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THE COMPARISON OF PULSE OXIMETRY (SPO_2) AND BLOOD GAS ANALYSIS (SAO_2) TO DETECT HYPOXEMIA IN LIVER CIRRHOSIS

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Abstract

Background: Hepatopulmonary syndrome is characterized by clinical triad of chronic liver disease, hypoxemia and intrapulmonary vascular dilatation. Routine screening of hypoxemia is not performed in all patients with liver cirrhosis. Blood gas analysis is difficult, fairly invasive, expensive and requires special skills; thus, another alternative is required for detection of hypoxemia including pulse oximetry (SpO_2).

Objective: To analyze the comparison of SpO_2 pulse oximetry with SaO_2 to detect hypoxemia in patients with liver cirrhosis.

Methods: Subjects were grouped into the severity based on Child Pugh score A, B, and C. The subjects were examined for blood gas analysis and pulse oximetry. Data were analyzed using Kruskal Wallis test and Wilcoxon test ($p < 0.05$).

Results: The highest cause of liver cirrhosis was hepatitis B of 19 patients (57.6%) and the severity based on Child Pugh B as many as 18 patients (54.5%). The proportion of hypoxemia (<80 mmHg) was 15%. The comparison of SpO_2 and SaO_2 in LC patients showed no significant difference between SPO_2 and SaO_2 (child B, $p = 0.15$ and child C, $p = 0.07$).

Conclusion: There was no significant difference between SpO_2 (pulse oximetry) and SaO_2 (Blood Gas Analysis) in liver cirroshis patients.

Keywords: *cirrhosis of the liver, pulse oximetry, SaO_2, SpO_2*

Introduction

One complication of liver cirrhosis is found to be Hepatopulmonary syndrome. Hepatopulmonary syndrome is characterized by classical clinical triads of chronic liver disease, hypoxemia and intrapulmonary vascular dilatation. The diagnosis of the syndrome is not clinically easy, as some patients are asymptomatic [*Ghayumi SM et al., 2010, Koch DG, Fallon MB, 2014*]. Hypoxemia as one of the Hepatopulmonary syndrome criteria can be established by blood gas analysis. The Blood gas analysis examination is difficult for uncooperative patients, obesity, and edema patients because pulsation is difficult to touch. liver cirrhosis patients are often found edema [*Larkin BG, Zimmanck JR, 2015*]. In addition, Blood gas analysis examination is quite invasive and requires considerable cost [*Swanson KL, 2007*].

The initial manifestation of Hepatopulmonary syndrome is the tightness that is aggravated by activity. At a more severe level, it will be found tachypnoea, dyspnea at rest, and platypnea or cyanosis can also occur [*Alizadeh AHM et al., 2006, Tumgor G, 2014*]. Patients with severe Hepatopulmonary syndrome may have very low MELD scores; thus, it is not eligible for transplantation [*Swanson KL, 2007*]. Severe hypoxemia can lead to cardiopulmonary system failure or acute respiratory failure [*Shoji K et al., 2014*]. Hypoxemia in Hepatopulmonary syndrome, liver cirrhosis patients has a poor prognosis. A prospective study of

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27 Hepatopulmonary syndrome patients showed that Hepatopulmonary syndrome was a major independent risk factor with median survival time of 10.6 months compared with liver cirrhosis patients without Hepatopulmonary syndrome of 40.8 months [*Schenk P et al., 2003*].

The cost effectiveness of the screening test depends on the prevalence of the disease, the sensitivity of the test, and the effective intervention. The guidelines for screening hypoxemia in patients with liver cirrhosis are currently underdeveloped. Regular blood gas analysis test and insignificant cost expenditures with benefits still invite controversy. Routine screening is not performed on all liver cirrhosis patients [*Roberts DN et al., 2007, Swanson KL, 2007*].

An alternative test is by oxygen saturation test (SpO_2) using pulse oximetry. Pulse oximetry can be performed simply, quickly, not invasively, and gives a good estimate of oxyhemoglobin saturation of the arteries (SaO_2). Moreover, it can reduce the cost, time, inconvenience, and risk of complications, compared to blood gas analysis test [*Roberts DN et al., 2007, Swanson KL, 2007*]. This examination is expected to improve the early detection of Hepatopulmonary syndrome. In addition, it is expected to improve survival by optimizing the time in performing liver transplant. A study in Indonesia on the comparison of the use of (SPO_2) pulse oximetry and (SaO_2) Blood gas analysis to detect hypoxemia does not yet exist. A study reported 41 patients with Hepatopulmonary syndrome in SpO_2, there was 96% of sensitivity, Oxymetric pulse of 100% and specificity of 88%. The data of these studies require further study. To support the study, the researchers consider that it is necessary to study the comparison of SpO_2 pulse oximetry and SaO_2 value from Blood gas analysis to detect hypoxemia (PaO_2 <80) in liver cirrhosis patients [*Arguedas MR et al., 2007*]. It is therefore necessary to compare SpO_2 pulse oximetry with SaO_2 blood gas analysis to detect hypoxemia in liver cirrhosis.

MATERIAL AND METHODS

The subjects of this study were liver cirrhosis patients who underwent the treatment of dr. Soetomo General Hospital Surabaya Indonesia. The inclusion criteria included: clinically proven liver cirrhosis patients and supported by ultrasound images and fulfilled Child Pugh A, B, and C score criteria, and aged over 18 years old. The exclusion criteria included liver cirrhosis patients who had lung disease, primary cardiopulmonary disease, shock, hepatoma, and hematemesis-melena. Patients who were willing to participate in the study filled the informed consent sheet.

The design of this study used cross sectional with consecutive sampling in the period of April to June 2013. The research was conducted in Inpatient wards of Internal Diseases and Outpatient of gastro-hepatology in Dr. Soetomo General Hospital Surabaya, Indonesia. SpO_2 data collection used Oxypleth oxymetric pulse (520A pulse oximeter, Novametrics, Respironics Inc.) which was applied for 15 minutes and the SaO_2 data was taken by taking a 2 cc Blood gas analysis blood sample.

The collected data were first tested for normality using Shapiro Wilk test and homogenity test using Levene's test. If the data was normal and homogenous, then the statistic test used was ANOVA and paired t-test ($p < 0.05$). If the data was not normal and homogeneous, then the statistical test used was Kruskal Wallis test ($p < 0.05$). The tools used in the statistical analysis were SPSS version 20.0 (SPSS, Inc., Chicago, IL).

RESULTS

Subject Characteristics

The liver cirrhosis patients in this study, which were the majority of females (54.55%), were caused by hepatitis B (57.57%), and the Child B severity (54.55). The most subjects suffer from moderate ascites (27.27%). The most common description of blood gas analysis was in the normal category (36.36). Detailed description of blood gas analysis can be seen in table 1.Subjects aged in the range 31 - 72 years old with a mean of 51.39±10.59. The subjects had hemoglobin levels of 10.52 ± 1.46, total Bilirubin of 2.17 ± 1.62, and Albumin of 2.96 ± 0.62. The results of the blood gas analysis of the subjects obtained pH (7.44 ± 0.48), pCO_2 (32.80 ± 6.60), pO_2 (94.90 ± 6.59), HCO_3 (22.77 ± 6.27), SaO_2 (97.5 ± 1.42), and A-a DO_2 (16.15 ± 12.21; table 2). Patients with liver cirrhosis child A had higher mean SpO_2 and SaO_2, followed by the mean SpO_2 and SaO_2 levels in patients with liver cirrhosis child B and C. Each had a similar value

of SaO_2 and SpO_2 among liver cirrhosis patients in the same group of severity. The mean value of SpO_2 and SaO_2 are also almost equal in one group of liver cirrhosis severity (table 3).

TABLE 1.

The Frequency Distribution of Subject Characteristics

Characteristics			n (%)
Gender			
Male			15 (45.45%)
Female			18 (54.55%)
Ascites			
None			6 (18.18%)
Minimal			8 (24.24%)
Moderate			9 (27.27%)
LC causes			
Hepatitis B			19 (57.57%)
Hepatitis C			9 (27.27%)
Unknown			5 (15.15%)
Severity			
Child A			9 (27.27%)
Child B			18 (54.55%)
Child C			6 (18.18%)
Blood Gas Analysis image			
Normal			12 (36.36%)
Metabolic acidosis	acidosis	Respiratory	1 (3.03%)
Respiratory alkalosis	Alkalosis	Metabolic	0 (0.00%)
Combination			7 (21.21%) 10 (30.30%) 3 (9.09%)

TABLE 2.

Mean Characteristic of Subjects

Characteristics	Mean ± SD
Age	51.39 ± 10.59
Hemoglobin	10.52 ± 1.46
Total Bilirubin	2.17 ± 1.62
Albumin	2.96 ± 0.62
pH	7.44 ± 0.48
pCO_2	32.80 ± 6.60
pO_2	94.90 ± 6.59
HCO_3	22.77 ± 6.27
SaO_2	97.35 ± 1.42
A-a DO_2	16.15 ± 12.21

TABLE 3.

Distribution of SpO2 and SaO2 in patients with liver cirrhosis

	Child A	Child B	Child C	p
SpO_2	98.22 ± 0.44	97.56 ± 1.50	97.17 ± 1.47	0.83
SaO_2	97.84 ± 0.84	97.34 ± 1.48	96.65 ± 1.82	0.58

The mean distribution of SpO_2 and SaO_2 in hypoxemia patients were 28 subjects and non hypoxemia were 5 subjects. SpO_2 value in hypoxemia subjects was (95.20 ± 1.30) and non hypoxemia subjects was (98.11 ± 0.68). The value of SaO_2 in the subjects of hypoxemia was (94.78 ± 1.22) and the non hypoxaemic subjects was (97.81 ± 0.85). A-aO_2 value in hypoxemia subjects was (35.40 ± 3.70) and non hypoxemia subjects was (13.56 ± 10.03).

Liver cirrhosis patients in the severity both based on SpO_2 and SaO_2 had p value of 0.83 and 0.58 which meant no significant difference between SpO_2 and SaO_2 examination results (table 3). The comparison between SaO2 and SpO2 in liver cirrhosis child A patients obtained p value of 0.04 which meant that in liver cirrhosis child A patients there was a significant difference between SPO_2 and SaO_2 examination results. Patients with liver cirrhosis child B and C obtained p value of 0.15 and 0.07 which meant in liver cirrhosis child B and child C patients that there was no significant difference between SPO_2 and SaO_2 examination results (table 4).

TABLE 4.

Wilcoxon test results in the comparison of SpO_2 and SaO_2

Severity	P
Child A	0.04
Child B	0.15
Child C	0.07

DISCUSSION

The comparison of SpO_2 and SaO_2 in liver cirrhosis patients showed similar results with previous studies. The study states that SpO2 of 96% has a sensitivity of 84% to detect hypoxemia, but has a specificity of 91%. SpO_2 of 97% had high sensitivity (96%) and moderate specificity (75%). In SpO_2 of 94% to 98%, blood gas analysis examination was conducted to determine blood gas exchange abnormalities, the presence of liver cirrhosis did not affect the accuracy of pulse oximetry. The study also found no significant differences in age, child scores, hemoglobin values, or bilirubin levels. There was no significant difference between SPO_2 (pulse oximetry) and SaO_2 (Blood gas analysis) [*Abrams G, 2002*]. Other research also pro-

vides similar results; O_2 saturation (SpO_2) can determine hypoxemia in the supine position and upright position with significant results. SpO_2 readings may also be influenced by hyperbilirubinemia, but the effect is too minimal to cause reading errors [*Deibert P et al., 2006*].

In a prospective study of 200 transplant candidates, it was found that pulse oximetry was a useful screening for detecting hypoxemia in patients with liver cirrhosis. With a 96% SpO_2 limit as a reference, blood gas analysis examination was performed to detect hypoxemia (PaO_2 <60 *mmHg*) with the best sensitivity and specificity [*Fallon MB et al., 2008*]. Another study also mentioned that pulse oximetry with a limit value of SpO_2 <96% is a sensitive method for detecting hypoxemia and most over estimate of SaO2. Therefore, a value of SpO_2 ≤96% is recommended for blood gas analysis examination. Blood gas analysis test is quite invasive and does not always work. The alternative test is a pulse oximetry test that can be conducted quickly, simply, not invasively. Blood gas analysis examination can be recommended in SpO_2 ≤96% to detect hypoxemia [*Ghayumi SMA et al., 2014*]. However, pulse oximetry does not describe the complete picture of oxygen transport.

In contrast to other studies showing a 96% cut-off point with sensitivity of 50% and a specificity of 89%, SpO_2 97% had sensitivity of 64% and specificity of 68%, while in SpO_2 98% had a sensitivity of 88% and a specificity of 44%. This may be due to the different diagnosis criteria for hypoxemia, the characteristics and conditions of different study samples [*Arguedas MR et al., 2007*]. Similarly, other studies found SpO_2 underestimated SaO_2 at 42.6% with a range of bias between -13.2% - 12%. In addition, due to several factors limiting the accuracy of pulse oximetry, such as carboxyhemoglobin, methemoglobin, vasoconstriction, probe position instability, hypothermia, edema, hypotension, skin pigmentation, jaundice, fingernail color, anemia and tool calibration. Delivery way and delay in blood sample for Blood gas analysis examination will also affect the results of this study [*Jensen LO, 1998*]. In this study, there was no distinguishing presence of edema in place of pulse oximetry, gradations of skin pigmentation or color and limits of smoking criteria, which may affect pulse oximetry results.

CONCLUSION

In this study, there was no distinguishing presence of edema in place of pulse oximetry, gradations of skin pigmentation or color and limits of smoking criteria, which may affect pulse oximetry results.

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