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Altered mental status predicts length of stay but not death in a community-based cohort of hospitalized COVID-19 patients

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ABSTRACT

Introduction: Altered Mental Status (AMS) is a common neurological complication in patients hospitalized with the diagnosis of COVID-19 (Umapathi et al., 2020; Liotta et al., 2020). Studies show that AMS is associated with death and prolonged hospital stay. In addition to respiratory insufficiency, COVID-19 causes multi-organ failure and multiple metabolic derangements, which can cause AMS, and the multi-system involvement could account for the prolonged hospital stay and increased mortality. In this study, we built on our previous publication (Chachkhiani et al., 2020) using a new, larger cohort to investigate whether we could reproduce our previous findings while addressing some of the prior study’s limitations. Most notably, we sought to determine whether AMS still predicted prolonged hospital stay and increased mortality after controlling for systemic complications such as sepsis, liver failure, kidney failure, and electrolyte abnormalities.

Objectives: The primary purpose was to document the frequency of AMS in patients with COVID-19 at the time of presentation to the emergency room. Secondary aims were to determine: 1) if AMS at presentation was associated with worse outcomes as measured by prolonged hospitalization and death; and 2) if AMS remained a predictor of worse outcome after adjusting for concomitant organ failure and metabolic derangements.

Results: Out of 367 patients, 95 (26%) had AMS as a main or one of the presenting symptoms. Our sample has a higher representation of African Americans (53%) than the US average and a high frequency of comorbidities, such as obesity (average BMI 29.1), hypertension (53%), and diabetes (30%). Similar to our previous report, AMS was the most frequent neurological chief complaint. At their admission, out of 95 patients with AMS, 83 (88%) had organ failure or one of the systemic problems that could have caused AMS. However, a similar proportion (86%) of patients without AMS had one or more of these same problems. Age, race, and ethnicity were the main demographic predictors. African Americans had shorter hospital stay [HR1.3(1.0,1.7), p = 0.02] than Caucasians. Hispanics also had shorter hospital stay than non-Hispanics [HR1.6(1.2,2.1), p = 0.001]. Hypoxia, liver failure, hypernatremia, and kidney failure were also predictors of prolonged hospital stay. In the multivariate model, hypoxia, liver failure, and acute kidney injury were the remaining predictors of longer hospital stay, as well as people with AMS at baseline [HR0.7(0.6,0.9), p < 0.02] after adjusting for the demographic characteristics and clinical predictors. AMS at baseline predicted death, but not after adjusting for demographics and clinical variables in the multivariate model. Hypoxia and hyperglycemia at baseline were the strongest predictors of death.

Conclusion: Altered mental status is an independent predictor of prolonged hospital stay, but not death. Further studies are needed to evaluate the causes of AMS in patients with COVID-19.

1. Introduction

Despite the availability of effective and safe vaccines [1,2], Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) remains a significant problem worldwide with the daily new positive tests of ~800,000 and daily deaths of ~14,000 at the time of writing this paper (https://www.nytimes.com). Disease caused by SARS-CoV-2 is called coronavirus disease 2019 [3] (COVID-19). There is a growing body of evidence that COVID-19 is associated with neurologic complications [4–6].
2. Background

Altered Mental Status (AMS) is a common neurological complication in patients hospitalized with the diagnosis of COVID-19 \cite{7,8}. Studies show that AMS is associated with death and prolonged hospital stay \cite{9,10}.

Our understanding of the pathology of COVID-19 in the brain that could be the cause of the AMS is still limited \cite{11}. A systematic review of the findings of 20 manuscripts with 184 neuropathology case reports found a broad range of findings, including microglial activation, lymphoid inflammation, acute hypoxic-ischemic changes, astrogliosis, acute/subacute infarcts, hemorrhages, and microthrombi \cite{12}. The virus was detected by polymerase chain reaction (PCR) test in up to 53% of cases, although the copy numbers were low, and the virus may have only been present inside the blood vessels. On immunohistochemistry, the virus was present in 28% of the cases but with a disconnect between viral presence and inflammation. Tuma et al. (2020) studied cerebrospinal fluid (CSF) and imaging data in COVID-19 patients with encephalopathy and showed that only 1 out of 21 patients who underwent the CSF analysis had a positive CSF PCR test, and only a few had changes on neuroimaging \cite{13}. An autopsy study from Columbia University showed minimal presence of the viral RNA and protein in the brain tissue \cite{14}.

In addition to respiratory insufficiency, COVID-19 causes multi-organ failure and multiple metabolic derangements \cite{15}. Multiple organ failure can cause AMS, and the multi-system involvement could account for the prolonged hospital stay and increased mortality.

In our current study, we built on our previous publication \cite{9} using a new, larger cohort to investigate whether we could reproduce our previous findings while addressing some of the prior study’s limitations. Most notably, we sought to determine whether AMS still predicted prolonged hospital stay and increased mortality after controlling for systemic complications such as sepsis, liver failure, kidney failure, and electrolyte abnormalities.

3. Methods

The Louisiana Health Sciences Center – New Orleans Institutional Review Board and the University Medical Center Clinical Research Review Committee approved the study protocol. The primary purpose was to document the frequency of AMS in patients with COVID-19 at the time of presentation to the emergency room. Secondary aims were to determine: 1) if AMS at presentation was associated with worse outcomes as measured by prolonged hospitalization and death; and 2) if AMS remained a predictor of worse outcome after adjusting for concomitant organ failure and metabolic derangements.

We reviewed the electronic medical records (EMR) of patients hospitalized from April 1, 2020, through July 31, 2020, at the University Medical Center New Orleans (UMCNO), who tested positive for SARS-CoV-2 during the same hospitalization. The EMR team generated a list of 368 patients admitted for COVID-19. Two neurology residents (DC, MI) reviewed the EMR in detail to capture the relevant medical history, presenting symptoms. Table 1 shows the demographic characteristics frequently in those with AMS (5% vs. 1%), while hypoxia was common frequently (2% vs. 18%). Hypercarbia was rare, but occurred more common in patients with AMS (44%) compared to patients with no AMS without AMS had one or more of these same problems. Sepsis was more common in patients with AMS (44%) compared to patients with no AMS (36%). Hypernatremia was more common in the AMS group than in the group without AMS (18% vs. 5%), while hyponatremia occurred less frequently (2% vs. 18%). Hypercarbia was rare, but occurred more frequently in those with AMS (5% vs. 1%), while hypoxia was common and occurred less frequently in those with AMS (33% AMS vs. 38%).

3.1. Definition of variables

Age was grouped by decade (e.g. 20–29, 30–39, etc.). Hypoxia was defined as blood oxygen level <92; hypertension was defined as systolic >130, diastolic >80; liver failure was defined as AST >45, ALT >46; hypoglycemia was defined as glucose <70; hyperglycemia was defined as glucose >200; hyponatremia was defined as <135; hypernatremia was defined as >146; and hypercarbia was defined PaCO2 above 45 mm Hg on Arterial Blood Gas readings. All laboratory measurements were captured at the time of admission so intensive care unit (ICU) stay would not affect elevation of the liver function tests (LFTs).

3.2. Statistical analysis

We used SAS and Microsoft Excel to generate summary tables. To analyze length of hospital stay or death, we fitted a competing risk proportional hazards model for time to discharge or death using the Proc Phreg \cite{16} of the SAS® software, Version 9.4 for Windows. (Copyright © 2016 SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA). The competing risks model allows the analysis of hospital stay, considering that censoring due to death is not random. For each model, we determined baseline demographic and clinical variables predictive of the outcomes and generated adjusted models.

4. Results

Out of 367 patients, 95 (26%) had AMS as a main or one of the presenting symptoms. Table 1 shows the demographic characteristics and comorbidities. Our sample has a higher representation of African Americans (53%) and a lower percentage of white (27%) than the US average and a high frequency of comorbidities, such as obesity (average BMI 29.1), hypertension (53%), and diabetes (30%).

Table 2 shows the most common neurological chief complaints. Similar to our previous report \cite{9}, AMS was the most frequent neurological chief complaint. At their admission, out of 95 patients with AMS, 83 (88%) had organ failure or one of the systemic problems that could have caused AMS. However, a similar proportion (86%) of patients without AMS had one or more of these same problems. Sepsis was more common in patients with AMS (44%) compared to patients with no AMS (36%). Hypernatremia was more common in the AMS group than in the group without AMS (18% vs. 5%), while hyponatremia occurred less frequently (2% vs. 18%). Hypercarbia was rare, but occurred more frequently in those with AMS (5% vs. 1%), while hypoxia was common and occurred less frequently in those with AMS (33% AMS vs. 38%).

4.1. Predictors of hospital stay

Table 3 shows the results for the competing risks model for length of hospital stay. In this part of the analysis, discharge is the event of interest, and thus higher hazard ratios indicate a shorter hospital stay. There were very few Asians and Hawaiians, so we combined these race categories under the “other” category with those who had no race reported. Too few patients had a glucose< 70, SIRS, hypercarbia, or a postical state to analyze these variables.

Age, race, and ethnicity were the main demographic predictors. African Americans had shorter hospital stay \cite{HR1.1.1.7,p = 0.02} than Caucasians. Hispanics also had shorter hospital stay than non-Hispanics \cite{HR1.6.1.2.2.1, p = 0.001}. Former and current smokers had similar times to discharge than nonsmokers, but the group with unknown smoking status had significantly longer hospital stays \cite{HR0.6.0.4.0.8, p < 0.001}. Hypoxia, liver failure, hypernatremia, and kidney failure were also predictors of prolonged hospital stay.

Table 4 shows the results of the final multivariate model built after sequential stepwise selection. In this multivariate model, people with AMS at baseline had a more extended hospital stay \cite{HR0.7.0.6.0.9,p <
AMS at baseline predicted death in the univariate test, but not death. If AMS indicates a direct relationship between the virus and the brain, it may complicate recovery but not be associated with the systemic issues found among deaths from the COVID-19 virus. This may also explain why AMS predicts length of hospital stay after accounting for the metabolic disarrangements and systemic confounders. Although there is significant overlap in what clinicians consider AMS and lethargy, only AMS predicted prolonged hospital stay after accounting for the metabolic disarrangements and organ system failure. A possible explanation is that the patients that are altered but not lethargic may have direct brain dysfunction due to the virus instead of indirect brain dysfunction due to the systemic complications of the virus. This may also explain why AMS predicts length of stay, but not death. If AMS indicates a direct relationship between the virus and the brain, it may complicate recovery but not be associated with the systemic issues found among deaths from the COVID-19 virus.

We noted that persons with “no documented smoking status” had a significantly longer hospital stay than those with known smoking status, including current or previous smokers and nonsmokers. While there could be a more complex reason for this finding, we hypothesize that patients who had no documented smoking status could have presented with more severe disease state, preventing the capture of smoking status. This retrospective analysis only included people who presented to the emergency room, had to be admitted, and tested positive for COVID-

### 5. Discussion

The aim of this follow up study was to replicate the analyses we used in a previous study using an expanded number of subjects. To address a serious limitation in our first sample analysis, we also controlled for potential confounders which were unavailable during our previous analysis. In this sample, we still had a high number of African Americans (53%) however, it was a significantly lower portion as compared to our first study (80%). Interestingly, AMS remained the most common neurological chief complaint at presentation. In our first study, we found that AMS was a predictor of prolonged hospital stay and death, however, after controlling for covariables in this second study, AMS no longer predicted death. AMS did remain predictive of prolonged hospital stay.

### 6. Limitations

This retrospective analysis only included people who presented to the emergency room, had to be admitted, and tested positive for COVID-
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Table 3
Univariate hazard ratios for prediction of length of stay.

| Parameter | Description | Pr > ChiSq | HR (95% CI) |
|-----------|-------------|------------|-------------|
| Age (10 years) | <0.0001 | 0.8 (0.8,0.9) |
| Sex | Female | 0.8 | 1.0 (0.8,1.3) |
| Race<sup>a</sup> | AA | 0.02 | 1.3 (1.0,1.7) |
| Smoking | Current | 0.5 | 0.9 (0.7,1.2) |
| Unknown | | | 1.0 (0.7,1.4) |
| CVA | Yes | 0.9 | 1.0 (0.7,1.4) |
| HTN | Yes | 0.4 | 0.9 (0.7,1.1) |
| BMI | Yes | 0.05 | 0.6 (0.3,1.0) |
| Asthma | Yes | 0.7 | 0.9 (0.6,1.3) |
| CC | Yes | 0.8 | 1.0 (1.0,1.0) |
| Ethnicity Hispanic | 0.001 | 1.6 (1.2,2.1) |
| Smoking | Current | 0.5 | 0.9 (0.7,1.2) |
| Form | 1.0 | 1.0 (0.7,1.4) |
| Known | 0.0001 | 0.6 (0.4,0.8) |
| CVA | Yes | 0.9 | 1.0 (0.7,1.4) |
| HTN | Yes | 0.4 | 0.9 (0.7,1.1) |
| BMI | Yes | 0.05 | 0.6 (0.3,1.0) |
| Asthma_COPD | Yes | 0.7 | 0.9 (0.6,1.3) |
| CC | Yes | 0.8 | 1.0 (1.0,1.0) |
| Ethnicity Hispanic | 0.001 | 1.6 (1.2,2.1) |
| Smoking | Current | 0.5 | 0.9 (0.7,1.2) |
| Unknown | | | 0.6 (0.4,0.8) |
| CVA | Yes | 0.9 | 1.0 (0.7,1.4) |
| HTN | Yes | 0.4 | 0.9 (0.7,1.1) |
| BMI | Yes | 0.05 | 0.6 (0.3,1.0) |
| Asthma_COPD | Yes | 0.7 | 0.9 (0.6,1.3) |
| CC | Yes | 0.8 | 1.0 (1.0,1.0) |
| Ethnicity Hispanic | 0.001 | 1.6 (1.2,2.1) |
| Smoking | Current | 0.5 | 0.9 (0.7,1.2) |
| Unknown | | | 0.6 (0.4,0.8) |

CVA: cerebrovascular accident; HTN: hypertension, DM: diabetes mellitus; COPD: chronic obstructive pulmonary disease; BMI: body mass index; CC: chief complaint; AMS: altered mental status; B: baseline; AKI: acute kidney injury.

<sup>a</sup> To calculate race HR AA and “Other” were compared to Caucasians.

<sup>b</sup> Other refers to individuals where race was not reported, Asians, and Hawaiians.

Table 4
Univariate hazard ratios for prediction of length of stay.

| Parameter | Description | Pr > ChiSq | HR (95% CI) |
|-----------|-------------|------------|-------------|
| Age 10y | <0.0001 | 0.9 (0.8,0.9) |
| Sex | Female | 0.4 | 0.9 (0.7,1.1) |
| Race<sup>a</sup> | AA | 0.01 | 1.5 (1.2,2.0) |
| Smoking | Current | 0.5 | 0.9 (0.6,1.2) |
| Unknown | | | 1.1 (0.8,1.5) |
| CC | Yes | 0.03 | 0.7 (0.5,1.0) |
| CC_ASI | 0.005 | 0.7 (0.6,1.0) |
| B_Hypoxia | <0.001 | 0.9 (0.7,1.1) |
| B_LiverFailure | <0.003 | 0.6 (0.5,0.7) |
| B_AKI | 0.01 | 0.8 (0.6,1.0) |
| CC | Yes | 0.03 | 0.7 (0.6,1.0) |
| CC_ASI | 0.005 | 0.7 (0.6,1.0) |
| B_Hypoxia | <0.001 | 0.9 (0.7,1.1) |
| B_LiverFailure | <0.003 | 0.6 (0.5,0.7) |
| B_AKI | 0.01 | 0.8 (0.6,1.0) |

CC: chief complaint; AKI: acute kidney injury.

<sup>a</sup> To calculate race HR AA and “Other” were compared to Caucasians.

<sup>b</sup> Other refers to individuals where race was not reported, Asians, and Hawaiians.

Table 5
Univariate hazard ratios for prediction of death.

| Parameter | Description | Pr > ChiSq | HR (95% CI) |
|-----------|-------------|------------|-------------|
| Age (10 years) | <0.0001 | 1.4 (1.2,1.6) |
| Sex | Female | 0.8 | 0.9 (0.6,1.6) |
| Race<sup>a</sup> | AA | 0.8 | 0.9 (0.5,1.6) |
| Smoking | Current | 0.4 | 1.4 (0.7,2.7) |
| Unknown | | | 1.0 (0.7,2.2) |
| CVA | Yes | 0.6 | 0.8 (0.3,2.1) |
| HTN | Yes | 0.6 | 1.2 (0.7,2.0) |
| DM | Yes | 0.3 | 1.3 (0.8,2.3) |
| Epilepsy | Yes | 0.2 | 2.1 (0.6,6.8) |
| Asthma_COPD | Yes | 0.2 | 1.5 (0.8,3.1) |
| CC | Yes | 1.0 | 1.0 (1.0,1.0) |
| Ethnicity Hispanic | 0.002 | 2.4 (1.4,4.0) |
| CC_Hypoxia | Yes | 0.3 | 0.5 (0.2,1.7) |
| CC_Sync | Yes | 0.7 | 0.3 (0.5,3.3) |
| CC_Lethargy | Yes | 0.001 | 2.1 (1.5,4.7) |
| Baseline Sepsis Criteria | Yes | 0.1 | 0.6 (0.9,2.7) |
| Baseline Hypoxia | Yes | <0.0001 | 2.9 (1.7,5.0) |
| Baseline HTN | Yes | 0.1 | 0.6 (0.3,1.2) |
| Baseline Liver Failure | Yes | 0.1 | 1.6 (0.9,2.7) |
| Baseline Hyperglycemia | Yes | 0.001 | 2.6 (1.5,4.5) |
| Baseline Hypoatremia | Yes | 0.3 | 1.4 (0.7,2.8) |
| Baseline Hypertension | Yes | <0.0001 | 4.0 (1.7,7.6) |
| Baseline AKI | | | 0.0007 | 2.5 (1.5,4.2) |

CC: cerebrovascular accident; HTN: hypertension, DM: diabetes mellitus; COPD: chronic obstructive pulmonary disease; BMI: body mass index; CC: chief complaint; AMS: altered mental status; B: baseline; AKI: acute kidney injury.

<sup>a</sup> To calculate race HR AA and “Other” were compared to Caucasians.

<sup>b</sup> Other refers to individuals Asians, Hawaiians and individual whose race was not reported.

To calculate race HR AA and “Other” were compared to Caucasians.

<sup>a</sup> Other refers to individuals where race was not reported, Asians, and Hawaiians.

mental status and the metabolic complications and use these as time-dependent covariates to more accurately predict the time to discharge or death, but compiling these data was beyond our manpower resources. We did not analyze other important outcomes, such as disability at discharge because, unfortunately it is not systematically recorded.

Altered Mental Status is a nonspecific term. Ideally, we should use more specific terms, e.g. delirium, or agitation. Given the nature of the study, we depended on the documentation available and this limitation was unavoidable. It is also debatable whether lethargy is AMS or not, which prompted us to report this complication in combination with AMS and separately.
7. Conclusion

Altered mental status is an independent predictor of prolonged hospital stay, but not death. Further studies are needed to evaluate the causes of AMS in patients with COVID-19.

CRedit authorship contribution statement

David Chachkhiani MD* Conceptualization, Methodology, Investigation, Writing - original draft visualization. Marine Isakadze MD Conceptualization, Methodology, Investigation. Nicole R. Villemarette-Pittman PhD Methodology, Writing - review & editing, Supervision, Visualisation. Deidre J. Devier PhD Methodology, Data curation, Writing - review & editing, Supervision. Jesus F. Lovera MD, MsPH* Methodology, Formal analysis, Data curation, Supervision.

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