UTILITY OF NEUTROPHIL-TO-LYMPHOCYTE RATIO, PLATELETS-TO-LYMPHOCYTE RATIO AND CALL SCORE FOR PROGNOSIS ASSESSMENT IN COVID-19 PATIENTS

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ABSTRACT

Objective: To validate if Neutrophil-to-Lymphocyte ratio (NLR), Platelet-to-Lymphocyte ratio (PLR) or CALL score (a novel scoring model) predict worse prognosis such as need for Intensive Care Unit (ICU) Admission and Mortality in COVID 19 patients.

Study Design: Prospective observational cohort study.

Place and Duration of Study: Combined Military Hospital Lahore, from Mar 2020 to May 2020.

Methodology: Consecutive symptomatic patients with confirmed COVID-19 infection by RT-PCR were included. Patients' age, gender, comorbids and labs data including complete blood counts and serum LDH was recorded. neutrophil-to-lymphocyte ratio, platelet-to-lymphocyte ratio and CALL Score were calculated. Main outcomes were need for Intensive Care Unit Admission/ventilator support and mortality.

Results: A total of 125 patients were admitted with the diagnosis of COVID-19 infection. There were 35 (28%) Intensive Care Unit admissions, 17 (13.6%) required mechanical ventilation and 17 (13.6%) patients were deceased. Regression Analysis was done. For Intensive Care Unit Admission/ventilator support significant predictors were neutrophil-to-lymphocyte ratio (p=0.03), age greater than 50 (p=0.02), moderate CALL score (p=0.02) and high CALL Score (p=0.004). For hospital deaths, significant predictors included neutrophil-to-lymphocyte ratio (p=0.001) and age more than 50 years (p=0.01), CALL Score was not significant (p=0.3 & 0.9). Platelet-to-lymphocyte ratio (p=0.9 and 0.8) and Diabetes (p=0.1 & 0.6) were not significant.

Conclusion: Neutrophil-to-lymphocyte ratio and age more than 50 years are significant predictors for need for Intensive Care Unit Admission or Ventilatory support and in-hospital mortality. High CALL Score is a significant predictor of Intensive Care Unit Admission or ventilator support but not for in hospital mortality.

Keywords: CALL Score, COVID 19, Neutrophil to Lymphocyte Ratio, Platelet to Lymphocyte Ratio, Prognostic Markers.

INTRODUCTION

Corona virus disease COVID-19 has emerged as a major health hazard globally. Not only has it got significant morbidity and mortality it also has a huge impact on economy. Efforts are under way in every part of the world to understand the disease spectrum and identifying the factors affecting its prognosis. Considering the huge burden on resources specially the requirement of oxygen and ventilatory support it is need of the hour to be able to identify the patients prone to developing complications at the time of presentation to avoid spending on the ones who can be managed without hospital support. Pakistan is one of the countries facing economic brunt due to this calamity[1].

The disease spectrum ranges from those with no or mild symptoms to critical illness. Majority of the patients encounter mild symptoms. Symptomatic patients may have symptoms with no oxygen requirement at one end and requiring mechanical ventilation with novel therapies at the other end[2]. Disease severity has been classified by various authorities in different ways. WHO classifies the disease into mild, moderate, severe and critical disease. Mild disease is defined as PCR proven disease with symptoms but no evidence of hypoxia or pneumonia. Moderate disease is described as pneumonia supported by presence of clinical signs but there is no evidence of severe pneumonia or hypoxia (SPO2 >90%).

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Presence of signs and symptoms of severe pneumonia comprises severe disease. It is accompanied by one of the three parameters which include, respiratory rate greater than 30 breaths/min, severe respiratory distress (PO_2/FiO_2 <300), SPO2 <90% on ambient air. Acute respiratory distress syndrome (ARDS), septic shock and mulltiorgan dysfunction constitute the Critical illness[3]. Numerous studies have shown certain parameters to be independent risk factors for poor outcome like advanced age, comorbids, lymphopenia, raised LDH and low albumin levels[4].

There has been interest in identifying simple hematologic and biochemical laboratory parameters which can help in triage of the patients on the basis of expected outcome. A few in process of evaluation are the neutrophil-to lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR) and lymphopenia. These have been recognized as the various indicators of inflammatory response. These have previously been studied in other disease conditions and malignancies as well and have proven to be quite helpful and sensitive. In a study done in patients with metastatic gastric cancer patient NLR was few to be an independent predictor of prognosis[5]. Similar data was found in studies on other malignancies[6]. However there is conflicting data in various studies. Few studies favoring NLR as a useful prediction tool for prognosis whereas a few others fail to demonstrate their usefulness[7,8].

Viral pneumonias have always been notorious for their potential of causing fatal outcomes. Efforts have been made to develop scoring systems to predict the mortality. Rapidly increasing number of patients is the reason it is very important to be able to predict patients expected outcome and therapeutic plan at the time of presentation. Researches have been looking into the possibility of evolving rapid scoring systems to expedite the treatment process. CALL score is one of the scoring systems developed to predict the progression of patients presenting with severe disease[9]. It is a relatively straight forward scoring system requiring only 4 parameters which are comorbidity, age lymphocyte and LDH. Significant comorbids include at least one of the followings: diabetes, hypertension, cardiovascular disease, chronic liver disease, chronic lung disease, asthma, HIV infections and malignancy for at least 6 months[10]. To date there is no published data on the application of these laboratory parameters or any scoring system in our population. Objective of this study is to validate if NLR, PLR or CALL score predict worse prognosis outcomes in our patients. The adverse prognoses in this study includes the need for admission in Intensive Care Unit (ICU) or need for mechanical ventilation and fatal outcome in the form of death during hospitalization in patients admitted with serological and clinical picture of COVID-19 infection. Overall goal is to enable the physicians to predict the prognosis of patients as well as progression of disease at the time of admission. This might help in channelizing the resources in a right direction and help the front-line workers to decide the appropriate health facility for their treatment.

METHODOLOGY

This was a prospective observational cohort study conducted in Combined Military Hospital, Lahore. Consecutive symptomatic patients with confirmed COVID-19 infection by RT-PCR (Genesig by Primer design UK) admitted during March 2020 and May 2020 were included. Permission from institutional ERC and relevant department was sought before data collection (ERB: 189/2020).

Data of all the inpatients meeting inclusion criteria was collected using a Performa. Patients' age, gender, presence of concomitant medical conditions and labs data including complete blood counts and serum LDH was recorded NLR and PLR were calculated. Complete blood count estimation was done by Sysmex KX21 analyzer and LDH was measured using Roche Cobas C501 Analyzer using spectrophotometery technique. CALL score was calculated using age, concomitant medical conditions, serum LDH and Lymphocyte count[10]. Informed consent was taken from the patients or their next of kin before

data collection and strict patient confidentiality was maintained during data collection. To ensure confidentiality patients were assigned with codes.

Statistical Analysis: Categorical variables were described using frequencies and percentages and quantitative variables using means and standard deviations. Median and IQR was utilized if the data had non parametric distribution. Outcomes and mortality and need of ICU /mechanical ventilation were described using percentages. Univariable analysis was performed to ascertain association of indepen-

Table-I: Baseline characteristics and their distribution according to need of Intensive Care Unit / mechanical ventilation.

Parameter	Need of Intensive Care Unit/mechanical ventilation		Unadjusted OR (95% CI)	*p*-value
	Yes (n=35)	No (n=90)		
Age (years)	57.8 ± 12.8	38.9 ± 13.8	1.11 (1.06-1.14)	<0.001
Age ≥50 years	28 (80)	25 (27.8)	10.4 (4.0-26.8)	<0.001
Males	8 (22.9)	13 (14.4)	1.8 (0.6-4.7)	0.29
Presence of any comorbid	31 (88.6)	19 (21.1)	28.9 (9.1-92.2)	<0.001
Diabetes	17 (48.6)	4 (4.4)	20.3 (6.1-67.5)	<0.001
Hypertension	8 (22.9)	4 (4.4)	6.4 (1.8-22.8)	0.004
Ischemic heart disease	7 (20)	2 (2.2)	11.0 (2.1-56.0)	0.001
Neurological illness	3 (8.6)	1 (1.1)	8.3(0.8-83.1)	0.06
Pulmonary disease	4 (11.1)	4 (4.4)	2.8 (0.6-11.8)	0.1
Renal disease	2 (5.7)	-	*-	0.02
Liver disease	3 (8.6)	1 (1.1)	8.3(0.8-83.1)	0.06
Underlying malignancy	3 (8.6)	1 (1.1)	8.3(0.8-83.1)	0.06
Hemoglobin (gm/dL)	12.7 ± 2.7	15.4 ± 7.2	0.75 (0.6-0.9)	0.003
Leukocytes 10^9/L	10.8 ± 5.9	6.4 ± 2.0	1.4 (1.2-1.7)	<0.001
% Neutrophils	73 ± 14	57 ± 12	1.10 (1.06-1.13)	<0.001
Absolute Neutrophil Count 10^9/L	8.4 ± 5.7	3.7 ± 1.7	1.5 (1.3-1.9)	<0.001
% Lymphocytes	20 ± 11	33 ± 12	0.90 (0.86-0.94)	<0.001
Absolute Lymphocyte Count 10^9/L	1.7 ± 0.9	2.0 ± 0.9	0.6 (0.3-1.0)	0.08
Platelets 10^9/L	251.3 ± 132	220.9 ± 80	1.0 (0.99-1.0)	0.1
Neutrophil-to-lymphocyte ratio	5.0 (2.5-8.7)	1.8 (1-2.5)	1.5 (1.2-1.9)	<0.001
Platelet-to-lymphocyte ratio	24 (15-34)	35 (27-46)	0.94-(0.91-0.98)	0.001
Serum Lactate Dehydrogenase (mg/dL)	1019 ± 721	565 ± 313	1.00 (1.001-1.003)	<0.001
Disease Severity at Presentation				
Mild	-	67 (74.4)		
Moderate	3 (8.6)	23 (25.6)		0.001
Severe	32 (91.4)	-		
Median CALL score	9 (9-11)	6 (5-8)	2.6 (1.8-3.6)	<0.001
CALL Score Categories				
Low risk	3 (8.6)	62 (68.9)	Reference	-
Intermediate	15 (42.9)	26 (28.9)	11.9 (3.2-44.7)	<0.001
High	17 (48.6)	2 (2.2)	175 (27.1-1127)	<0.001
Hospital stay in days	11 ± 6.5	14 ± 2.1	0.8 (0.7-0.9)	0.002

OR: Odds ratio, CI: Confidence interval. Mean are accompanied by inter quartile ranges. Mann Whitney U-test was utilized for comparison of medians. Univariate logistic regression was used to derive ORs and 95% CIs. *Due to Zeros in cells, Odds ratios are not reported.

Patients were followed during their hospital course till discharge or death.

Main outcomes were: 1) deterioration in clinical condition requiring admitted to the ICU or need for mechanical ventilation for respiratory failure, and 2) Death during hospitalization.

dent variables with both the outcomes separately. Applied logistic regression modeling was performed to assess proposed predictors of adverse outcomes including NLR, PLR and CALL score. Adjusted Odds Ratios were reported with 95% Confidence intervals. A *p*-value of less than 0.05 was considered significant. SPSS 20.0 was utilized for data analysis.

RESULTS

A total of 125 symptomatic patients were admitted with confirmed diagnosis of COVID-19 infection with RT-PCR during the study period. Mean age was 44.24 ± 15.97 years. Those who were younger than 50 years were 72 (57.6%). Majority, 104 (83.2%) were males. Fifty patients (40%) had at least one concomitant medical condition while 93 (74.4%) were admitted with mild or moderate symptom severity. Mean leukocyte count was 7.6 ± 4.1 x 10^9/L while mean hemoglobin was 14.7 ± 8.8 g/dL. Median percentage neutrophils were 61 (53-70) and median percent lymphocytes were 29 (20.5-30.7). Mean platelet count was 229 ± 98 x 10^9/L. Mean serum LDH was 692 ± 580 mg/dL (414-778). Median duration

Table-II: Baseline characteristics and their distribution according hospital mortality.

Parameter	Hospital mortality		Unadjusted OR (95% CI)	*p*-value
	Yes (n=17)	No (n=108)		
Age (years)	59.4 ± 10.1	41.8 ± 15.4	1.09 (1.04-1.14)	<0.001
Age ≥ 50 years	15 (88.2)	38 (35.2)	13.8 (3.0-6.66)	<0.001
Males	4 (23.5)	13 (15.7)	1.6 (0.5-5.7)	0.4
Presence of any comorbids	15 (88.2)	35 (32.4)	15.6 (3.4-72.2)	<0.001
Diabetes	9 (52.9)	12 (11.1)	9.0 (2.9-27.1)	<0.001
Hypertension	4 (23.5)	8 (7.4)	3.8 (1.1-14.6)	0.04
Ischemic heart disease	4 (23.5)	5 (4.6)	6.3 (1.5-26.6)	0.005
Neurological illness	3 (17.6)	1 (0.9)	22.9 (2.2-223.1)	<0.001
Pulmonary disease	2 (11.6)	6 (5.6)	2.2 (0.4-11.2)	0.3
Renal disease	1 (5.9)	1 (0.9)	-	0.1
Liver disease	1 (5.9)	3 (2.8)	2.2 (0.2-22.1)	0.4
Underlying malignancy	2 (11.8)	2 (1.9)	7.1 (0.9-53.9)	0.08
Hemoglobin (gm/dL)	12.2 ± 2.6	15.1 ± 7.1	6.7 (0.4-112)	0.3
Leukocytes 10^9/L	12.3 ± 5.7	6.9 ± 3.2	1.3 (1.1-1.5)	<0.001
% Neutrophils	79 ± 11	59 ± 12	1.2 (1.1-1.22)	<0.001
Absolute Neutrophil Count 10^9/L	10.1 ± 5.3	4.2 ± 2.9	1.4 (1.2-1.6)	<0.001
% Lymphocytes	14 ± 9	32 ± 12	0.84 (0.78-0.91)	<0.001
Absolute Lymphocyte Count 10^9/L	1.4 ± 0.8	2.0 ± 0.9	0.2 (0.1-0.6)	0.003
Platelets 10^9/L	276 ± 171	222 ± 80	1.01 (1.00-1.01)	0.05
Neutrophil-to-lymphocyte ratio	8.5 (3-14)	1.9 (1-3)	1.5 (1.2-1.8)	<0.001
Platelet-to-lymphocyte ratio	19 (12-33)	35 (26-43)	0.94 (0.89-0.98)	0.008
Serum Lactate Dehydrogenase (mg/dL)	1252.1 ± 843	604 ± 362.7	1.00 (1.001-1.003)	0.001
Disease Severity at Presentation				
Mild	-	67 (62)		
Moderate	-	26 (24.1)		<0.001
Severe	17 (100.0)	15 (13.9)		
Median CALL score	11 (9-11)	6 (5-8)	2.1 (1.5-2.9)	<0.001
CALL Score Categories				
Low risk	1 (5.9)	64 (59.3)	Reference	-
Intermediate	7 (41.2)	34 (31.5)	13.2 (1.5-111.5)	0.02
High	9 (52.9)	10 (9.3)	57.6 (6.7-504)	<0.001
Hospital stay in days	6 ± 4.3	14 ± 2.7	0.5 (0.4-0.6)	<0.001

of hospital stay was 14 (IQR 12-15) days. Median values for NLR and PLR were 2.1 (1.4-3.4) and 32.5 (22.9-41.9) respectively.

There were 35 (28%) ICU admissions, 17 (13.6%) required mechanical ventilation and 17 (13.6%) patients were deceased during hospitalization. Age more than 50 years at presentation, presence of comorbids, severity of disease at presentation, increased NLR, PLR and LDH; and worsening CALL score were found to be significantly associated with both ICU admission and hospital mortality separately. Among individual medical conditions, DM, HTN and IHD were also significantly associated with adverse outcomes while gender, Hemoglobin and Total Leukocyte Count were statistically non-significant.

Table-III: Adjusted models for adverse outcomes after regression analysis.

Parameters	Adjusted Odds Ratio	95% Confidence interval	*p*-value
Need of Intensive Care Unit / Mechanical Ventilation			
Neutrophil-to-lymphocyte ratio	1.3	1.03-1.7	0.03
Age more than 50 years	4.0	1.8-13.3	0.02
Moderate risk CALL score	5.2	1.2-22.3	0.02
High risk CALL score	22.1	2.7-182.1	0.004
Platelet-to-lymphocyte ratio	1.0	0.95-1.0	0.9
Diabetes	3.4	0.7-16.3	0.1
Hospital Mortality			
Neutrophil-to-lymphocyte ratio	1.5	1.3-1.8	0.001
Age more than 50 years	8.2	1.5-46.0	0.01
Moderate risk CALL score	3.5	0.3-40.0	0.3
High risk CALL score	1.1	0.04-26	0.9
Platelet-to-lymphocyte ratio	1.0	0.9-1.04)	0.8
Diabetes	0.7	0.1-4.8	0.6

On regression modeling to assess predictors of need of ICU stay/ mechanical ventilation, after adjusting for clinically and statistically relevant variables, NLR, age greater than 50 and CALL score categories were found to be significant predictors. (Adjusted odds ratios and 95% CI shown in table-III).

Similarly for hospital deaths, significant predictors included NLR and age >50 years. CALL score categories failed to show significance in regression analysis as predictors for in hospital mortality.

PLR failed to show statistical significance when adjusted for other independent variables for both outcomes of need of ICU and hospital mortality.

DISCUSSION

Our study clearly shows the value of NLR as a prognostic indicator. The studies done in various centers in world also support the fact. A recent meta analysis done on 6 studies including 828 patient found out that NLR value was greatly increased in COVID-19 patients with severe disease. All these studies are from various centers in China only[11]. Another study carried out on 245 patients of COVID-19 in a centre in China showed in-hospital mortality of 13.7% and the multivariate analysis revealed a rise in mortality by 8% for each unit increase in NLR. Therefore NLR could be considered as an independent risk factor mortality for patient with severe disease[12]. A study done on 415 patients in a centre in China revealed both NLR and PLR to be significantly high in patients with severe disease compared with non-severe disease[13]. It also showed increased incidence of diabetes mellitus and hypertension in severe disease category which is very much similar to our study.

NLR and age have also been reported as important indicators of mortality in a study whereas PLR did not prove to be a reliable

marker which is once again in agreement with the results of our study[7,14]. There are studies that have assessed isolated PLR as a prognostic indicator and marker for disease severity. A single center case series of 30 COVID patients in a hospital in China proved PLR as an indicator of cytokine storm[15]. This is quite conflicting to the finding of our study. PLR did not show statistical significance as a predictor for ICU admission and in-hospital mortality.

Association of clinical feature and comorbids with outcomes was also evaluated in our study. Age more 50 years at presentation, disease severity at admission, pre-existing diabetes, hypertension and ischemic heart disease were found to have significant association with both ICU admission and in-hospital mortality individually. As far as age is concerned, most of the studies show a cut off of more than 60 years as a risk factor for severity. Whereas we have found age of more than 50 years to be significantly associated with adverse outcome[16,17]. Another study done on 703 patient from 16 hospitals across China documented that patients with potentially adverse outcome could reliably be identified on the basis of multiple comorbids, advanced age, lymphopenia and leukocytosis[18]. All the studies mentioned so far have been done on Chinese ethnicity. A large scale study done across 68 French centers is CORONADO (Coronavirus SARS-CoV-2 and Diabetes Outcomes) study. This study has shown metabolic syndrome, obesity and Diabetes mellitus as most important risk factors for severe disease[19].

In addition to above mentioned laboratory and clinical parameters numerous scores have been developed by various set ups. Aim behind development of all these scoring systems is to facilitate the healthcare workers in identifying the patients at risk of developing complications and triaging patients for ICU admissions. CALL score is a simple scoring system based on four parameters. It is being used at different centers more so in China and has been shown to be very helpful in predicting risk of mortality[9]. A study done on Italian COVID-19 patients shows that it has got significance in predicting in-hospital mortality but cannot predict the disease progression[20]. We have not been able to find a single study on our population where CALL score was applied. In our study CALL score failed to show significance for in hospital mortality which is contradictory to the few studies we could find in literature.

LIMITATION OF THE STUDY

More research with larger studies are needed to revalidate the results.

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CONCLUSION

NLR and age more than 50 years are significant predictors for need for ICU Admission or Ventilatory support and in-hospital mortality. High CALL Score is a significant predictor of need for ICU Admission or ventilator support but not for in hospital mortality.

CONFLICT OF INTEREST

This study has no conflict of interest to be declared by any author.

REFERENCES

1. Waris A, Atta UK, Ali M, Asmat A, Baset A. COVID-19 outbreak: current scenario of Pakistan. New Microbe New Infect 2020; 35(2): 100681.
2. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 2020; 395(10223): 497-506.
3. Clinical management of COVID-19: interim guidance. [online] 2020 Available from: https://www.who.int/publications/i/item/clinical-management-of-covid-19
4. Zhou F, Yu T, Du R, Fan G, LiuY, Xiang J et al. Clinical course and risk factors for mortality of adult in patients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet 2020; 395(10229): 1054-62.
5. Zhao G, Liu N, Wang S, Guo J, Song X, Qi Y, et al. Prognostic significance of the neutrophil-to-lymphocyte and platelet-to-lymphocyte ratio in patients with metastatic gastric cancer. Medicine (Baltimore) 2020; 99(10): e19405.
6. Liu J, Li S, Zhang S, Liu Y, Ma L, Zhu J, et al. Systemic immune-inflammation index, neutrophil-to-lymphocyte ratio, platelet-to-lymphocyte ratio can predict clinical outcomes in patients with metastatic non-small-cell lung cancer treated with nivolumab. J Clin Lab Anal 2019; 33(8): e22964.
7. Yang AP, Liu JP, Tao WQ, Li HM. The diagnostic and predictive role of NLR, d-NLR and PLR in COVID-19 patients. Int Immunopharmacol 2020; 84: 106504.

8. Liu J, Liu Y, Xiang P, Pu L, Xiong H, Li C, et al. Neutrophil-to-Lymphocyte ratio predicts severe illness patients with 2019 novel coronavirus in the early stage. Med Rxiv 2020. [internet] Available from https://doi.org/10.1101/2020.02.10.20021584
9. Ji D, Zhang D, Xu J, Chen Z, Yang T, Zhao P, et al. Prediction for progression risk in patients with COVID-19 pneumonia: the call score. Clinical infectious diseases: an official publication of the Infect Dis Soc America. 2020. Available from https://doi.org/10.1093/cid/ciaa414
10. Ji D, Zhang D, Chen Z, Xu Z, Zhao P, Zhang M, et al. Clinical Characteristics Predicting Progression of COVID-19. [Internet] Available from: https://ssrn.com/abstract=3539674
11. Lagunas-Rangel FA. Neutrophil-to-lymphocyte ratio and lymphocyte-to-C-reactive protein ratio in patients with severe coronavirus disease 2019 (COVID-19): A meta-analysis. J Med Virol 2020; 10: 1002.
12. Liu Y, Du X, Chen J, Jin Y, Peng L, Wang HHX, et al. Neutrophil-to-lymphocyte ratio as an independent risk factor for mortality in hospitalized patients with COVID-19. J Infect 2020; 81(1): e6–e12.
13. Huang S, Huang M, Li X, Zhang T, Lu H. Significance of neutrophil-to-lymphocyte ratio, platelet-to-lymphocyte ratio for predicting clinical outcomes in COVID-19. Med Rxiv 2020; 5(4): 20090431.
14. Fan BE, Chong V, Chan S, Lim GH, Lim K, Tan GB, et al. Hematologic Parameters in Patients with COVID–19 Infection. Am J Hematol 2020; 95(1): e131-e34.
15. Qu R, Ling Y, Zhang YH, Wei LY, Chen X, Li XM, et al. Platelet-to-lymphocyte ratio is associated with prognosis in patients with coronavirus disease-19. J Med Virology 2020; 1002: 25767.
16. Zhang JJ, Dong X, Cao YY, Yuan YD, Yang YB, Yan YQ, et al. Clinical characteristics of 140 patients infected with SARS-CoV-2 in Wuhan, China. Allergy 2020; 75(7): 1730-41.
17. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus infected pneumonia in Wuhan, China. J Am Med Assoc 2020; 323(11): 1061-69.
18. Xu PP, Tian RH, Luo S, Zu ZY, Fan B, Wang XM,et al. Risk factors for adverse clinical outcomes with COVID-19 in China: a multicenter, retrospective, observational study. Theranostics 2020; 10(14): 6372-83.
19. Scheen AJ, Marre M, Thivolet C. Prognostic factors in patients with diabetes hospitalized for COVID-19: Findings from the CORONADO study and other recent reports. Diabetes Metab 2020; S1262-3636(20): 30085-89.
20. Grifoni E, Valoriani A, Cei F, Vannucchi V, Moroni F, Pelagatti L, et al. The CALL score for predicting outcomes in patients with COVID-19. Clin Infect Dis 2020: ciaa686.