Impact of Coronavirus Disease 2019 in a French Cohort of Myasthenia Gravis

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Abstract

Objective

To describe the clinical characteristics and outcomes of coronavirus disease 2019 (COVID-19) among patients with myasthenia gravis (MG) and identify factors associated with COVID-19 severity in patients with MG.

Methods

The CO-MY-COVID registry was a multicenter, retrospective, observational cohort study conducted in neuromuscular referral centers and general hospitals of the FILNEMUS (Filière Neuromusculaire) network (between March 1, 2020, and June 8, 2020), including patients with MG with a confirmed or highly suspected diagnosis of COVID-19. COVID-19 was diagnosed based on a PCR test from a nasopharyngeal swab or severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) serology, thoracic CT scan, or typical symptoms. The main outcome was COVID-19 severity based on location of treatment/management (home, hospitalized in a medical unit, or in an intensive care unit). We collected information on demographic variables, general history, and risk factors for severe COVID-19. Multivariate ordinal regression models were used to identify factors associated with severe COVID-19 outcomes.

Results

Among 3,558 patients with MG registered in the French database for rare disorders, 34 (0.96%) had COVID-19. The mean age at COVID-19 onset was 55.0 ± 19.9 years (mean MG duration: 8.5 ± 8.5 years). By the end of the study period, 28 patients recovered from COVID-19, 1 remained affected, and 5 died. Only high Myasthenia Gravis Foundation of America (MGFA) class ($\geq$ IV) before COVID-19 was associated with severe COVID-19 ($p = 0.004$); factors that were not associated included sex, MG duration, and medium MGFA classes ($\leq$ IIIb). The type of MG treatment had no independent effect on COVID-19 severity.

Conclusions

This registry-based cohort study shows that COVID-19 had a limited effect on most patients, and immunosuppressive medications and corticosteroids used for MG management are not risk

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Glossary

Anti-AChR = anti-acetylcholine receptor antibodies; **anti-MuSK** = anti-muscle-specific kinase antibodies; **ARDS** = acute respiratory distress syndrome; **COVID-19** = coronavirus disease 2019; **FILNEMUS** = Filière Neuromusculaire; **IBD** = inflammatory bowel disease; **ICU** = intensive care unit; **IVIg** = IV immunoglobulin; **MG** = myasthenia gravis; **MGFA** = Myasthenia Gravis Foundation of America; **MU** = medical unit; **NMD** = neuromuscular disorder; **SARS-CoV-2** = severe acute respiratory syndrome coronavirus 2.

factors for poorer outcomes. However, the risk of severe COVID-19 is elevated in patients with high MGFA classes (odds ratio, 102.6 [4.4–2,371.9]). These results are important for establishing evidence-based guidelines for the management of patients with MG during the COVID-19 pandemic.

Coronavirus disease 2019 (COVID-19) is caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and was first reported in China at the end of 2019.¹ COVID-19 is a worldwide pandemic that continues to spread, with 38,998,580 known cases and 1,099,409 deaths as of October 16, 2020 (coronavirus.jhu.edu/map.html).² COVID-19 is a predominantly respiratory tract disease that can cause acute respiratory distress syndrome (ARDS) in some patients, and severe disease appears to be linked to risk factors such as advanced age and obesity.^{3,4}

Among neuromuscular disorders (NMDs), myasthenia gravis (MG) would be particularly at risk of being negatively affected by COVID-19 not only due to the use of immunosuppressive therapies for MG management but also because it can lead to a MG crisis. Some general recommendations have been established for the management of NMD during the COVID-19 pandemic,^{5,6} and specific recommendations for MG are available.⁷ Nonetheless, evidence for the continuation of corticosteroids and immunosuppressive medications is lacking,⁷ as only a few case reports of patients managed in hospitals are available^{8–11} and available data from the international CARE-MG registry are limited.¹²

This study from the French neuromuscular rare disease network (FILNEMUS [Filière Neuromusculaire]) investigated the clinical course and prognosis of patients with MG with COVID-19 to help improve MG management while the COVID-19 pandemic remains active.

Methods

Data Collection

The CO-MY-COVID registry is an observational, retrospective, national, multicenter study in 12 French sites. Registry listing was accomplished by a call for participation addressed to all sites of the French network of neuromuscular rare diseases (FILNEMUS). During the first phase of the COVID-19 epidemic, FILNEMUS network centers created patient contact cells for identifying patients with MG possibly infected by SARS-CoV-2. Patient associations (AFM-Téléthon [Association Française

contre les Myopathies–Téléthon] and AMIS [Association des Myasthéniques Isolés et Solidaires]) informed their members of the existence of the registry so that patients could report to their usual monitoring center.

Patients' neurologists and medical unit (MU) and intensive care unit (ICU) physicians recorded information on (1) medical history and risk factors (see below) for severe forms of COVID-19; (2) type and history of management of MG up to the onset of COVID-19 infection; (3) diagnosis and management of COVID-19; and (4) evolution and management of MG during and after COVID-19. Risk factors for severe forms of COVID-19 were age >65 years, obesity (body mass index >30), chronic obstructive pulmonary disease, obstructive sleep apnea syndrome, noninvasive ventilation, arterial hypertension, and diabetes.

Standard Protocol Approvals, Registrations, and Patient Consents

Patients were recruited and informed by physicians of the FILNEMUS network and provided consent (nonopposition) for the use of medical data, which was based on French law, good clinical practice, and the General Data Protection Regulation. Pseudonymized data were located on a secure server authorized to store health data. The CO-MY-COVID registry was approved by the Île-de-France-1 Personal Protection Committee on May 20, 2020 (national number: 2020-A01218-31). Recruitment is still open, but for these analyses, data from patients registered until June 8, 2020, were used. This study followed Strengthening Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Population of Interest

The diagnosis of MG was established based on the presence of suggestive symptoms and at least one of the following criteria: (1) presence of anti-acetylcholine receptor (anti-AChR) or anti-muscle-specific kinase (anti-MuSK) antibodies, (2) more than 10% decrement at repetitive nerve stimulation, (3) consistent improvement with anticholinesterase medications. Patients with congenital myasthenia or Lambert-Eaton syndrome were not included in this study. A COVID-19 diagnosis was considered definite if confirmed by a positive

PCR test for SARS-CoV-2 on a nasopharyngeal swab or SARS-CoV-2 serology; it was considered probable if the patient presented with symptoms of a viral syndrome and at least one of the following criteria: (1) contact with a patient considered to have a definite diagnosis of COVID-19, (2) specific signs (anosmia, ageusia, or skin signs),¹³ (3) suggestive abnormalities on thoracic CT scan.¹⁴ Patients with possible COVID-19 infection, defined as symptoms of a viral syndrome after March 17, 2020 (date of the French lockdown), were not included.

Definition of Study End Points

The main end point was the severity of COVID-19 infection, which was defined based on management modality, namely, home-managed COVID-19 if not hospitalized, intermediate COVID-19 if hospitalized in a MU, and severe COVID-19 if the patient required ICU care. Deceased patients were categorized as severe COVID-19 irrespective of where they were managed.

Statistical Analysis

Baseline characteristics of the participants are described based on the severity of COVID-19 (represented by the nadir of care). For analyses, patients were grouped into 4 categories based on MG medications as on neither corticosteroids nor immunosuppressants, corticosteroids alone, immunosuppressants alone, or both corticosteroids and immunosuppressants. The severity of MG was assessed using the Myasthenia Gravis Foundation of America (MGFA) classification,¹⁵ and this scoring system was categorized into 3 groups for ease of statistical analysis as low-MGFA group (MGFA class I), medium-MGFA (classes II, IIa, IIb, III, IIIa, or IIIb), and high-MGFA (classes IV, IVa, IVb, or V). MG exacerbation was defined as increased MGFA class during COVID-19 and MG crisis as moving to MGFA class V or rapid worsening and severe muscular weakness.¹⁶ The final impact of COVID-19 on MG was assessed by categorizing changes at the last evaluation in MGFA class as stable MG/improvement (when MGFA class decreased or remained stable), or MG worsening/death (when MGFA class increased or death occurred). Patients were grouped into 2 categories based on COVID-19 onset date as on early COVID-19 onset for patients with first signs before March 24 (date of the French national lockdown and 6 incubation days) and late COVID-19 onset (after March 24). To evaluate variables that could affect the severity of COVID-19, we performed univariate ordinal regression analyses with severity of COVID-19 (home-managed, intermediate COVID-19, or severe COVID-19) as the dependent variable and the following factors as independent variables: risk factors for COVID-19 (including age if >65 years), sex, disease duration of MG, MG medication groups (4 groups and no medication as reference), and the 3 MGFA categories (with class I as reference). Independent variables associated with severity of COVID-19 and having a *p* value < 0.2 in the univariate model were used in the multivariate ordinal model, wherein a *p* value of <0.05 was considered statistically significant and the fit of the models was verified.

Data Availability

The authors confirm that the deidentified data supporting the findings of this study are available from the corresponding authors on reasonable request.

Results

Study Population

As of June 8, 2020, 3,558 patients (56% female) with definite or probable diagnosis of MG were recorded in the French National Database for Rare Disorders (BNDMR). The mean age of patients recorded in the BNDMR was 61.5 ± 20.4 years (66.4 ± 18.4 for men). Forty patients were listed in the COMY-COVID registry. We excluded 6 patients due to criteria such as congenital myasthenia (*n* = 2) and possible COVID-19 (*n* = 4) (figure 1), and therefore included 34 patients (0.96%) in this study: of these, 20 had definite and 14 had probable COVID-19.

MG Baseline Characteristics

The 34 patients comprised 19 female (55.9%) and 15 male (44.1%) patients; the mean age at MG onset was 46.4 ± 20.9 years (range 14–86) (table 1). The mean duration of MG was 8.47 ± 8.5 years (range 0–33), with the disease lasting >2 years in 25 patients (73.5%). A classical distribution of age at MG onset was observed for women but not for men, without a preponderance for men older than 50 years (figure 2). The mean age at COVID-19 onset was 55.0 ± 19.9 years, 57.7 ± 23.6 for men, 46.0 ± 10 for early COVID-19 onset, and 63.1 ± 23.1 for late COVID-19 onset (*p* = 0.02). Eleven patients (32.4%) were older than 65 years, but

Figure 1 Study Flowchart

COVID-19 = coronavirus disease 2019; MG = myasthenia gravis.

Table 1 Demographic and Disease Characteristics of Patients With Myasthenia Gravis (MG) Diagnosed With Coronavirus Disease 2019 (COVID-19) in the CO-MY-COVID Registry, as of June 8, 2020 (n = 34)

Demographic and disease characteristics of MG (n = 34)	N (%) or mean $\pm$ SD	Disease characteristics and outcomes of COVID-19 (n = 34)	N (%)
Demographics		Inclusion criteria	
Number of patients with MG and COVID-19	34	Definite COVID-19	20 (58.8)
Male/female	19/15	Probable COVID-19	14 (41.2)
Age at COVID-19, y	55 $\pm$ 19.9	Risk factors of severe COVID-19	
MG history		Male	15 (44.1)
Antibody type		Age >65 y	11 (32.4)
Anti-AChR	25 (73.5)	BMI >30	8 (23.5)
Anti-MuSK	1 (2.9)	COPD	1 (2.9)
Neither anti-AChR nor anti-MuSK	8 (23.5)	OSAS	4 (11.8)
Age at MG diagnosis, y	46.4 $\pm$ 20.9	Ventilation	1 (2.9)
Maximum MGFA class		HBP	7 (20.6)
Low MGFA ^a	2 (5.9)	DM	5 (14.7)
Medium MGFA ^b	12 (35.3)	Other	5 (14.7)
High MGFA ^c	20 (58.8)	COVID-19 onset	
MG duration, y	8.5 $\pm$ 8.5	Early onset (before March 24, 2020)	16 (47.1)
Thymectomy	6 (17.6)	Late onset (after March 24, 2020)	18 (52.9)
MG assessment at the beginning of COVID-19		Age at COVID-19, y	
MGFA class		Early onset (before March 24, 2020)	46.0 $\pm$ 10
Low MGFA ^a	9 (26.5)	Late onset (after March 24, 2020)	63.1 $\pm$ 23.1
Medium MGFA ^b	19 (55.9)	COVID-19 total duration, d	
High MGFA ^c	6 (17.6)	COVID-19 severity	
MG-ADL score ^d	5.18 $\pm$ 3.77	Home-managed	15 (44.1)
Treatment		Intermediate	10 (29.4)
Anticholinesterase	33 (97.1)	Severe	9 (26.5)
Neither corticosteroids or immunosuppressants	8 (23.5)	Affected organs	
Corticosteroids (without immunosuppressants)	4 (11.8)	Upper airways	24 (70.6)
Immunosuppressants (without corticosteroids)	11 (32.4)	Lower airways	29 (85.3)
AZA	6 (17.7)	Smell/taste loss	10 (29.4)
MFM	3 (8.8)	CNS involvement	4 (11/7)
Rituximab	2 (5.9)	PNS involvement	0 (0)
Immunosuppressants + corticosteroids	11 (32.4)	Gastrointestinal tract	16 (47.1)
AZA	4 (11.8)	Heart	2 (5.9)
MFM ^e	3 (8.8)	Thromboembolic disease	0 (0)
Rituximab ^e	4 (11.8)	Skin	5 (14.7)
Tacrolimus	1 (2.9)	Management localization	
PLEX (in the last 6 months)	—	Home	15 (44.1)
SCIg or IVIg (in the last 6 months)	3 (8.8)	Medical unit	11 (32.4)

Continued

Table 1 Demographic and Disease Characteristics of Patients With Myasthenia Gravis (MG) Diagnosed With Coronavirus Disease 2019 (COVID-19) in the CO-MY-COVID Registry, as of June 8, 2020 (n = 34) (continued)

Demographic and disease characteristics of MG (n = 34)	N (%) or mean ± SD	Disease characteristics and outcomes of COVID-19 (n = 34)	N (%)
MG outcome at last evaluation		ICU	8 (23.5)
Death	5 (14.7)	Total duration of hospitalization, d^h	11.2 ± 9.6
MGFA class evolution^f		Duration of hospitalization in ICU, dⁱ	16.9 ± 15.6
Return to the previous state or improvement	25 (86.2)	Duration of total follow-up, d	38.9 ± 18.5
Worsening	15 (13.8)	Treatment changes due to COVID-19	
MG-ADL score^g	4.57 ± 3.86	Increase of corticosteroids	2 (5.9)
		Modification of immunosuppressants	5 (14.7)
		HCQ	3 (8.8)
		Azithromycin	4 (11.8)
		Tocilizumab	1 (2.9)
		Antiretroviral therapy	3 (8.8)
		IVIg	1 (2.9)
		COVID-19 outcome at last evaluation	
		Cured	28 (82.4)
		Ongoing	1 (2.9)
		Death	5 (14.7)

Abbreviations: anti-AChR = anti-acetylcholine receptor antibodies; anti-MuSK = anti-muscle-specific kinase antibodies; AZA = azathioprine; COPD = chronic obstructive pulmonary disease; DM = diabetes mellitus; HBP = high blood pressure; HCQ = hydroxychloroquine; ICU = intensive care unit; IVIg = IV immunoglobulin; MG-ADL = Myasthenia Gravis Activities of Daily Living; MGFA = Myasthenia Gravis Foundation of America; MFM = mycophenolate mofetil; OSAS = obstructive sleep apnea syndrome; PLEX = plasmapheresis; PNS = peripheral nervous system; SCIg = subcutaneous immunoglobulin.

^a Low MGFA = score I.

^b Medium MGFA = score II, IIa, IIb, III, IIIa, or IIIb.

^c High MGFA = score IV, IVa, IVb, or V.

^d n = 28 (6 missing data).

^e One patient was on corticosteroids, MFM, and rituximab.

^f Deceased patients (not included).

^g n = 28 (5 deceased patients and 1 missing data).

^h n = 19.

ⁱ n = 8.

none were in the high-MGFA group. Further, 25 patients (73.5%) had anti-AChR antibodies, 1 (2.9%) had anti-MuSK antibodies, and 8 (23.5%) had neither anti-AChR nor anti-MuSK antibodies. Next, 9 patients (26.5%) were categorized as low MGFA, 19 (55.9%) as medium MGFA, and 6 (17.6%) as high MGFA. All patients but one used anticholinesterase, 8 (23.5%) had no other MG therapy; some were treated by corticosteroids alone (n = 4; 11.8%), immunosuppressants alone (n = 11; 32.4%), or both (n = 11; 32.4%) (figure 3A). Among patients treated with immunosuppressants, rituximab was prescribed to 6 patients in the following manner: rituximab-corticosteroids combination for 3, corticosteroids with mycophenolate mofetil for 1, and rituximab alone for 2 patients. Further, 2 anti-AChR-positive patients had received IV immunoglobulin (IVIg) in the last 6 months before COVID-19, whereas one patient (without antibody positivity) was treated with SC immunoglobulin.

COVID-19 Characteristics and Outcome

At the COVID-19 nadir, 15 patients (44.1%) were home-managed, 10 patients (29.4%) had intermediate COVID-19, and 9 (26.5%) had severe COVID-19 (table 1). The mean number of risk factors for severe COVID-19 was 1.3 ± 1.6 (range 0–6). Eleven patients (32.4%) were older than 65; of these, 3 were home-managed, 6 had intermediate COVID-19, and 2 had severe COVID-19. Obesity was observed in 8 patients (23.5%); of these, 4 were home-managed, 3 had intermediate COVID-19, and 1 had severe COVID-19.

Five patients (14.7%) died due to COVID-19; of these, 2 (40%) died from ARDS only, 2 (40%) from concomitant ARDS and multiorgan failure, and 1 (20%) from concomitant ARDS and bacterial infections (table 2). Four patients were managed in the ICU, 1 in the MU; none of them were diagnosed as MG crisis. Among the 29

Figure 2 Age and Sex Distribution at the Onset of Myasthenia Gravis (MG)

survivors, 10 (34.5%) were considered to have MG exacerbation (1 case of MG crisis was due to a rapid MG weakness worsening treated by IVIg). MG medications were modified for 6: pyridostigmine was increased for 1, corticosteroids were temporarily increased for 1, and immunosuppressants were temporarily modified or stopped for 4. Five patients with a poor prognosis were treated by hydroxychloroquine and/or azithromycin: 2 died, MGFA class was stable for 1, MGFA worsened for 1, and MGFA improved for 1. MGFA class at the last evaluation was either stable or improved in 25 patients (86.2%), but worsened in 4 patients (13.8%).

Risk Factors Associated With COVID-19 Severity and MG Worsening

In univariate analysis, high MGFA class was strongly associated with severe COVID-19 ($p = 0.0008$) (table 3 and figure 3B), while medium MGFA class only tended to be associated with severe COVID-19 ($p = 0.064$). Treatment of MG with corticosteroids alone showed nonsignificant trend for association with severe COVID-19 ($p = 0.067$), while immunosuppressants alone or immunosuppressants + corticosteroids showed significant association with severe COVID-19 (respectively $p = 0.038$ and $p = 0.035$) (figure 3A). No dose effect was identified; no other independent variable tested was associated with a severe form of COVID-19. Treatment group and MGFA categories were introduced in the multivariate model based on variables determined to be significant in the univariate ordinal models. Within a given category of MGFA class, the type of treatment had no effect on the severity of COVID-19, and only high MGFA before COVID-19 was independently associated ($p = 0.004$) with a more severe course of COVID-19 (table 3 and figure 3C). In univariate analysis, no group was associated with poorer outcomes for MG (table 4).

Discussion

MG is an immune-mediated NMD that results in muscle weakness (including bulbar and respiratory muscles) often requiring corticosteroids or immunosuppressants therapy. Infections (usually pneumonia or upper respiratory infection) are a common precipitating factor for myasthenic crisis¹⁷ and are a source of therapeutic dilemma in the management of MG.^{18,19} International experts and French experts from the FILNEMUS network were quick to propose guidelines for COVID-19 management in patients with MG.^{6,7} As France was one of the earliest countries to endure a widespread COVID-19 outbreak, our experience with real-life cases may facilitate the development of evidence-based guidance.

The known risk factors for the severe form of COVID-19 are older age, cardiovascular disease, diabetes, chronic respiratory disease, hypertension, obesity, and cancer.²⁰ Interestingly, in our cohort, univariate analysis only identified immunosuppressants use and severe form of MG at COVID-19 onset as risk factors rather than variables such as age. Multivariate analysis showed only MG severity as an independent risk factor for severe COVID-19 with a very high odds ratio: the impact of MG severity is so high that it probably cancels the effect of classic risk factors of severe COVID-19 such as age. Another explanation for the absence of age effect could be the lack of older patients in our series: the mean age at COVID-19 onset (55.3 years) observed was younger than that in our national database (61.5 years) and the analysis of age distribution at MG onset did not show a classical peak after 60 years, especially for men (figure 2).²¹ To explain why older patients with MG were less likely to get infected by SARS-CoV-2, we looked at the age of patients infected until March 24 (date of the national French lockdown +6 incubation days) and after: patients infected in the early phase were younger (46.0 years) than those infected in the late phase (63.1 years, $p = 0.02$). The younger the people, the more social interaction and the more at risk to get infected. The same phenomenon is now observed in the second wave in France.²² This and information campaigns led by FILNEMUS and patient associations could explain why no high MGFA patient was older than 65 years.

As severe MG is predominantly treated by corticosteroids or immunosuppressants (figure 2C), management of immunosuppressed patients with MG with COVID-19 is challenging. Since the announcement of the first results of the RECOVERY trial,²³ corticosteroids (dexamethasone) are widely used for severe COVID-19. The benefit of dexamethasone use in severe COVID-19 was confirmed in a recent meta-analysis,²⁴ but this effect had not been shown for hydrocortisone²⁵ or methylprednisolone.²⁴ By contrast, in our series, corticosteroids were not significantly associated with poor COVID-19 outcome but had no protective effect (whatever the dose was). Corticosteroids were also identified as a risk factor for severe COVID-19 in 2 large series of 600 patients with rheumatic disease²⁶ and 523 patients with inflammatory bowel disease (IBD).²⁷ These different results are not contradictory: in RECOVERY,

Figure 3 Categorization of Patients With Myasthenia Gravis Diagnosed With Coronavirus Disease 2019 (COVID-19) in the CO-MY-COVID Registry, as of June 8, 2020

(A–C) CS = corticosteroids; MGFA = Myasthenia Gravis Foundation of America; IS = immunosuppressants.

dexamethasone was efficient in the treatment of severe COVID-19 and ARDS but did not have a preventive effect on the patients who did not need ventilatory support. In this population, the fatality rate was 17.8% in the dexamethasone arm and 14% in the placebo arm ($p = 0.14$). Most other studies about dexamethasone have focused only on ICU patients and not patients with slight to moderate symptoms (as in our case). We showed that immunosuppressants are associated with a poor COVID-19 outcome in univariate analysis and not in multivariate analysis. The same absence of effect of immunosuppressants on COVID-19 outcome was also observed in large series of multiple sclerosis²⁸ and rheumatic disease,²⁶ including drugs targeting CD19 B cells, azathioprine, cyclophosphamide, cyclosporine, mycophenolate mofetil/mycophenolic acid, and tacrolimus. These results confirm expert-based guidelines that recommend immunosuppressants continuation.^{5,6,26}

Distinguishing the respiratory effects of COVID-19 from MG crisis remains challenging, despite the use of chest CT scan, arterial blood gas, or spirometry.^{29,30} In our series, MG crisis was

considered for 1 patient who experienced a rapid worsening and received IVIg; MG exacerbation was identified in 10 other patients and MG medications were increased for 2. This rate of MG exacerbation and crisis (33.3%) is consistent with that observed after COVID-19 in the CARE-MG registry,¹² 2 small series,^{8,11} and after influenza-like illness (40%).³¹ These series and the few reports of clinical cases were predominantly focused on hospitalized patients^{8–10} and did not provide information on home-managed patients, whereas most patients with COVID-19 present with mild to moderate symptoms.² The fatality rate in our study (14.7%) was lower than that observed in the preliminary results of the CARE-MG registry (24%)¹² but higher than in studies of other immune-mediated diseases such as IBD (3%),²⁷ rheumatic disease (6%–9%),^{26,32} or multiple sclerosis (3.46%).²⁸ One could hypothesize that either MG or COVID-19 can negatively affect respiratory function, whereas IBD, rheumatic disease, or multiple sclerosis does not. Moreover, in patients such as kidney transplant recipients ($n = 144$), higher mortality rate (32%) was observed because of higher proportion of older patients and higher level of immunosuppression.³³

Table 2 Characteristics of Patients With Myasthenia Gravis (MG) Who Died Due to Coronavirus Disease 2019 (COVID-19) From the CO-MY-COVID Registry, as of June 8, 2020 (n = 5)

	Patient				
	1	2	3	4	5
M/F	M	F	F	M	M
Age, y	62	83	39	44	92
BMI, kg/m ²	19.9	25.2	20.0	26.1	27.1
Other comorbidities	Dyslip	HBP, Dyslip	Inv Vent, DM, Biermer	—	HBP
MG					
Antibody type	AntiAChR Ab	AntiAChR Ab	AntiAChR Ab	AntiAChR Ab	AntiAChR Ab
Duration, y	3	1	23	16	7
Thymectomy	Thymoma (2014)	—	—	—	—
MGFA severity class at the beginning of MG	IIb	IIIa	V	IVb	IVb
MGFA severity class at beginning of COVID-19	IIb	IIIa	V	IVb	II
MG treatment at the beginning of COVID-19	Pyr 180 mg/d	Abe 100 mg/d Pred 70 mg/d	Abe 40 mg/d Pred 15 mg/d Tacro 3 mg/d	Pyr 60 mg/d AZA 100 mg/d	Pyr 180 mg/d MFM 2g/d
Rituximab in the last 6 months	—	—	—	—	—
PLEX or IVIg in the last 6 months	—	—	—	—	—
COVID-19					
Diagnoses	Probable	Definite	Definite	Definite	Definite
PCR	—	+	+	+	+
Chest CT scan	+	+	ND	+	+
Affected organs					
Upper airways	+	+	—	—	—
Lower airways	+	+	+	+	+
Smell/taste loss	—	—	—	—	—
CNS	+	—	—	—	—
Peripheral nervous system	—	—	—	—	—
Liver	+	—	—	—	—
Heart	—	—	+	+	—
Renal Failure	—	—	+	+	—
Thromboembolic disease	—	—	—	—	—
Skin	—	—	—	—	—
Causes of death	ARDS several bacterial infections	ARDS	ARDS Multi-organ failure	ARDS Multi-organ failure	ARDS
COVID-19 total duration, d	25	7	9	28	21
Total duration of hospital stay, d	18	7	6	20	17
Total duration of ICU stay, d	18	7	6	20	0
MG treatment during COVID-19	Not modified	Not modified	Not modified	Stop AZA	Not modified
COVID-19 treatment	Pred	Tocilizumab	HCQ Ritonavir Darunavir	HCQ Azi	—

Abbreviations: Abe = ambenonium; anti-AChR Ab = anti-acetylcholine receptor antibody; ARDS = acute respiratory distress syndrome; Azi = azithromycin = AZA = azathioprine; DM = diabetes mellitus; Dyslip = dyslipidemia; HCQ = hydroxychloroquine; IVIg = IV immunoglobulin; Inv Vent = invasive ventilation; HBP = high blood pressure; MGFA = Myasthenia Gravis Foundation of America; MFM = mycophenolate mofetil; ND = not done; PLEX = plasmapheresis; Pred = prednisone; Pyr = pyridostigmine; Tacro = tacrolimus.

Table 3 Risk Factors for Severe Coronavirus Disease 2019 (COVID-19): Univariate Ordinal Analysis and Multivariate Ordinal Regression Model Based on COVID-19 Severity (Home-Managed vs Intermediate vs Severe) Among Patients With Myasthenia Gravis (MG) (n = 34)

	Univariate ordinal analysis (n = 34)		Multivariate ordinal regression model (n = 34), OR (95% CI)
	Coefficient	p Value	
Risk factors of severe COVID-19			
Age	0.02	0.27	—
Age >65 y	0.37	0.557	—
Male (reference = female)	−0.11	0.865	—
BMI >30 kg/m ²	−0.53	0.479	—
Total number of comorbidities	0.22	0.274	—
≥1 Comorbidity	−0.05	0.938	—
MG history			
MG duration	0.01	0.742	—
MG duration >2 years	0.8	0.281	—
High ^b maximum MGFA class (reference: low + moderate)	0.19	0.773	—
MG treatment at the beginning of COVID-19 (reference = neither corticosteroids nor immunosuppressants)			
Corticosteroids (without immunosuppressants)	2.56	0.067	9.7 (0.4–154.4)
Immunosuppressants (without corticosteroids)	2.56	0.038	7.2 (0.6–89.7)
Immunosuppressants + corticosteroids	2.56	0.035	3.1 (0.2–43.8)
Corticosteroids dose (reference prednisone ≤20 mg/d)			
Prednisone >20 mg/d	1.84	0.122	—
MGFA class at the beginning of COVID-19 (reference = low MGFA)			
Medium MGFA	1.7	0.064	3.7 (0.5–28.8)
High MGFA	4.81	0.0008	102.6 (4.4–2,371.9)

Abbreviations: BMI = body mass index; CI = confidence interval; MG-ADL = Myasthenia Gravis Activities of Daily Living; MGFA = Myasthenia Gravis Foundation of America; OR = odds ratio.

Strengths and Limitations

To our knowledge, this is the first large case series with detailed data on patients with MG with COVID-19. Eligible patients were included irrespective of where they were managed; thus, we could obtain information about milder forms of COVID-19 that have not been reported until now. Importantly, this diversity in COVID-19 severity allowed us to evaluate risk factors for severe COVID-19 in patients with MG. Lastly, this is a nationwide, multicenter study, which minimizes bias due to differences in the management of patients and due to regional variations in the prevalence rate of COVID-19.

Our study has several limitations. First, despite the large number of patients with MG recorded in the French national database for rare disorders, the total number of patients in this study remained low. The incidence rate of symptomatic COVID-19

among patients with MG is not known, but we can hypothesize that it is at least 0.96% (34/3,558). This result is similar to the incidence rate observed among patients with rheumatic disease (0.62%) and in the general population (0.66%) in Northern Italy.³⁴ Second, although 40% of the infected patients were asymptomatic,³⁵ only symptomatic patients were included in this study; thus, we excluded patients with MG who were asymptomatic and the consequences of asymptomatic COVID-19 in patients with MG remain unknown. Third, it is possible that patients with very mild COVID-19 were less likely to be included in our cohort than those who were hospitalized, despite extensive advertising about this cohort through patient associations and contact cells of the referral centers.

Even though COVID-19 and MG represent risk factors for respiratory failure, most patients with MG infected with

Table 4 Risk Factors for Worsening of Myasthenia Gravis (MG): Univariate Logistic Analysis Categorized Based on the Evolution of MG Among Patients (n = 34)

	Coefficients	p Value
Risk factors of severe COVID-19		
Age >65 y	0.06	0.94
Male (reference: female)	0.63	0.42
BMI >30, kg/m ²	-0.1	0.91
Total number of comorbidities	-0.18	0.82
MG treatment at the beginning of COVID-19 (reference: neither corticosteroids nor immunosuppressants)		
Corticosteroids (without immunosuppressants)	1.95	0.18
Immunosuppressants (without corticosteroids)	1.39	0.26
Corticosteroids and immunosuppressants	0.44	0.74
High ^b maximum MGFA class in MG history (reference: low + moderate)	-0.7985	0.312
MGFA score at the beginning of COVID-19 (reference: low)		
Medium ^a	17.79	0.99
High ^b	18.57	0.99
MG-ADL score at the beginning of COVID-19	0.13	0.26
COVID-19 severity (reference: home-managed)		
Intermediate	18.18	1
Severe	20.82	0.99

Abbreviations: BMI = body mass index; COVID-19 = coronavirus disease 2019; MG-ADL = Myasthenia Gravis Activities of Daily Living; MGFA = Myasthenia Gravis Foundation of America.

^a Medium MGFA = score II, IIa, IIb, III, IIIa, or IIIb.

^b High MGFA = score IV, IVa, IVb, or V.

SARS-CoV-2 recovered, indicating good prognosis. Immunosuppressants and corticosteroids are not independent risk factors of severe COVID-19 in MG, but we observed higher risk of severe COVID-19 in patients with high MGFA. These results will help to establish evidence-based guidelines for the management of patients with MG during the COVID-19 pandemic outbreak.

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Disclosure

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Appendix (continued)

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Continued

Appendix (continued)

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References

- Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72314 cases from the Chinese Center for Disease Control and Prevention. *JAMA* 2020;323:1239–1242.
- Shi Y, Wang G, Cai XP, et al. An overview of COVID-19. *J Zhejiang Univ Sci B* 2020; 21:343–360.
- World Health Organization. Clinical Management of Severe Acute Respiratory Infection when Novel Coronavirus (nCoV) Infection is Suspected: Interim Guidance, 2020. Geneva: World Health Organization; 2020.
- Sharma A, Tiwari S, Deb MK, Marty JL. Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2): a global pandemic and treatment strategies. *Int J Antimicrob Agents* 2020;56:106054.
- Guidon AC, Amato AA. COVID-19 and neuromuscular disorders. *Neurology* 2020; 94:959–969.
- Solé G, Salort-Campana E, Peréon Y, et al. Guidance for the care of neuromuscular patients during the COVID-19 pandemic outbreak from the French Rare Health Care for Neuromuscular Diseases Network. *Rev Neurol* 2020;176:507–515.
- Jacob S, Muppidi S, Guidon A, et al. Guidance for the management of myasthenia gravis (MG) and Lambert-Eaton Myasthenic Syndrome (LEMS) during the COVID-19 pandemic. *J Neurol Sci* 2020;412:116803.
- Anand P, Slama MCC, Kaku M, et al. COVID-19 in patients with myasthenia gravis. *Muscle Nerve* 2020;62:254–258.
- Singh S, Govindarajan R. COVID-19 and generalized myasthenia gravis exacerbation: a case report. *Clin Neurol Neurosurg* 2020;196:106045.
- Kushlaf H. COVID-19 in muscle-specific kinase myasthenia gravis: a case report. *Muscle Nerve* 2020;62:E65–E66.
- Hubers A, Lascano AM, Lalive PH. Management of patients with generalised myasthenia gravis and COVID-19: four case reports. *J Neurol Neurosurg Psychiatry* 2020; 91:1124–1125.
- Muppidi S, Guptill JT, Jacob S, et al. COVID-19-associated risks and effects in myasthenia gravis (CARE-MG). *Lancet Neurol* 2020;19:970–971.
- Wollina U, Karadag AS, Rowland-Payne C, Chiriac A, Lotti T. Cutaneous signs in COVID-19 patients: a review. *Dermatol Ther* 2020:e13549.
- Huang P, Liu T, Huang L, et al. Use of chest CT in combination with negative RT-PCR assay for the 2019 novel coronavirus but high clinical suspicion. *Radiology* 2020; 295:22–23.
- Jaretzki A III, Barohn RJ, Ernstoff RM, et al. Myasthenia gravis: recommendations for clinical research standards. Task Force of the Medical Scientific Advisory Board of the Myasthenia Gravis Foundation of America. *Neurology* 2000;55:16–23.
- Gilhus NE. Myasthenia gravis. *N Engl J Med* 2016;375:2570–2581.
- Thomas CE, Mayer SA, Gungor Y, et al. Myasthenic crisis: clinical features, mortality, complications, and risk factors for prolonged intubation. *Neurology* 1997;48: 1253–1260.
- Gilhus NE, Romi F, Hong Y, Skeie GO. Myasthenia gravis and infectious disease. *J Neurol* 2018;265:1251–1258.
- Ramos-Fransi A, Rojas-Garcia R, Segovia S, et al. Myasthenia gravis: descriptive analysis of life-threatening events in a recent nationwide registry. *Eur J Neurol* 2015; 22:1056–1061.
- Jordan RE, Adab P, Cheng KK. Covid-19: risk factors for severe disease and death. *BMJ* 2020;368:m1198.
- Carr AS, Cardwell CR, McCarron PO, McConville J. A systematic review of population based epidemiological studies in myasthenia gravis. *BMC Neurol* 2010;10:46.
- Santé Publique France. COVID-19: Point épidémiologique hebdomadaire du 01 octobre 2020. Santé Publique France; 2020.
- Horby P, Lim WS, Emberson JR, et al. Dexamethasone in hospitalized patients with Covid-19: preliminary report. *N Engl J Med* 2020;NEJMoa2021436.
- Sterne JAC, Murthy S, Diaz JV, et al. Association between administration of systemic corticosteroids and mortality among critically ill patients with COVID-19: a meta-analysis. *JAMA* 2020;324:1330–1341.
- Angus DC, Derde L, Al-Beidh F, et al. Effect of hydrocortisone on mortality and organ support in patients with severe COVID-19: the REMAP-CAP COVID-19 corticosteroid domain randomized clinical trial. *JAMA* 2020;324:1317–1329.
- Gianfrancesco M, Hyrich KL, Al-Adely S, et al. Characteristics associated with hospitalisation for COVID-19 in people with rheumatic disease: data from the COVID-19 Global Rheumatology Alliance Physician-Reported Registry. *Ann Rheum Dis* 2020;79:859–866.
- Cappello M, Busacca A, Guida L. The course of COVID-19 in inflammatory bowel disease: protective role of TNF antagonists response to corticosteroids, but not TNF antagonists, are associated with adverse COVID-19 outcomes in patients with inflammatory bowel diseases: results from an international registry. *Gastroenterology* Epub 2020 Jul 6.
- Louapre C, Collongues N, Stankoff B, et al. Clinical characteristics and outcomes in patients with Coronavirus disease 2019 and multiple sclerosis. *JAMA Neurol* 2020;77: 1079–1088.
- Anand P, Slama MCC, Kaku M, et al. Comment on COVID-19 in patients with myasthenia gravis: author response. *Muscle Nerve* 2020;62:E87–E88.
- Sharifian-Dorche M, Huot P, Oshero M, et al. Neurological complications of coronavirus infection; a comparative review and lessons learned during the COVID-19 pandemic. *J Neurol Sci* 2020;417:117085.
- Seok HY, Shin HY, Kim JK, et al. The impacts of influenza infection and vaccination on exacerbation of myasthenia gravis. *J Clin Neurol* 2017;13:325–330.
- D'Silva KM, Serling-Boyd N, Wallwork R, et al. Clinical characteristics and outcomes of patients with coronavirus disease 2019 (COVID-19) and rheumatic disease: a comparative cohort study from a US 'hot spot'. *Ann Rheum Dis* 2020;79:1156–1162.
- Cravedi P, Suraj SM, Azzi Y, et al. COVID-19 and kidney transplantation: results from the TANGO International Transplant Consortium. *Am J Transpl* 2020;20: 3140–3148.
- Favalli EG, Monti S, Ingegnoli F, Balduzzi S, Caporali R, Montecucco C. Incidence of COVID-19 in patients with rheumatic diseases treated with targeted immunosuppressive drugs: what can we learn from observational data? *Arthritis Rheumatol* 2020; 72:1600–1606.
- Oran DP, Topol EJ. Prevalence of asymptomatic SARS-CoV-2 infection: a narrative review. *Ann Intern Med* 2020;173:362–367.

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