day and mortality in chronic obstructive pulmonary disease. *PLoS One* 2016;20:1–11.
- 20 Murphy PB, Rehal S, Arbane G, et al: Effect of home noninvasive ventilation with oxygen therapy vs oxygen therapy alone on hospital readmission or death after an acute COPD exacerbation: a randomized clinical trial. *JAMA* 2017;317:2177–2186.