ramr
American Review of Respiratory Medicine
Revista Americana de Medicina Respiratoria

CASE REPORT

ISSN 1852-236X

Oxygen Therapy in Acute Respiratory Failure: Impact of Automated Oxygen Administration (Preliminary Study)

Oxigenoterapia en insuficiencia respiratoria aguda: Impacto de la automatización del flujo de oxígeno (estudio preliminar)

Torres, Rubén[1]; Masdeu, Martín[1]; Meza, Adriana[1]; Morón, Karen[1]; Vespa, Franco[1]; Codinardo, Carlos[1]

Received: 23/12/2022
Accepted: 15/06/2023

Correspondence
Rubén Torres. E-mail:
rubencildo79@gmail.com

ABSTRACT

The control of oxygen saturation during hospital admission is a daily challenge for the treating physician, whether in the context of a COPD exacerbation or any acute disease that occurs with respiratory failure. The adjustment of the oxygen flow administered to the patient is mostly manual, usually without a clear medical prescription for the desired SpO_2 range, implying an overload of the nursing service with the risk of making an inadequate contribution, either over-administering it or providing it incorrectly. insufficient. The objective of this work is to describe a preliminary experience with the automated administration of the O_2 flow through the use of the O_2matic device. A group of adult patients with acute respiratory failure who were hospitalized using continuous oxygen therapy with conventional flowmeters and periodic nursing manual controls was studied, after which it was indicated to start oxygen therapy in a controlled manner using the O_2matic device for 30 minutes. It was observed that the oxygen flow achieved using the O_2matic automatic control device has been lower than the flow used in manual control, with significant differences between both values found, with adequate safety and patient tolerance. Whether the automation of oxygen therapy during hospital admission could reduce the length of admission, and possibly improve survival among patients with acute respiratory failure remains to be determined, requiring future randomized studies with a larger sample of patients.

Key words: Oxygen Inhalation Therapy; Respiratory Insufficiency

RESUMEN

El control de la saturación de oxígeno durante el ingreso hospitalario es un desafío cotidiano para el médico tratante, ya sea en contexto de una exacerbación de EPOC o cualquier enfermedad aguda que curse con insuficiencia respiratoria. El ajuste de flujo del oxígeno administrado al paciente es en la mayoría de los casos manual, habitualmente sin una prescripción médica clara del rango de SpO_2 deseado, lo que implica una sobrecarga del servicio de enfermería con el riesgo de realizar un aporte inadec-

Rev Am Med Resp 2024;24:50-56
https://doi.org/10.56538/ramr.YJNV3347

[1] Pulmonology Section, Department of Medicine, Hospital Pirovano, Buenos Aires, Argentina

uado de este, ya sea por sobreadministración o por aporte insuficiente. El presente trabajo tiene como objetivo describir una experiencia preliminar con la administración automatizada del flujo de O_2 mediante el uso del dispositivo O_2matic. Se estudió un grupo de pacientes adultos con insuficiencia respiratoria aguda quienes se encontraban internados usando oxigenoterapia continua con flujímetros convencionales y controles manuales periódicos de enfermería, por lo que se indica, luego, iniciar oxigenoterapia en forma controlada usando el dispositivo O_2matic durante 30 min. Se ha observado que el flujo de oxígeno alcanzado utilizando el dispositivo de control automático O_2matic ha sido menor al flujo utilizado en el control manual, con diferencias significativas entre ambos valores hallados, con adecuada seguridad y tolerancia del paciente. Que la automatización de la oxigenoterapia durante el ingreso hospitalario pueda reducir la duración de la admisión, y posiblemente mejorar la supervivencia entre pacientes con insuficiencia respiratoria aguda queda aún por determinar, por lo que son necesarios futuros estudios aleatorizados con una muestra mayor de pacientes.

Palabras clave: Terapia por Inhalación de Oxígeno; Insuficiencia Respirator

INTRODUCTION

Treatment with supplementary oxygen is essential for the proper management of hospitalized patients suffering from hypoxemic acute respiratory failure (ARF) or worsening of chronic respiratory failure. Like other drugs, medical oxygen is a gaseous medication that should be administered with previously titrated doses or previously specified oxygen flow values. Since the last century, the administration of medical oxygen flow has been controlled through flowmeters with a manually adjustable scale in order to correct hypoxemia. Following verbal or written medical instructions, the nursing staff manually adjusts the value to achieve an acceptable saturation, recommended to be between 88 % and 92 % if there is suspicion of hypercapnia, or between 92 % and 96 % if there is no such risk or suspicion. This is suggested by several specific published international guidelines on the treatment of acute hypoxemic respiratory failure.[1-3]

Supplementary oxygen is often administered generously and freely to patients with respiratory failure, a methodology that has been used worldwide for over 100 years.

In recent years, automated devices have been available in other countries (models FreeO_2 from the OxyNov company in Canada and O_2matic from the O_2matic company in Denmark), with clear benefits demonstrated in clinical trials.[4-6]

The purpose of this preliminary study has been to examine the ability of the O_2matic device to maintain the SpO_2 of patients with ARF within a prespecified target interval. The findings were compared with the previous manual control of oxygen flow in the same patient, and the patient' s perception and sense of safety regarding automated oxygen control were evaluated.

METHODOLOGY AND STUDY DESIGN

This is a descriptive study in which, in November 2022, we recruited a group of hospitalized adult patients with acute respiratory failure who were using continuous oxygen therapy with conventional flowmeters, with periodic manual control by nursing staff. Five (5) patients were recruited and entered the study in a descriptive design of oxygen use. The study was authorized by the Ethics Committee of the Hospital Dr. I Pirovano, without obtaining informed consent from the selected patients.

Device or equipment used (O_2matic)

The O_2matic oxygen therapy device is an electronic equipment that complies with the CE standards and is currently authorized for use in hospitals in several European countries. It has an electronic closed-loop system that, based on continuous monitoring of heart rate and SpO_2 by a standard wired pulse oximeter, adjusts oxygen flow to the patient (Figure 1). The algorithm in O_2matic allows it to calculate increments or decrements in oxygen flow based on the last 15 seconds sensed by the pulse oximeter. Increments and decrements change proportionally in relation to the difference between

Figure 1. O_2matic.

the actual SpO_2 and the prespecified target SpO_2. The oxygen flow can be specified to fit the actual condition and the device used for delivering oxygen to the patient (nasal cannula). O_2matic allows for flow up to 15 L/minute in automatic mode, but in the original study, most patients received an acceptable flow range from 0 to 8 L/minute with a standard nasal cannula. If minimal prespecified SpO_2 cannot be maintained with the maximal oxygen flow allowed, an alarm will sound that will intensify if SpO_2 drops 0.3 % below the target interval or below 85 %. The alarms will also be visible and audible and activate if the heart rate is outside the range defined by the user.

Patients

Adult patients recruited for the study showed acute respiratory failure with minimum previous hospitalization for 48 hours. Inclusion required a PaO_2 of less than 60 mmHg or SpO_2 of up to 88 %, on room air. Patients were excluded if they were hemodynamically unstable or had an impaired level of consciousness. Patients deemed at high risk for need of mechanical ventilation were not included in the study.

Study intervention

Enrolled patients were receiving oxygen under "manual control", using a conventional manual ball flowmeter. Thus, SpO_2 and pulse rate were measured at baseline with another pulse oximeter (model NONIN 8500) in order to adjust oxygen supply. Then it was indicated to initiate oxygen therapy in a controlled fashion using the O_2matic device for 30 minutes (Figure 2). Allocation to the sequence was consecutive in each patient, with no defined randomization.

Previously, the corresponding mode was selected in the device, with SpO_2 target range set between 92 %-96 % and oxygen flow between 0 and 8 L/minute. Patients were monitored for SpO_2, oxygen flow, heart rate and other data. All events during the 30-minute period were managed by personnel assigned to the study. The patient was instructed to lie in bed during the study. Oxygen flow was delivered without humidification by standard nasal cannula.

RESULTS

Eight (8) patients were considered as candidates, and five (5) of them were selected. Three patients were unable to participate due to difficulties in connecting the regulator to the wall oxygen outlet; 4 patients (80 %) had acute community-acquired pneumonia. At inclusion, the mean baseline SpO_2 was 87.8 % with an average supplemental oxygen flow of 3 liters/minute, and the flow range on the device was set between 0 and 8 liters /minute. See Table 1.

On average, patients received oxygen with O_2matic in automatic mode for 30 minutes compared to 30 minutes in the previous manual mode (P=XX). Mean oxygen flow was 2.54 liters/minute in automatic mode and 3 liters/minute in baseline

Figure 2. Installed O_2matic.

manual control mode (P=0.05). Mean heart rate was similar in the two periods (83.2/minute for baseline vs. 87.6/minute under automatic control P=XX). See Table 3.

Primary outcome

We have observed that the oxygen flow rate achieved using the O_2matic automatic control device was lower than the one achieved with manual control, with significant differences between both values. See Table 3.

The target interval in the SpO_2 device was between 92 % and 96 %, for all analyzed patients, as can be seen in Table 3. Comparison of SpO_2 before and after using O_2matic.

Secondary outcomes

Subjective tolerance to the use of the device was adequate and expressed by all patients, with no references of dyspnea symptoms or discomfort related to the use of oxygen therapy. To collect this information, simple questions were asked, not based on a previously validated questionnaire.

Safety of use of the device

In one case, audible and visible alarms for lack of power supply and low battery were ignored, resulting in the need to connect the device to AC power (in accordance with battery life specifications in O_2matic). No other safety issues were observed. The battery of the device allows for stand-alone use without connection to power supply for 4 (four) hours.

Other outcomes

Data could be analyzed from the 5 (five) patients who completed the study out of the 8 (eight) candidate patients. None of the patients showed specific symptoms related to the use of the device, with confidence proportional to the use of oxygen through the conventional nasal cannula used.

TABLE 1. Description of baseline data of analyzed patients

	Gender	Edad	F Card	SpO_2	PaO_2	$PaCO_2$	O_2 flow
1	F	76	107	88	55	45	3
2	M	82	90	87	50	45	2
3	M	88	60	92	61	43	3
4	F	75	80	88	57	43	2
5	M	64	79	82	55	42	5

TABLE 2. Description of the characteristics of patients using O_2matic for O_2 flow control

	Gender	HR (beats/min)	SpO_2 (%)	O_2 flow L/minute
1	F	102	93	2
2	M	90	96	3
3	M	82	96	0,8
4	F	80	94	1,4
5	M	84	93	5,5

TABLE 3. Differences observed in average oxygen flow, SpO_2, and heart rate between baseline data and control with O_2matic

	O_2 flow	SpO_2	HR
Baseline	3.01 L/minute	87.8 %	83/minute
With O_2matic	2.54 L/minute	94.4 %	87/minute
Difference	-0.47 L/minute	+ 6.6 %	+4/minute

Two patients showed some limitation of movement caused by the pulse oximeter cable. All patients felt confident using the device. On two occasions, difficulty was noted in attaching the device to the wall's medical gas outlet polyduct due to missing fasteners. Unfortunately, this difficulty had not been evaluated prior to the study.

In general, the sense of safety was very strong with the automated oxygen concept, although this was a subjective impression of the investigators on an observational basis.

DISCUSSION

The observed data have allowed us to say that automated control of oxygen supply to the patient is reliable, feasible and superior to manual control in the use of oxygen therapy, to make it possible for the SpO_2 to reach the target prescribed by the treating physician.

Although oxygen flow has been lower when using automated flow control, no significant difference in medical oxygen consumption could be demonstrated with O_2matic compared to manual control. The mean oxygen flow was 2.54 L/minute using O_2matic and 3 L/minute with manual control. We believe that the limited number of patients does not allow us to infer a lower oxygen consumption, although our study was not powered to study this result. In the two cited studies with the use of FreeO_2, there was a reduction in oxygen consumption from 1.2 L/minute to 0.7 L/minute (P=0.06), and no overall difference was observed in another study where the average flow was 4.6 L/minute with FreeO_2 and 4.2 L/minute with manual control.[5,6]

However, the trend observed in our study toward higher flow with manual control compared to O_2matic is consistent with such findings in the literature.

Medical prescribing practices for oxygen use in patients with ARF are limited and reflect a lack of awareness of the need for accurate oxygen prescription and therapy.[3,7] A 2013 audit by the British Thoracic Society found that only 55 % of patients who had received oxygen during hospitalization had a written prescription. However, this has improved since 2008, where only 32 % of patients supplied with oxygen had had it prescribed in written form.[8] In an audit carried out in Australia, only 3 % of patients hospitalized with a COPD exacerbation had a written oxygen prescription regardless of the fact that 79 % of patients required oxygen supplements.[8] A large European retrospective study conducted an audit in 2011 of 16,018 patients with a COPD exacerbation, and found that 10.1 % received inadequate treatment with oxygen therapy, either with high-flow oxygen or no oxygen at all, despite having hypoxemia.[9]

Patient acceptance of automated oxygen administration in our study was very high, and in general, patients were highly confident that they were receiving oxygen in an adequate manner. However, limitation of movement due to the pulse oximeter cable has been a problem for some patients. As our study was limited to 30 minutes of continuous SpO_2 monitoring during the day, prolonged studies including overnight would be necessary to adequately assess the individual patient experience with continuous monitoring under automated oxygen flow control. Our work is a preliminary and descriptive study and, therefore, did not allow the examination of certain outcomes such as time to oxygen weaning and overall duration of hospitalization, which would have been valuable to understand the real value of these new technologies.

A retrospective study of 680 patients with COPD exacerbation showed that SpO_2 control during hospital admission is a time-consuming task for the nursing staff, considering that closed-loop control of oxygenation could reduce their workload and increase patient safety through better SpO_2 control.

In another study controlled by a closed-loop system, FreeO2®, OxyNov Inc., Quebec, Canada, an increase in time with target SpO_2 was observed between 51 % and 81 % compared to manual control.[6] Results for FreeO_2 were confirmed in a shorter 3-hour study of 187 patients with hypoxemic respiratory failure due to different conditions in the emergency room.[3,6]

Other studies have shown that closed-loop control of oxygen probably allows for faster oxygen weaning and shorter hospital length of stay; therefore, it could be beneficial to the management of resources, in comparison with manual control by the nursing staff.[5,6] The automatic adjustment of oxygen flow would optimize the use of this resource that is frequently over-administered when

flow control is manual, as it has already been mentioned.

These findings inspire us to carry out a comparative study between 2 (two) groups of patients, one under manual control of oxygen therapy by a conventional flowmeter, and another group using O_2matic permanently for at least 24 to 48 hours, in a number of patients of at least 3 digits, so as to be able to evaluate differences in real nursing working time, in the patient's number of hospitalization days, and total time in hypoxemia under oxygen therapy, among other objectives.

A relevant issue is the clinical importance of keeping the SpO_2 within a fairly narrow interval. Controlled studies of outcome in terms of prescription and adherence to different oxygen dosing regimens are still necessary, for example, for patients with an exacerbation of COPD. Thus, either a disproportionately elevated or decreased SpO_2 on admission has been associated with worse outcomes in terms of mortality or other serious adverse effects.[4,5] It seems reasonable to assume that findings from studies at the pre-hospital and admission level can be extrapolated to similar conditions during hospitalization, but further studies are needed to evaluate the outcomes related to episodes of prolonged hypoxemia and hyperoxia.

We were unable to evaluate the effect of the closed-loop oxygen control on arterial pressure of CO_2 ($PaCO_2$) in our study. It is well known that an increase in arterial pressure of oxygen can increase $PaCO_2$ as a consequence of the Haldane effect and increased dead space ventilation caused by the reversing of pulmonary vasoconstriction due to hypoxemia and worsening of ventilation-perfusion inequality.[3,10] However, the recommended strategy to avoid CO_2 retention is to avoid hyperoxia and control SpO_2 between 88 % and 92 %.[2] This makes CO_2 retention more unlikely when SpO_2 is better controlled.

This study describes preliminary data on the clinical use of an automated oxygen administration control device (O_2matic device) in patients hospitalized with respiratory failure in general wards of a University Hospital in Buenos Aires, Argentina.

CONCLUSION

In a limited number of patients with acute respiratory failure, we have observed that this device (O_2matic) allows for the optimization of the automatic control of SpO_2 in hospitalized patients with respiratory failure, and we can describe some of the benefits observed.

The use of O_2matic has been more effective than conventional manual control in maintaining the patient's SpO_2 within the specified target interval. Patients accepted the automatic oxygen control well and felt confident about getting the right amount of oxygen.

The possibility to analyze the effect of automated oxygen flow control on the duration of the patient's hospital length of stay and the actual time spent by the nursing staff to manually correct the flow, optimizing hidden factors in the management and handling of oxygen therapy during hospitalization remains to be determined in a study with a larger number of patients.

In conclusion, the question of whether the automation of oxygen therapy during hospital admission can reduce the duration of admission, and possibly improve survival among patients with acute respiratory failure remains to be determined.

We are grateful for the collaboration of the Linde-Praxair Company of Argentina, for providing an O_2matic device and for the training in the use and control of data collection by Engineer Rocío Santamaría, manager of said Company.

REFERENCES

1. Global Initiative for Chronic Obstructive Lung Disease. Global strategy for the diagnosis, management and prevention of COPD; 2018. Available from: https://goldcopd.org/wp-content/uploads/2017/11/GOLD- 2018-v6.0-FINAL-revised-20-Nov_WMS.pdf. Accessed December 02, 2018.
2. British Thoracic Society Emergency Oxygen Guideline Development Group. BTS guideline for oxygen use in adults in healthcare and emergency settings. Thorax. 2017;72:i1-i90. https://doi.org/10.1136/thoraxjnl-2016-209729
3. Codinardo y cols. Oxigenoterapia: Usos médicos en situaciones agudas y crónicas. Edición 2020. Editorial Journal.
4. Hansen EF, Hove JD, Bech CS, Jensen JS, Kallemose T, Vestbo J. Automated oxygen control with O2matic® during admission with exacerbation of COPD. Int J Chron Obstruct Pulmon Dis. 2018;13:3997-4003. https://doi.org/10.2147/COPD.S183762
5. Lellouche F, Bouchard PA, Roberge M, et al. Automated oxygen titration and weaning with FreeO2 in patients with acute exacerbation of COPD: a pilot randomized trial. Int J Chron Obstruct Pulmon Dis. 2016;11:1983-90. https://doi.org/10.2147/COPD.S112820

6. L'Her E, Dias P, Gouillou M, et al. Automatic versus manual oxygen administration in the emergency department. Eur Respir J. 2017;50:1602552. https://doi.org/10.1183/13993003.02552-2016
7. Cousins JL, Wark PA, McDonald VM. Acute oxygen therapy: a review of prescribing and delivery practices. Int J Chron Obstruct Pulmon Dis. 2016;11:1067-75. https://doi.org/10.2147/COPD.S103607
8. O'Driscoll BR. British Thoracic Society. Emergency oxygen audit 2013. Available from: https://www.brit-thoracic.org.uk/document-library/ audit-and-quality-improvement/audit-reports/bts-emergency-oxygen-audit-report-2013/. Accessed August 15, 2018.
10. Roberts CM, López-Campos JL, Pozo-Rodríguez F, Hartl S; European COPD Audit team. European hospital adherence to GOLD recommendations for chronic obstructive pulmonary disease (COPD) exacerbation admissions. Thorax. 2013;68:116971. https://doi.org/10.1136/thoraxjnl-2013-203465
11. Abdo WF, Heunks LM. Oxygen-induced hypercapnia in COPD: myths and facts. Crit Care. 2012;16:323. https://doi.org/10.1186/cc11475