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Reply:

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REPLY:

We thank the authors for their comments and for their interest in our paper. We completely agree that although the underlying pathomechanism of hemorrhagic manifestations in critically ill patients with coronavirus 2019 (COVID-19) remains uncertain, it is likely multifactorial. We have expanded on this series of patients in a larger cohort (currently under submission), and as the authors suggest, a few broad imaging themes have begun to allude to some of these potential underlying mechanisms. These imaging features include cerebral microhemorrhages, venular thrombosis, arterial infarcts, subarachnoid hemorrhage, petechial or juxtacortical microhemorrhages, leukoencephalopathy, and catastrophic large-volume hemorrhages (including intraventricular hemorrhages). These myriad imaging findings could all result from downstream pathophysiological outcomes resulting from hypoxemia, hypercoagulability, and endotheliitis, all of which seem to be more common in patients with COVID-19. As the authors have correctly stated, the addition of systemic anticoagulation may also be an additional factor leading to hemorrhage in some of these patients.

Although there is much uncertainty regarding the cause of these findings at present, with the literature being populated with relatively small-series single-center studies (such as our own), we eagerly await the results of several ongoing large-cohort

studies to help clarify imaging findings and neurologic outcomes in these patients. For example, the C-VASC COVID-19 study is a prospective, pragmatic, longitudinal multicenter Canadian cohort study looking at stroke outcomes in these patients. Data sharing from many of these trials is also being harmonized through collaborations with organizations such as the Neurocritical Care Society and other international partners, pointing to the strengths of the collaborations that arose as a result of the COVID-19 pandemic. It is becoming increasingly clear that far from being “just a respiratory disease,” COVID-19 is, in fact, a multisystem illness that can have serious consequences for a certain subset of patients. We therefore look forward to the results of these larger studies to help us to get a better picture regarding both short- and long-term neurologic outcomes in these patients.

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