Status of Plasma Lactate and Dissolved Gases in Patients with Chronic Obstructive Pulmonary Disease (COPD) and Effects of Rehabilitation Exercise

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Abstract:

Background: In Chronic obstructive pulmonary disease (COPD) patients doing strenuous work or exercise, characteristic biochemical change occur which is the development of anaerobic status, dyspnea, leading to accumulation of Lactate and production of CO2.

Aim: Present study described estimation of lactate, and pressure of blood gases (O2 and CO2) in COPD patients undergoing O2 assisted and non-assisted pulmonary rehabilitation exercises.

Materials and Methods: Fifteen COPD patients for both non-assisted and O2 assisted pulmonary rehabilitation studies were selected, aged 27-42 yrs. In non assisted exercise group, all subjects performed treadmill walks with interval and blood was collected at specified time lines. In O2 assisted study, performed after gap of one day, all subjects performed walks, with O2 assistance started at 15th minutes after start of exercise, with 20 minutes interval between the two, and blood was collected at specified time lines. PCO2, PO2, pH and HCO3 and lactate were analyzed by standards methods. Data were analyzed and compared pre, intra and post exercise in both groups using SPSS ver 22.0 (USA) with level of significance <0.05.

Results: In both groups of exercising COPD patients, it was noted that the group without O2 assistance, Lactate and dissolved gases concentration are higher as compared to the group with O2 assistance, exhibiting compensatory viable intervention of O2 assistance in pulmonary and metabolic system of the exercising individuals

Conclusion: This has been concluded that assistance with extra O2 supply not only compensates and /or counteracts pulmonary dysfunctions, limitations, but also cause lungs to perform better by resisting acidic environment (production of lactate), alterations in pCO2, pO2 and removing radical components.

Key words: Chronic obstructive pulmonary disease (COPD**),** Dyspnea, Lactate

Tob Regul Sci. ™ 2022;8(1): 1850-1855
DOI: doi.org/10.18001/TRS.8.1.141
Short Title: COPD patients and rehabilitation exercises

Introduction:

Patients suffering from Chronic obstructive pulmonary disease (COPD) face very harsh but assisted-normal clinical condition (Arnold et al., 2020; Polkey et al., 2000). As disease progresses, patient starts avoiding routine physical activities, exercising, office or domestic work that could induce pulmonary or physical stress leading to dyspnoea (Witecvk et al, 2005; Waschki et al., 2015; WHO, 2020). Further deterioration of pulmonary strength cause the individual to avoid even simplest physical activity with insidious decline in capacity to exercise and move around easily, leading to marked dyspnea, de-conditioning and waning of clinical condition (Pitta et al., 2005; Papen et al., 2007; Van Buul et al., 2017). Reduction in physical activity or exercise then becomes a strong facilitator of poor health and even early mortality (Holz et al., 2020; Rabe and Watz, 2017). One very characteristic clinical condition that occurs in COPD patients, when doing strenuous work or exercise, is the development of anaerobic status leading to accumulation of Lactate (Holz et al., 2020; Polkey et al., 2000; Papen et al., 2007; Rabe and Watz, 2017; Van Buul et al., 2017). In patients with severe and progressing COPD, hyperlactataemia cause CO2 generation, which leads to hindrance in physical activity and exercise (Polkey et al., 2000). For rehabilitation purpose, such patients are provided with O2 assistance, and/or non-invasive pressure support (IPS) or assisted oxygen supply, which facilitates reduction of dyspnea, and helps patients to continue exercise and in some cases intensify (Holz et al., 2020; Polkey et al., 2000; Papen et al., 2007; Rabe and Watz, 2017; Van Buul et al., 2017). Therefore, present study described estimation of lactate, and pressure of blood gases (O2 and CO2) in COPD patients undergoing assisted and non-assisted pulmonary rehabilitation exercises.

Materials and Methods: Fifteen COPD patients for both non assisted and assisted (IPS) pulmonary rehabilitation studies were selected after thorough investigation via clinical data, assessment of signs and symptoms, consented to participate and documented. Inclusion criteria were male COPD patients aged 27-42 yrs, non smokers, without cardiac, neurological, physical, gastric or metabolic problems, or surgeries, with habits of normal diet, weighing 50 to 60 kg. Exclusion criteria were patients below age 27 yrs and above 42 yrs, smokers, with previous history of cardiac, gastric, surgical, neurological history and/or metabolic problems, under or overweight. In study without IPS (Table 1), all subjects performed two twenty minutes treadmill walks with 20 minutes interval between the two walks, and blood was collected at baseline, 10 minutes before exercise and 15 minutes after completion of whole exercise regiments. In IPS study, performed after gap of one day, all subjects performed two twenty minute's treadmill walks, with IPS started at 15^{th} minutes after start of exercise, with 20 minutes interval between the two walks. Similarly as in case of non IPS, blood was collected at baseline, 10

minutes before exercise, 15 minutes after IPS exercise and 15 minutes after completion of whole exercise regiments. Oxygen was supplied via tightly fixed oro-nasal face mask with concentration 5.0 $L.min^{-1}$(Alison et al., 2019). PCO2, PO2, pH and HCO3 were analyzed on Nova Phox Pro Arterial blood gas analyzer (Nova Biomedical, Massachusetts, USA), whereas Lactate was determined in serum by L-Lactate PAP (4-amino-antipyrine) colorimetric method on Roche's Cobas c501 chemistry analyzer. The principle was based in the conversion of lactate into H_2O_2 and then to a purple colored end product after addition of TOOS (N-ethyl 2-OH-3-Sulphopropyl m-toluidine). Color intensity is directly proportional to increased lactate concentration in serum. Data were analyzed and compared pre, intra and post exercise in both groups using SPSS ver 22.0 (USA) with level of significance <0.05.

Results: Results are summarized in Tables 1 and 2. Plasma Lactate and dissolved gases status of COPD patients, at baseline (before exercise) and at the end of exercise showed marked significant difference (P< 0.00001) as pressure of O2 decrease, pH lowered (Table 1), lactate elevated and due to compensatory mechanism, HOC3 increase gradually after exercise as treadmill regiments progressed. In group receiving IPS/O2 assistance, a comparatively milder changes observed in pCO2 (P< 0.007), PO2 (P <0.002), pH (P < 0.002) and HOC3 (P < 0.015) after intra exercise regiment, as compared to groups without IPS, exhibiting compensatory viable intervention of O2 assistance in pulmonary and metabolic system of the exercising individuals (Table 2). Data confirmed facilitating and compensatory role of assisted O2 intervention in COPD patients during exercise, which not only induced better O2 saturation for aerobic processes but also helped in prolonging exercise regiments and timings without any extensive deviations or adverse outcome.

Discussion: Present study described blood gases, lactate and bicarbonate pattern in patients with COPD, undergoing pulmonary rehabilitation exercise, with and without O2 assistance, also known as non-invasive pressure support (IPS) and/or assisted O2 supply. Variable data was observed after specified exercise regiments which were treadmill walks in both groups, suggesting interventional O2 supply does have a compensatory role in prolonging exercise timings and creating better endurance. Lactate produced due to anaerobic glycolysis, and more enhanced production due to restricted respiration in COPD patients, showed elevated levels in both COPD groups of individuals, however in O2 assisted groups, elevation was milder as compared to non-assisted group, suggesting compensatory viability of O2 support. Furthermore, time of exercise also prolonged in O2 assisted group, without any drastic changes in blood gases or Lactate, confirming the creation of endurance. Several studies reported about changes in blood gases, lactate, metabolites in patients with COPD and role of assisted O2 supply. A study done in recent past with smokers and non smokers COPD patients reported that exercise induced alteration in metabolites are comparable with those observed routinely in such studies (Holz et al., 2020). Decreased glucose and increase in lactate and pyruvate in both

smoking and non smoking COPD patients indicated anaerobic glycolysis and hence decline in endurance and strength. An earlier study recorded that IPS assistance during treadmill exercise for COPD patients does induce strength, endurance, pulmonary stability and cause patients to prolong their pulmonary rehabilitation exercise (Polkey et al., 2000). It was hypothesized that IPS used for COPD patients undergoing rehabilitation programs might enhance pulmonary strength, thus facilitating patients to exercise more without much compromising metabolism and respiratory indices. COPD, itself is a debilitating condition, causing multi-level impairments, and deteriorate, if patients are unable to exercise due to pulmonary limitations, including cardiovascular comorbids and musculoskeletal dysfunctions (Arnold et al., 2020). Fatigues in legs due to reduced citrate synthase of oxidative pathways are cited as one of the factors for limitation in exercise (Bernard et al., 1998). Earlier onset of lactic acidosis, as we have seen in our study as well, induces cellular changes, resulting in production of more of acidic metabolites causing subsequent exhaustion in limbs, thus limiting exercise performance (Gosketr et al., 2007; Puente-Maestu et al., 2009). Therefore extra O2 supply not only compensates and /or counteracts pulmonary dysfunctions, limitations, but also cause lungs to perform better by resisting acidic environment and removing radical components.

Conclusion: COPD is a known debilitating condition, causing multi-level impairments, induces physical deterioration, if patients are unable to perform rehabilitation exercise due to pulmonary limitations, including cardiovascular comorbids and musculoskeletal dysfunctions. Therefore assistance with extra O2 supply not only compensates and /or counteracts pulmonary dysfunctions, limitations, but also cause lungs to perform better by resisting acidic environment (production of lactate), alterations in pCO2, pO2 and removing radical components.

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Table 1: Plasma Lactate and dissolved gases status of COPD patients, at baseline (before exercise) and at the end of exercise

Parameters	Base line	End of exercise	P < 0.05	t-value
pO_2 (mmHg)	89.14 ± 2.54	76.04 ±2.46	P< 0.00001	18.510
pCO_2 (mmHg)	45.22 ±1.45	51.57± 3.37	P<0.00001	-9.134
HCO_3 (mM/L)	25.25± 0.41	28.33 ± 0.21	P<0.00001	-12.304
pH	7.37 ±0.01	7.22 ±0.02	P<0.00001	14.910

Lactate (mmol/L)	1.42 ±0.03	3.07 ±0.06	P<0.00001	-20.410

Results are presented as mean ± SD. Significance is P < 0.05

Table 2: Plasma Lactate and dissolved gases status of COPD patients, at baseline (before exercise), Isotime (O2 assisted, 15 min after baseline) and at the end of exercise

Parameters	Base line (before start of exercise) A	Isotime (O2 assisted, 15 min after baseline) B	End of exercise C	P <0.05	t-value
pO_2 (mmHg)	88.6 ± 3.3	83.8 ± 5.7	74.92±0.93	A vs B P< 0.007	A vs B 3.577
				A vs C P< 0.00001	A vs C 15.621
pCO_2 (mmHg)	44.91 ±0.54	47.78 ±1.64	51.86 ±3.79	A vs B P< 0.002	A vs B -4.342
				A vs C P<0.00001	A vs C -7.469
HCO_3 (mM/L)	25.17 ±0.48	26.87 ±0.26	28.55 ±0.27	A vs B P<0.002	A vs B -4.410
				A vs C P< 0.00002	A vs C -8.800
pH	7.36± 0.02	7.30±0.01	7.21± 0.02	A vs B <0.015	A vs B 3.047
				A vs C P<0.00008	A vs C 7.314
Lactate (mmol/L)	1.40 ±0.001	1.83 ±0.002	3.10 ±0.01	A vs B P< 0.00001	A vs B -12.359
				A vs C P< 0.00001	A vs C -28.522

Results are presented as mean ± SD. Significance is P < 0.05