Comparison of Perioperative Characteristics and Clinical Outcomes of COVID-19 and non-COVID-19 Patients Undergoing Neurosurgery—A Retrospective Analysis

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J Neuroanaesthesiol Crit Care 2022;9:99–105.

Abstract

Background Patients with coronavirus disease 2019 (COVID-19) presenting for neurosurgery are not rare. Considering the lack of literature informing the outcomes in this subset, present study was conducted to compare perioperative management and postoperative outcomes between COVID-19 and non-COVID-19 neurosurgical patients.

Methods After ethics committee approval, data of all patients with COVID-19 along with an equal number of age and diagnosis matched non-COVID-19 patients undergoing neurosurgery between April 2020 and January 2021 was analyzed retrospectively. Predictors of poor outcome were identified using multivariate logistic regression analysis.

Results During the study period, 50 COVID-19 patients (28 laboratory confirmed (group-C) and 22 clinicoradiological diagnosed [group-CR]) underwent neurosurgery and were compared with 50 matched non-COVID-19 patients. Preoperatively, clinicoradiological diagnosed COVID-19 patients had higher American Society of Anesthesiologists (ASA) grade ($p = 0.01$), lower Glasgow Coma Scale (GCS) score ($p < 0.001$), and more pulmonary involvement ($p = 0.004$). The duration of intensive care unit stay was significantly longer in laboratory confirmed patients ($p = 0.03$). Poor clinical outcome (in-hospital mortality or discharge motor-GCS ≤ 5) did not differ significantly between the groups ($p = 0.28$). On univariate analysis, younger age, higher ASA grade, lower preoperative GCS, and motor-GCS, higher intraoperative blood and fluid administration and traumatic brain injury diagnosis were associated with poor outcome. On multivariable logistic regression. only lower preoperative motor-GCS remained the predictor of poor outcome.

Conclusions The concomitant presence of COVID-19 infection did not translate into poor outcome in patients undergoing neurosurgery. Preoperative motor-GCS predicted neurological outcome in both COVID-19 and non-COVID-19 neurosurgical patients.

Keywords
► COVID-19
► neurosurgery
► outcomes
► perioperative care

published online
July 25, 2022

DOI https://doi.org/10.1055/s-0042-1749144.
ISSN 2348-0548.

Thieme Medical and Scientific Publishers Pvt. Ltd., A-12, 2nd Floor, Sector 2, Noida-201301 UP, India

Introduction

The coronavirus disease 2019 (COVID-19) is caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2).[1] Many COVID-19 patients require surgical interventions for existing neurological ailments or neurological sequels developed due to the SARS-CoV-2 infection. These patients pose challenges to the health-care professionals (HCPs), necessitating adequate preparation and modifications in perioperative care.[2] The anesthetic and perioperative management of COVID-19 neurosurgical patients involves significant transformations and reorganizations of the existing manpower and infrastructure, coordination with various facilities, and most importantly, use of personal protective equipment (PPE).[3,4] The difficulty level for anesthesiologists during airway management also increases many times while using PPE.[5] Apart from these challenges, the outcomes of these patients greatly depend on the perioperative factors and care provided. Many studies suggest an increase in postoperative morbidity and early mortality in patients undergoing surgery with COVID-19 infection.[6] A recent study recommends a 7-week delay for performing elective surgery after COVID-19.[7] On the contrary, there is literature documenting no significant difference in mortality, neurological outcome, hospital stay, and surgical or anesthesia times between the first wave of COVID-19 patients undergoing neurosurgery and matched pre-COVID-19 cohorts.[8] Consensus-based guidelines during the early part of the pandemic provided guidance on anesthetic[4,9] and intensive care unit (ICU) management[10] of COVID-19 patients undergoing neurosurgery. However, currently, there is a dearth of data to inform implications of perioperative care in neurosurgical patients with COVID-19 or the impact of COVID-19 on clinical outcomes after neurosurgery. We hypothesize that there is a difference in perioperative characteristics and clinical outcomes in neurosurgical patients due to the presence of COVID-19 infection. Our primary aim in this study was to compare the mortality and neurological status at hospital discharge in COVID-19 and non-COVID-19 patients undergoing neurosurgery during the same time period. Our secondary objectives were to compare intraoperative parameters and postoperative outcomes in these patients.

Materials and Methods

Study Design and Participants

This retrospective study was conducted after approval from the Institute Ethics Committee (NIMHANS/IEC [BS & NS DIV.]/28th meeting/2020–21 dated 08–02–2021). Patients with COVID-19 diagnosis undergoing neurosurgical procedures between April 2020 and January 2021 were included in this study. We also included an equal number of patients unaffected by COVID-19 who underwent neurosurgical interventions during the same time period. These patients were randomly selected but were matched for age and diagnosis. All neurosurgical interventions were either urgent or emergent in nature. As per our hospital policy, neurosurgical patients with clinicoradiological diagnosis or laboratory confirmation of COVID-19 infection and patients without COVID-19 were cared for (including surgery) in separate buildings to avoid cross-infection.

Matching and Grouping of the Patients

First, we divided the COVID-19 group into four major diagnostic categories: intracranial space-occupying lesion (ICSOL), cerebrovascular pathology, traumatic brain injury (TBI), and others. Then, we estimated the first quartile (Q1) and third quartile (Q3) to identify our age range (Q1–Q3) in each of the diagnoses. We recruited an equal number of neurosurgical patients not affected by COVID-19 belonging to the predefined age range and diagnoses and designated them as non-COVID-19 group (group-NC). The COVID-19 patients were further divided as follows: patients whose COVID-19 infection was confirmed by any of the laboratory methods were grouped as group-C, while patients with clinicoradiological findings suggesting COVID-19 were grouped into group-CR.

Data Collection

The data regarding demographics, clinical characteristics, intraoperative parameters, imaging findings, and outcome details were collected from the manual and electronic hospital records of neurosurgical patients in both the groups from their hospital admission till discharge. We collected intraoperative data regarding anesthesia drugs, airway management technique, rapid sequence intubation (RSI), fluid administration, blood transfusion, desaturation—defined as peripheral oxygen saturation (SpO_2) < 95%, high airway pressure—defined as peak airway pressure (Paw) > 30 cmH_2O, and hypotension—defined as systolic blood pressure < 90 mm Hg.

Outcomes

The duration of mechanical ventilation (MV), ICU stay, hospital stay, and Glasgow Coma Scale (GCS) score and motor component of GCS (M-GCS) score at hospital discharge and in-hospital mortality were studied. We dichotomized the outcome as poor (in-hospital mortality or M-GCS $\leq$ 5 at hospital discharge) and good (M-GCS > 5 at hospital discharge).

Statistical Analyses

Data was collected on Microsoft Excel version 2007 spreadsheet and analyzed using R version 3.5.3. Interval scale and ordinal data were described using median and interquartile range. Nominal variables were described as frequency and percentages. The differences between the groups C, CR, and NC were estimated using chi-squared or Fisher's exact test and Kruskal–Wallis test, as appropriate. We also analyzed the intergroup differences between groups C & CR, C & NC, and CR & NC. The association of the variables with neurological outcome was analyzed for the whole cohort of COVID-19 and non-COVID-19 patients using chi-squared or Fisher's exact test and Mann–Whitney U test as appropriate. Finally, we performed multivariate logistic regression model to identify the predictors of poor outcome. We have tested age against other covariates that were associated with outcome, and we found that a diagnosis of TBI and intraoperative fluid administration were significant. Hence, the interaction term for these two variables was done in the final model of multivariate analysis. A $p < 0.05$ was considered statistically significant. Results of the regression model are presented as odds ratios with their 95% confidence intervals.

Results

Demographics and Clinical Characteristics

During the study period, 50 COVID-19 patients (28 laboratory confirmed and 22 clinicoradiologically diagnosed) underwent neurosurgical interventions for various diagnoses. Age and diagnosis matched 50 non-COVID-19 patients who underwent neurosurgery during the same period were also included for comparison (►**Fig. 1**). The demographics and clinical characteristics of all the three groups are described in ►**Table 1**. The group-CR had higher American Society of Anesthesiologists (ASA) physical status grade ($p = 0.01$). Preoperative GCS was the lowest in group-CR and the highest in group-NC. More patients in group-CR had abnormal lung findings on chest imaging than other groups ($p = 0.004$). However, between-group analysis revealed group C and CR were comparable with regard to preoperative GCS ($p = 0.29$), ASA grade ($p = 0.77$), and respiratory involvement ($p = 0.27$).

Perioperative Management

All patients received standard perioperative care as per the guidelines of the Indian Society of Neuroanaesthesiology and Critical Care[4] and the Society for Neuroscience in Anesthesiology and Critical Care.[9] All HCPs involved in the conduct of neurosurgery for COVID-19 patients in the operating room (OR) including neurosurgeons, neuroanesthesiologists, technicians, nurses, and OR assistants used PPE throughout the intraoperative period. In all the patients included in the study, either intravenous thiopentone or propofol was used for induction of anesthesia. Fentanyl was used for intraoperative analgesia. Anesthesia was maintained with sevoflurane, air and oxygen mixture in the majority of the patients. Few patients with intraoperative brain bulge received propofol infusion in place of inhalational anesthesia. There was no difference between COVID-19 and non-COVID-19 patients with regard to the choice of drugs for induction and maintenance of anesthesia. There were significant differences in the airway management practices between COVID-19 and non-COVID-19 patients. The differences included the use of RSI to prevent prolonged mask ventilation, videolaryngoscope (to quickly and safely perform the intubation and minimize aerosol dispersion on the face of the anesthesiologist performing the intubation), and different methods to reduce aerosol dispersion during intubation (intubation box or plastic sheet covering the head and the upper part of the chest) in COVID-19 patients. The RSI was performed within 90 seconds of administering rocuronium 1 mg/kg or succinylcholine 1 mg/kg. Either C-MAC (Karl Storz, Tuttlingen, Germany) or McGrath videolaryngoscope (Aircraft Medical Ltd., Edinburgh, United Kingdom) was used for intubation in COVID-19 patients.

All the patients were mechanically ventilated with tidal volume and respiratory rate adjusted to maintain $SpO_2 > 95\%$ and end-tidal carbon dioxide between 30 and 36 mm Hg during surgery. One in five patients in the COVID-19 group (both group-C and group-CR) had intraoperative Paw > 30 cmH_2O, while no patient in group-NC had elevated Paw. Group-CR patients had higher Paw as compared with other groups and intergroup analysis revealed a statistically significant difference between group-CR and group-NC. There

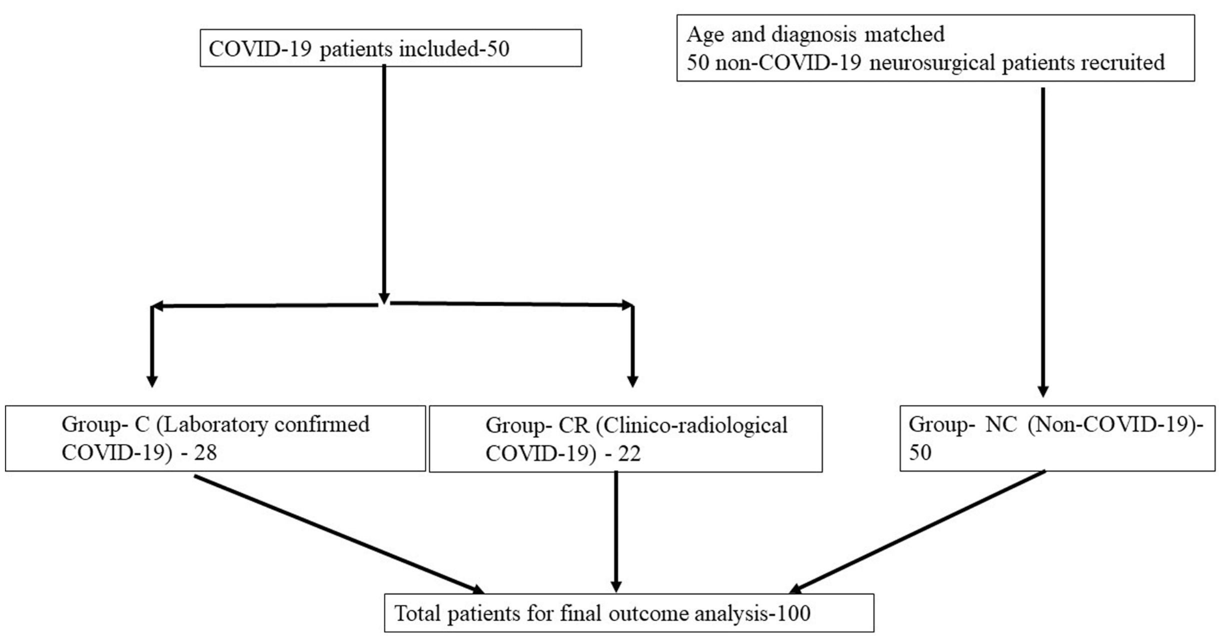

Fig. 1 Schematic diagram depicting flow of patients into the study. COVID-19, coronavirus disease 2019.

Table 1 Clinical and intraoperative variables of neurosurgical patients; values expressed as median (interquartile range) or number (percentage)

Variables		Group-NC	Group-C	Group-CR	*p*-Value
Age (years)		47 (40–53)	46.5 (38.5–58)	48 (35–62)	0.72
Male gender		34 (68)	18 (64)	17 (77)	0.60
ASA grade		2 (2–2)	3 (1.5–3)	3 (2–4)	0.01
Diagnosis	ICSOL	12 (24)	8 (28.6)	4 (18.2)	0.97
	Cerebrovascular	16 (32)	8 (28.6)	8 (36.4)	
	TBI	6 (12)	4 (14.2)	2 (9)	
	Others	16 (32)	8 (28.6)	8 (36.4)	
Presence of comorbidities		10 (20)	8 (28.6)	7 (33)	0.47
Preoperative GCS score		15 (14–15)	14 (10.5–15)	11 (10–15)	< 0.001
Preoperative M-GCS score		6 (6–6)	6 (5–6)	5 (5–6)	0.001
Abnormal pulmonary findings on chest imaging		16 (32)	15 (53.5)	16 (73)	0.004
Intraoperative parameters	$SpO_2 < 95\%$	2 (5.5)	2 (8)	3 (17)	0.40
	Paw > 30 cmH_2O	0 (0)	4 (17)	7 (39)	< 0.001
	Fluids administered (mL)	1832 (1050–2600)	1500 (1000–2800)	1800 (1000–2500)	0.85
	Blood transfusion	4 (11)	7 (28)	8 (40)	0.04
	SB*p* < 90 mm Hg	12 (31)	2 (8)	3 (16)	0.06
	Duration of anesthesia (min)	240 (145–345)	165 (140–230)	240 (150–315)	0.21
	Duration of surgery (min)	190 (112.5–265)	130 (90–200)	135 (100–220)	0.32

Abbreviations: ASA, American Society of Anesthesiologists; COVID-19, coronavirus disease 2019; GCS, Glasgow coma scale; Group-C, laboratory confirmed COVID-19 group; Group-CR, clinicoradiological diagnosed COVID-19 group; Group-NC, non-COVID-19 group; ICSOL, intracranial space occupying lesion; M-GCS, motor component of GCS; Paw, peak airway pressure; SB*p*, systolic blood pressure; SpO_2-, peripheral oxygen saturation; TBI, traumatic brain injury.

was a statistical difference with regard to intraoperative blood transfusion between the groups ($p = 0.04$) that was contributed by difference between group-CR and group-NC ($p = 0.02$). No difference was noted for the incidence of intraoperative desaturation ($SpO_2 < 95\%$), intraoperative fluid administration, and hypotension. There was no difference in the duration of anesthesia or surgery between the groups.

Clinical Outcomes

The duration of MV was longest in group-C as compared with other groups; however, this difference was not statistically significant, whereas there was a significant difference in the duration of ICU stay within the groups ($p = 0.03$). The durations of MV and ICU stay were the least for group-NC. Between groups analysis revealed significant difference in duration of ICU stay in groups C and NC. However, the duration of postoperative hospital stay, GCS score at discharge, and in-hospital mortality were similar between the groups. In our cohort, 32% of patients with clinicoradiological COVID-19, 18% with laboratory-confirmed COVID-19 and 16% of patients without COVID-19 had poor clinical outcome (in-hospital mortality or M-GCS $\leq$ 5 at discharge) and this difference was not statistically significant ($p = 0.28$) (►**Table 2**). This was despite a lower preoperative GCS score and significant lung involvement in patients with COVID-19. Hence, we analyzed the potential predictors of good and poor outcomes for the entire cohort (COVID-19 and non-COVID-19 together). We found that patients with poor outcome had a longer duration of MV, ICU stay, and hospital stay (►**Table 3**). On univariate analysis, we observed that younger age, higher ASA grade, lower preoperative GCS score and M-GCS score, larger quantities of intraoperative blood and fluid administration, and TBI pathology contributed to poor outcome (►**Table 3**). When these significant variables were entered into multivariable logistic regression model, only lower preoperative M-GCS remained as the predictor of poor outcome (►**Table 4**).

Discussion

Summary of Findings

There were important differences in some of the perioperative characteristics (ASA grade, preoperative GCS and M-GCS scores, pulmonary involvement, intraoperative blood transfusion, and Paw) and clinical outcomes (duration of MV and ICU stay) between patients with and without COVID-19 undergoing neurosurgery. Despite these differences, the overall composite outcome (in-hospital mortality and M-

Table 2 Postoperative outcomes of neurosurgical patients; values expressed as mean ± standard deviation, median (interquartile range) or number (percentage)

Outcome	Group-NC	Group-C	Group-CR	*p*-Value
Duration of MV (days)	0.65 ± 2.34	3.5 ± 8.09	3.2 ± 12.49	0.07
ICU stay (days)	1.13 ± 3.50	4.9 ± 10.3	4.8 ± 17.54	0.03
Hospital stay (days)	8.5 (4–14.5)	8 (5–13)	5.5 (4–11)	0.45
GCS score at discharge	15 (15–15)	15 (12–15)	15 (10.5–15)	0.59
In-hospital mortality	3 (6)	1 (3.6)	2 (9)	0.71
Poor outcome	8 (16)	5 (18)	7 (32)	0.28

Abbreviations: COVID-19, coronavirus disease 19; GCS, Glasgow coma scale; Group-C, laboratory confirmed COVID-19 group; Group-CR, clinicoradiological diagnosed COVID-19 group; Group-NC, non-COVID-19 group; ICU, intensive care unit; MV, mechanical ventilation.

GCS at discharge) was similar in both the groups. When we compared good and poor outcomes, younger age, higher ASA grade, and lower preoperative M-GCS were associated with poor outcome.

Comparison with Previous Literature

From our findings, it appears that COVID-19 per se did not result in adverse perioperative outcomes as both COVID-19 diagnosis and significant pulmonary involvement were not

Table 3 Descriptive variables of outcome of the whole cohort; values expressed as mean ± standard deviation, median (interquartile range or number (percentage)

Variables		Good outcome ($n = 80$)	Poor outcome ($n = 20$)	*p*-Value
Age (years)		49 (40–57)	40 (29.7–48.5)	0.01
Male gender		54 (67.5)	15 (75)	0.51
ASA grade		2 (1–2)	3.5 (2–4)	< 0.001
Diagnosis	ICSOL	21 (26.25)	3 (15)	0.003
	Cerebrovascular	25 (31.25)	7 (35)	
	TBI	5 (6.25)	7 (35)	
	Others	29 (36.25)	3 (15)	
COVID-19 infection	Laboratory confirmed	23 (29)	5 (25)	0.28
	Clinicoradiologically diagnosed		15 (18)	7 (35)
Presence of comorbidities		22 (28)	3 (15)	0.23
Preoperative GCS score		15 (14–15)	10.5 (8–12.5)	< 0.001
Preoperative M-GCS score		6 (6–6)	5 (5–6)	< 0.001
Abnormal pulmonary findings on chest imaging		36 (45)	11 (55)	0.42
Intra-operative parameters	$SpO_2 < 95\%$	5 (8)	2 (14)	0.44
	Paw > 30 cmH_2O	9 (14)	2 (14)	1.00
	Blood transfusion	12 (18)	7 (43)	0.03
	SB*p* < 90 mm Hg	11 (16)	6 (37.5)	0.06
	Fluids administered (mL)	1500 (1000–2300)	2791 (2000–3500)	0.007
	Duration of anesthesia (min)	230 (140–300)	240 (180–315)	0.68
	Duration of surgery (min)	170 (95–240)	170 (127.5–255)	0.63
Duration of MV (days)		0.6 ± 2.8	9.06 ± 16.04	< 0.001
ICU stay (days)		1.03 ± 3.71	12.17 ± 20.71	< 0.001
Hospital stay (days)		8 (4–11)	14 (9–61)	0.007

Abbreviations: ASA, American Society of Anesthesiologists; COVID-19, coronavirus disease 2019; GCS, Glasgow coma scale; ICSOL, intracranial space occupying lesion; ICU, intensive care unit; M-GCS, motor component of GCS; MV, mechanical ventilation; Paw, peak airway pressure; SB*p*, systolic blood pressure; SpO_2, peripheral oxygen saturation; TBI, traumatic brain injury.

Table 4 Multivariate logistics regression for predictors of poor outcome

Variables	OR	CI_Lo	CI_Hi	*p*-Value
Age (years)	0.92	0.75	1.09	0.343
ASA grade	3.74	1.14	22.47	0.062
Preoperative M-GCS	0.02	0.000	0.20	0.005
Diagnosis others	0.83	0.03	13.66	0.899
Diagnosis lesion	0.91	0.07	10.65	0.938
Diagnosis TBI	0.00	0.00	1.21	0.099
Intraoperative fluids administered	1.00	1.00	1.01	0.204
Intraoperative blood transfusion	0.04	0.00	0.84	0.077
Diagnosis TBI:age	1.48	0.99	2.62	0.091
Age:intraoperative fluids administered	1.00	1.00	1.00	0.356

Abbreviations: ASA, American Society of Anesthesiologists; CI_Hi, confidence interval high; CI_lo, confidence interval low; M-GCS, motor component of Glasgow coma scale; OR, odds ratio; TBI, traumatic brain injury.

predictors of poor outcome. Despite patients with COVID-19 having higher ASA grade, lower baseline GCS score, and significant lung involvement than non-COVID-19 patients, there was no difference in the outcomes such as hospital stay, M-GCS at discharge, or in-hospital mortality. There could be many reasons for this finding—incidental COVID-19 positivity during preoperative testing, presence of only mild-moderate infection, and administration of steroids for neurological indications in patients with ICSOL. Despite a longer duration of MV, good ICU management might have also resulted in a comparable outcome in COVID-19 and non-COVID-19 patients. In a retrospective analysis of neurosurgical patients, a poor Glasgow outcome score (GOS) was observed in non-ICU patients compared with those admitted to ICU. However, after propensity score matching, no difference in GOS was seen between the groups.[11] In another retrospective study, longer duration of MV and ICU stay was observed among survivors as compared with nonsurvivors of severe COVID-19 illness.[12] The duration of MV and ICU stay was more in COVID-19 patients in our study, probably due to the lower GCS score and pulmonary involvement at hospital admission.

When the outcome of the combined cohort was analyzed, younger age, higher ASA grade, lower GCS/M-GCS, more intraoperative blood, and fluid administration and TBI pathology were associated with poor outcome on univariable analysis. On multivariable analysis, only preoperative M-GCS remained significant predictor of poor outcome at discharge.

We observed that the higher ASA grade is associated with 3.74-fold increased odds of poor outcome. Similarly, previous published studies in patients undergoing craniotomy have concluded that higher ASA grade is associated with more morbidity, systemic and infectious complications.[13] Likewise, high ASA grade in COVID-19 patients was associated with the poor outcome.[14]

The important finding from our study is that poor M-GCS is associated with poor outcome. The M-GCS predicted outcomes in neurological patients, with a cutoff ≤ 3 being associated with mortality.[15] Similarly, in patients with poor grade aneurysmal subarachnoid hemorrhage (aSAH), even one point increase in motor examination during hospitalization was associated with 1.8-fold favorable long-term outcome.[16] In our study, we found out that one point increase in motor score in GCS was associated with a 98% reduction in poor outcome. In another study, no differences were noted in 30-day mortality, discharge GOS and pulmonary complications between neurosurgical patients operated during the COVID-19 pandemic and a matched non-COVID-19 patients from prepandemic time.[8] These findings are similar to our results though the population was different as only 2.2% of the pandemic patients in that study had a SARS-CoV-2 positive swab, while in our study 56% of the patients were SARS-CoV-2 positive. The rest were diagnosed to have COVID-19 on clinical and radiological assessment.

Most of the neurosurgeries in our cohort were performed on an emergent or urgent basis. Previous literature suggests delaying elective surgery wherever possible due to higher early mortality and complications noted in COVID-19 patients as compared with non-COVID-19 patients.[6] These findings may not be directly applicable for patients with significant neurosurgical pathologies. We have earlier noted prolonged laboratory confirmed COVID-19 positivity in a patient with aSAH and postponement of surgery for COVID-19 negative report resulted in poor outcome.[17] Our findings from the current study involving exclusive neurosurgical patients suggest that in-hospital mortality and neurological outcome at hospital discharge are not affected by the concomitant presence of COVID-19 infection but predominantly by admission M-GCS similar to that seen in non-COVID-19 neurosurgical population. Neurosurgical intervention therefore need not be delayed in these categories (diagnoses) of neurosurgical patients especially where the risk of potential neurological deterioration and consequent unfavorable outcomes are higher than unforeseen risk from mild to moderate COVID-19 infection. In a study published in May 2021, the authors did not observe unfavorable outcomes (major complications and mortality) in 29 COVID-19 positive patients undergoing general surgeries. This finding is similar to our observations. However, unlike our cohort, the surgical patients in that study were asymptomatic for COVID-19.[18] Another study involving 51 pediatric COVID-19 patients noted higher rates of perianesthetic respiratory complications as compared with matched COVID-19 negative patients. The incidence of complications was similar to earlier reports in children with upper respiratory tract infection. Moreover, severe morbidity and mortality were absent in both the groups.[19] Our findings are in concurrence with earlier studies in non-neurosurgical population that reported negligible impact of COVID-19 on clinical outcomes.

Strengths and Limitations

To the best of our knowledge, this is the first study to assess perioperative characteristics and clinical outcomes in

COVID-19 and matched non-COVID-19 patients undergoing neurosurgical procedures during the same time period. In the absence of any previous data in neurosurgical population comparing outcomes of COVID-19 with non-COVID-19 patients, our findings provide some guidance for making clinical decisions regarding neurosurgical interventions. However, this study has certain important limitations. First, this is a retrospective analysis of a small cohort of COVID-19 neurosurgical patients compared with matched non-COVID-19 patients. A prospective comparison involving large number of neurosurgical patients is desirable to better verify our observations but is unlikely considering the pandemic situation. Second, none of our COVID-19 neurosurgical patients required oxygen or ventilator therapy in the preoperative period as they maintained $SpO_2 > 95\%$. Hence, our findings may not be applicable to neurosurgical patients dependent on oxygen or ventilator therapy. Third, despite patients being randomly selected and matched for age and diagnosis, there could be possibility of selection bias. The diagnosis was overall matched (e.g., TBI with TBI, tumor with tumor) and was probably not a perfect fit that resulted in difference in baseline characteristics between group-C, group-CR, and group-NC. Matching of all the baseline factors would have minimized the selection bias.

Conclusions

Significant differences in perioperative characteristics and duration of ICU stay are seen between COVID-19 and non-COVID-19 patients undergoing neurosurgery. The concomitant presence of COVID-19 infection and COVID-19-related lung findings, however, does not translate into poor outcome in patients undergoing neurosurgical procedures. Lower preoperative M-GCS is the predictor of poor outcome (in-hospital mortality and neurological status at hospital discharge) in both COVID-19 positive and negative patients.

Conflict of Interest
None declared.

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