Open Forum Infectious Diseases

MAJOR ARTICLE

Performance of a Triage Protocol for Monoclonal Antibodies in a Mixed Vaccinated and Unvaccinated Cohort of COVID-19 Patients Treated With Intravenous Infusion or Subcutaneous Injection

Emily B. Rubin,[1,*] Mofei Liu,[2] Anita Giobbie-Hurder,[2] Lauren A. Canha,[3] C. Elizabeth Keleher,[3] Keri M. Sullivan,[3] and Michael Dougan[3]

[1]Division of Pulmonary and Critical Care Medicine, Department of Medicine, Massachusetts General Hospital, Boston, Massachusetts, USA, [2]Division of Biostatistics, Department of Data Science, Dana-Farber Cancer Institute, Boston, Massachusetts, USA, and [3]Division of Gastroenterology, Department of Medicine, Massachusetts General Hospital, Boston, Massachusetts, USA

Background. Several monoclonal antibodies (mAbs) have been shown to reduce rates of hospitalization in patients with coronavirus disease 2019 (COVID-19) who have risk factors for severe disease. Due to capacity constraints, many health systems have been unable to provide mAbs to all eligible patients. There is little evidence regarding the performance of triage protocols for allocation or the relative effectiveness of subcutaneous administration vs intravenous infusion.

Methods. This was a retrospective cohort study of 1063 patients with COVID-19 consecutively referred for monoclonal antibody therapy in a single large academic health care system, who were prioritized for mAb therapy using an allocation protocol grouping patients by risk.

Results. A triage protocol prioritizing patients who were not fully vaccinated and were at high risk of severe COVID-19 and patients who were heavily immunosuppressed performed well in terms of differentiating between groups of patients by risk of severe disease. The number needed to treat (NNT) to prevent 1 hospitalization was 4.4 for the highest priority group, 8.5 for the next highest priority group, and 21.7 for the third highest priority group. There was no significant correlation between route of administration and hospitalization for symptoms related to COVID-19 (odds ratio, 1.26 in the intravenous group compared with the subcutaneous group; 95% CI, 0.56–2.8; $P = .58$).

Conclusions. This study demonstrates that triaging mAbs for patients with COVID-19 by risk can optimize benefit in terms of reducing rates of hospitalization and that rates of hospitalization may be no different between patients treated with subcutaneous injection and patients treated with intravenous infusion.

Keywords. COVID; monoclonal antibodies; triage; allocation.

The Food and Drug Administration has issued Emergency Use Authorization (EUA) for multiple monoclonal antibodies ("mAbs") for outpatients with COVID-19 and mild to moderate symptoms who are at high risk for severe disease [1–3] based on evidence that the early administration of mAbs significantly reduces the need for hospitalization [4–6]. Multiple studies have confirmed the effectiveness of mAbs in reducing rates of hospitalization under real-world conditions [7, 8]. The current EUAs for bamlanivimab and etesevimab, casirivimab and imdevimab, and sotrovimab contain a list of qualifying risk factors for severe disease. But the list is not exhaustive, and health care providers have the discretion under the EUAs to prescribe mAbs to any patient with coronavirus disease 2019 (COVID-19) deemed to be at high risk for severe disease [1–3].

The evidence for efficacy of mAbs in reducing the need for hospitalization of high-risk patients with COVID-19 comes from studies in which mAbs were given via intravenous infusion [4–6]. Although trial data support the safety and efficacy of casirivimab and imdevimab administered via subcutaneous injection in preventing symptomatic disease in high-risk patients who have been exposed to SARS-CoV-2 [9], evidence regarding the efficacy of subcutaneous administration in preventing severe disease among patients who have COVID-19 is limited. Although the EUA for casirivimab and imdevimab permits subcutaneous injection if an intravenous (IV) infusion is not feasible or would cause a delay in treatment, it states that intravenous infusion is strongly preferred [1].

Received 19 December 2021; editorial decision 30 March 2022; accepted 7 April 2022; published online 12 April 2022

Correspondence: Emily B. Rubin, MD, JD, MSHP, Division of Pulmonary and Critical Care Medicine, Massachusetts General Hospital, 55 Fruit Street, Bullfinch Building, Boston, MA 02114 (erubin3@partners.org).

Open Forum Infectious Diseases®

https://doi.org/10.1093/ofid/ofac182

When COVID-19 case counts started to rise substantially in the state of Massachusetts in August 2021, our health system received substantially more referrals for mAb therapy for patients with COVID-19 than the system was able to accommodate. Other health systems have also experienced staffing, space, and other capacity constraints that have limited the ability to deliver monoclonal antibodies to all eligible patients with COVID-19 [10].

While efforts were underway to increase capacity to administer mAbs, we developed a protocol for triaging referrals based on risk of severe disease. Some referred patients received mAbs via intravenous infusion and others through subcutaneous injection. Although professional societies have since recommended prioritization of patients for mAb administration by risk of severe disease in the event of scarcity [11], there is little evidence regarding the performance of such allocation protocols [12].

We sought to determine whether our triage protocol appeared to have effectively distinguished between groups of patients based on risk of hospitalization and to determine whether the route of administration was associated with rates of hospitalization in treated patients.

METHODS

Monoclonal Antibody Allocation Protocol

Patients referred for mAb treatment in our health system were assigned to 1 of 5 priority categories (Figure 1), with high-risk unvaccinated patients and heavily immunosuppressed patients assigned top priority, followed by fully vaccinated patients either ≥65 years or age or with body mass index (BMI) ≥35, then fully vaccinated patients <65 years of age with BMI <35 and other established risk factors for severe disease. In certain circumstances, reviewing clinicians exercised judgment to cross patients into a higher or lower priority category than the strict framework would dictate. Some fully vaccinated adults age <65 and with BMI <35 who had multiple other risk factors were, for example, put in category 2. Some patients who were not fully vaccinated but had only risk factors with less of a clear correlation with severe disease were assigned to a lower group than Priority 1.

The mAb referrals were triaged and put into a queue on a rolling basis throughout each day with the goal of accommodating the highest risk patients as soon after identification and referral as possible. Patients in the same priority category were listed in the queue by descending random lottery number. Schedulers called patients to offer therapy in the order the patients were listed in the queue. On any given day, appointments for mAb administration were filled only for the following day.

Treated patients received 1 of the following: casirivimab and imdevimab via intravenous infusion, bamlanivimab and etesevimab via intravenous infusion, or casirivimab and imdevimab via subcutaneous injection. Given the paucity of evidence regarding the relative efficacy of subcutaneous administration for patients with COVID-19, and the statement in the EUA that infusion is strongly preferred for infected patients, attempts were made to schedule the patients in the highest priority categories for infusion as opposed to subcutaneous injection. This was not always possible depending on factors including availability of infusion slots, the order in which patients were able to be reached for scheduling, and patient willingness to travel to locations where infusion appointments were available. Getting patients treated as soon as possible after referral was prioritized over route of administration.

Data Analysis

We analyzed data from the first 1063 consecutive referrals placed for patients with a positive severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) test. The electronic health record (EHR) was reviewed to determine clinical characteristics of each patient, whether each patient was treated with mAb or not, the specific mAb and mode of therapy for those treated, and whether each patient was hospitalized for symptoms attributable to COVID-19 within 30 days of an mAb referral being placed.

The rates of hospitalization were stratified by triage priority category, receipt of therapy, and mode of therapy. Absolute risk reduction and number needed to treat for each priority category were calculated. For patients treated within our system, we compared the rates of hospitalization within 30 days between

Priority 1	Not fully vaccinated with at least 1 well-established risk factor for severe disease; or heavily immunosuppressed[a]
Priority 2	Fully vaccinated, not heavily immunosuppressed, age ≥65 or BMI ≥35
Priority 3	Fully vaccinated, not heavily immunosuppressed, age <65, BMI <35, other established risk factor for severe disease
Priority 4	Fully vaccinated, not heavily immunosuppressed, age <65, BMI <35, borderline risk factor (including BMI 25-29, mild asthma)
Priority 5	Fully vaccinated, referred at discretion of provider, no characteristics clearly tied to increased risk of severe disease

Figure 1. Priority categories for monoclonal antibody therapy. [a]Heavily immunosuppressed included patients on CD20 inhibitors, solid organ transplant patients, bone marrow transplant patients, other patients with high-risk hematologic malignancy, patients actively undergoing chemotherapy, and other similarly immunocompromised patients. Abbreviation: BMI, body mass index.

patients treated with intravenous infusion and those treated with subcutaneous injection. Because patients were not randomized to mode of administration, but instead some patients were offered infusion preferentially, there were multiple potential confounders. To address these potential confounders, we used logistic regression models with inverse probability of treatment weighting (IPTW) and robust sandwich error estimation for comparisons of rates of hospitalization episodes.

This modeling technique requires 2 steps for each end point and cohort. The first step creates exposure probability weights for each patient, incorporating various potential confounders. We used 2 separate models to create exposure probability weights. The first incorporated vaccination status, gender, race, and Monoclonal Antibody Screening Score (MASS), which is a composite scoring system for risk of severe disease developed by the Mayo Clinic (model 1) [7, 12, 13]. As MASS is a score based on several risk factors, we also calculated exposure weights based on vaccination status, gender, race, and individual factors including BMI category, heavy immunosuppression, chronic kidney disease, diabetes, chronic lung disease, cardiovascular disease, and hypertension (model 2). Although MASS score was used in the analysis of the data, it was not used in the priority categorization.

Estimation of the weights is based on multivariable logistic regression, with vaccination status, gender, race, and MASS or other individual risk factors as predictors. Models for the weights are not necessarily parsimonious and include relevant factors regardless of statistical significance. In the second step, associations with outcomes are estimated using weighted logistic regression models. Associations are reported as odds ratios (ORs) with 95% robust CIs. For the purposes of this analysis, we excluded patients who were treated outside of our system, as we had no way to verify route of administration for these patients.

RESULTS

Between August 6, 2021, and October 13, 2021, 1063 patients with COVID-19 were referred for monoclonal antibody therapy (Figure 2). Of those, 583 were treated inside our system—279 via intravenous infusion and 304 via subcutaneous administration. An additional 86 patients were documented in the electronic health record (EHR) to have been treated with mAbs outside of our system. The remaining 394 patients were neither treated within our system nor known to have been treated elsewhere. The demographic characteristics of all referred patients by treatment status are shown in Table 1. The demographic characteristics of the patients treated within our system, stratified by IV and subcutaneous (SQ) administration, are shown in Table 2. Notably, a significantly higher percentage of patients in the SQ were fully vaccinated (83.1% in the SQ group vs 68.1% in the IV group; $P < .001$), and a significantly higher percentage of patients in the IV group were heavily immunosuppressed (18.5% in the IV group vs 5.3% in the SQ group; $P < .001$).

The rates of hospitalization in the treated and untreated groups are shown by triage priority category in Table 3. Of all treated patients, 33/669 (4.9%) were hospitalized for COVID-19 within 30 days of the referral being placed, compared with 63/394 (16.0%) of untreated patients. Of all treated patients triaged as Priority 1, 16/216 (7.4%) were hospitalized

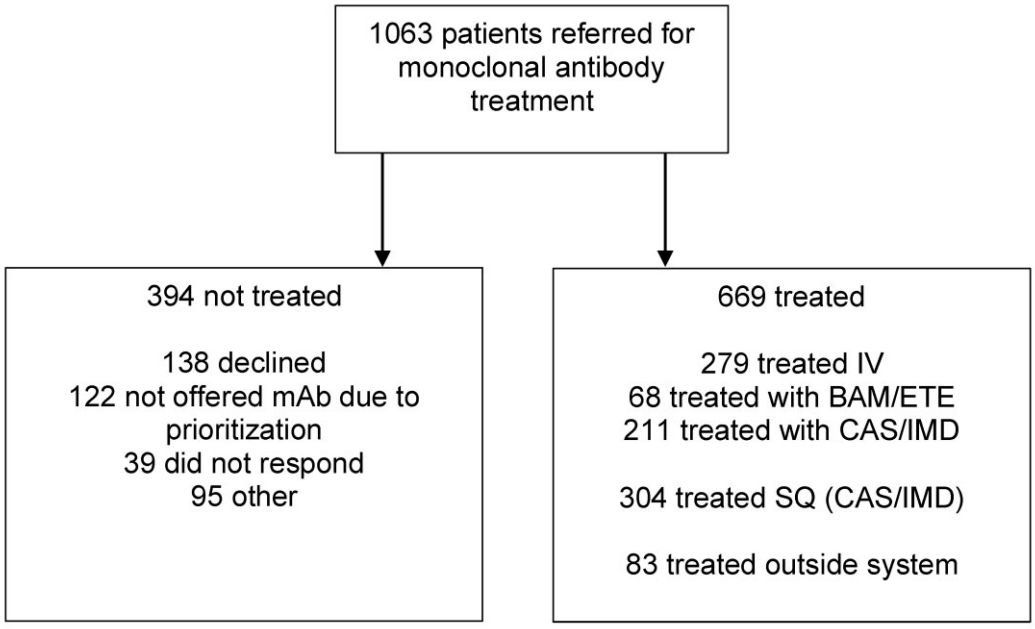

Figure 2. Outcomes of referrals for monoclonal antibodies. Abbreviations: BAM/ETE, bamlanivimab/etesevimab; CAS/IMD, casirivimab/imdevimab; IV, intravenous; mAb, monoclonal antibody; SQ, subcutaneous.

Table 1. Demographics Stratified by Treatment Status for All Patients

	Treatment Status		
	No (n = 394)	Yes (n = 669)[a]	Overall (n = 1063)
Vaccine status, No. (%)			
Fully vaccinated	279 (70.8)	510 (76.2)	789 (74.2)
Not fully vaccinated or unknown	115 (29.2)	159 (23.8)	274 (25.8)
Gender, No. (%)			
Female	207 (52.5)	408 (61.0)	615 (57.9)
Male	187 (47.5)	261 (39.0)	448 (42.1)
Race, No. (%)			
Black, not Hispanic	26 (6.6)	27 (4.0)	53 (5.0)
Hispanic	29 (7.4)	47 (7.0)	76 (7.1)
Other or unavailable	15 (3.8)	23 (3.4)	38 (3.6)
White	324 (82.2)	572 (85.5)	896 (84.3)
MASS			
Mean (SD)	2.90 (3.05)	3.55 (2.99)	3.31 (3.03)
Median [min, max]	2.00 [0, 14.0]	3.00 [0, 13.0]	3.00 [0, 14.0]
Age			
Mean (SD), y	56.4 (17.2)	57.7 (16.3)	57.2 (16.7)
Median [min, max], y	57.0 [18.0, 99.0]	60.0 [18.0, 94.0]	59.0 [18.0, 99.0]
Age (categorical), No. (%)			
<65 y	257 (65.2)	413 (61.7)	670 (63.0)
≥65 y	137 (34.8)	256 (38.3)	393 (37.0)
BMI, No. (%)			
≤25 kg/m^2	79 (20.1)	171 (25.6)	250 (23.5)
25–29 kg/m^2	125 (31.7)	193 (28.8)	318 (29.9)
30–35 kg/m^2	99 (25.1)	167 (25.0)	266 (25.0)
≥35 kg/m^2	81 (20.6)	128 (19.1)	209 (19.7)
Missing	10 (2.5)	10 (1.5)	20 (1.9)
Immunosuppression, No. (%)			
No	352 (89.3)	513 (76.7)	865 (81.4)
Yes	42 (10.7)	156 (23.3)	198 (18.6)
Heavy immunosuppression, No. (%)			
No	372 (94.4)	591 (88.3)	963 (90.6)
Yes	22 (5.6)	78 (11.7)	100 (9.4)
CKD, No. (%)			
No	358 (90.9)	586 (87.6)	944 (88.8)
Yes	36 (9.1)	83 (12.4)	119 (11.2)
DM, No. (%)			
No	313 (79.4)	535 (80.0)	848 (79.8)
Yes	81 (20.6)	134 (20.0)	215 (20.2)
CLD, No. (%)			
No	300 (76.1)	481 (71.9)	781 (73.5)
Yes	94 (23.9)	188 (28.1)	282 (26.5)
CVD, No. (%)			
No	289 (73.4)	479 (71.6)	768 (72.2)
Yes	105 (26.6)	190 (28.4)	295 (27.8)
HTN, No. (%)			
No	203 (51.5)	335 (50.1)	538 (50.6)
Yes	191 (48.5)	334 (49.9)	525 (49.4)
Hospitalized, No. (%)			
No	331 (84.0)	636 (95.1)	967 (91.0)
Yes	63 (16.0)	33 (4.9)	96 (9.0)

Abbreviations: BMI, body mass index; CKD, chronic kidney disease; CLD, chronic liver disease; CVD, cardiovascular disease; DM, diabetes mellitus; HTN, hypertension; MASS, Monoclonal Antibody Screening Score.

[a]Includes patients treated outside of our system.

Table 2. Demographics Stratified by Mode of Treatment of Patients Treated in our Health System

	IV (n = 279)	SQ (n = 304)	Overall (n = 583)
Vaccine status, No. (%)			
Fully vaccinated	190 (68.1)	253 (83.2)	443 (76.0)
Not fully vaccinated or unknown	89 (31.9)	51 (16.8)	140 (24.0)
Gender, No. (%)			
Female	164 (58.8)	191 (62.8)	355 (60.9)
Male	115 (41.2)	113 (37.2)	228 (39.1)
Race, No. (%)			
Black, not Hispanic	18 (6.5)	5 (1.6)	23 (3.9)
Hispanic	19 (6.8)	19 (6.3)	38 (6.5)
Other or unavailable	11 (3.9)	10 (3.3)	21 (3.6)
White	231 (82.8)	270 (88.8)	501 (85.9)
MASS			
Mean (SD)	3.75 (3.01)	3.38 (3.06)	3.56 (3.04)
Median [min, max]	3.00 [0, 13.0]	3.00 [0, 13.0]	3.00 [0, 13.0]
Age			
Mean (SD), y	57.4 (16.2)	58.0 (16.4)	57.7 (16.3)
Median [min, max], y	59.0 [21.0, 92.0]	60.0 [21.0, 94.0]	60.0 [21.0, 94.0]
Age (categorical), No. (%)			
<65 y	175 (62.7)	186 (61.2)	361 (61.9)
≥65 y	104 (37.3)	118 (38.8)	222 (38.1)
BMI, No. (%)			
≤25 kg/m^2	68 (24.4)	81 (26.6)	149 (25.6)
25–29 kg/m^2	85 (30.5)	85 (28.0)	170 (29.2)
30–35 kg/m^2	69 (24.7)	76 (25.0)	145 (24.9)
≥35 kg/m^2	53 (19.0)	57 (18.8)	110 (18.9)
Missing	4 (1.4)	5 (1.6)	9 (1.5)
Immunosuppression, No. (%)			
No	189 (67.7)	261 (85.9)	450 (77.2)
Yes	90 (32.3)	43 (14.1)	133 (22.8)
Heavy immunosuppression, No. (%)			
No	228 (81.7)	288 (94.7)	516 (88.5)
Yes	51 (18.3)	16 (5.3)	67 (11.5)
CKD, No. (%)			
No	244 (87.5)	264 (86.8)	508 (87.1)
Yes	35 (12.5)	40 (13.2)	75 (12.9)
DM, No. (%)			
No	222 (79.6)	246 (80.9)	468 (80.3)
Yes	57 (20.4)	58 (19.1)	115 (19.7)
CLD, No. (%)			
No	205 (73.5)	218 (71.7)	423 (72.6)
Yes	74 (26.5)	86 (28.3)	160 (27.4)
CVD, No. (%)			
No	194 (69.5)	218 (71.7)	412 (70.7)
Yes	85 (30.5)	86 (28.3)	171 (29.3)
HTN, No. (%)			
No	140 (50.2)	153 (50.3)	293 (50.3)
Yes	139 (49.8)	151 (49.7)	290 (49.7)
Hospitalized, No. (%)			
No	262 (93.9)	293 (96.4)	555 (95.2)
Yes	17 (6.1)	11 (3.6)	28 (4.8)

Abbreviations: BMI, body mass index; CKD, chronic kidney disease; CLD, chronic liver disease; CVD, cardiovascular disease; DM, diabetes mellitus; HTN, hypertension; IV, intravenous; MASS, Monoclonal Antibody Screening Score; SQ, subcutaneous.

compared with 32/106 (30.2%) of untreated patients triaged as Priority 1. The number needed to treat to prevent 1 hospitalization was 4.4 for Priority 1 patients, 8.5 for Priority 2 patients, and 21.7 for Priority 3 patients. Of the 71 patients in Priority 4 or Priority 5, only 2 patients (both triaged to Priority 4) were hospitalized, 1 of whom had been treated and 1 of whom had not.

Of a total of 789 vaccinated patients, 59 were hospitalized (7.5%), 38 of 279 in the untreated group (13.6%) and 21 of

Table 3. Rates of Hospitalization in Treated and Untreated Patients Stratified by Triage Priority Category

	Treated (n = 669), No. (%)	Untreated (n = 394), No. (%)	ARR, %	NNT[a]
All referred patients	Total: 33/669 (4.9)	63/394 (16.0)	11.1	9
	IV: 17/279 (6.3)			
	SQ: 11/304 (3.6)			
	Elsewhere: 5/86 (5.8)			
Priority 1	Total: 16/216 (7.4)	32/106 (30.2)	22.8	4.4
	IV: 10/130 (7.7)			
	SQ: 5/62 (8.1)			
	Elsewhere: 1/24 (4.2)			
Priority 2	Total: 14/303 (4.6)	24/146 (16.4)	11.8	8.5
	IV: 4/103 (3.9)			
	SQ: 6/157 (3.8)			
	Elsewhere: 4/43 (9.3)			
Priority 3	Total: 2/124 (1.6)	6/97 (6.2)	4.6	21.7
	IV: 2/39 (5.1)			
	SQ: 0/74 (0)			
	Elsewhere: 0/16 (0)			
Priority 4	Total: 1/24 (4.2)	1/30 (3.3)	−0.9	N/A (NNH 111)
	IV: 1/7 (14.3)			
	SQ: 0/11 (0)			
	Elsewhere: 0/6 (0)			
Priority 5	Total 0/2 (0)	0/15 (0)	No events	No events

Abbreviations: ARR, absolute risk reduction; IV, intravenous; NNT, number needed to treat; SQ, subcutaneous.

[a]Number needed to treat to prevent 1 hospitalization.

510 (4.1%) in the treated group. Of a total of 274 patients who were unvaccinated or with unknown vaccination status, 41 were hospitalized (15.0%), 28 of 115 in the untreated group (24.3%) and 13 of 158 in the treated group (8.2%).

Of the 583 patients treated with mAbs within our system, a total of 28 were hospitalized (4.8%). Seventeen of those 28 (60.7%) had been treated with intravenous infusion, and 11 (30.3%) had been treated with subcutaneous injection. Seventeen out of 217 patients treated with IV infusion (6.1%) were hospitalized, compared with 11 out of 304 patients treated with subcutaneous injection (3.6%). Using IPTW weighting model 1, the odds ratio of hospitalization was 1.26 in the IV group compared with the SQ group (95% CI, 0.56–2.8; $P = .58$). Using IPTW weighting model 2, the odds ratio of hospitalization was 1.28 in the IV group compared with the SQ group (95% CI, 0.56–2.92; $P = .55$) (Table 4). Neither weighted analysis showed a significant correlation between treatment type and hospitalization within 30 days of the mAb referral.

DISCUSSION

The triage protocol for mAbs for patients with COVID-19 implemented by our health system in the setting of limited capacity appears to have successfully distinguished between groups of patients by risk of hospitalization, as evidenced by the fact that the NNT to prevent 1 hospitalization declined with each subsequent priority category. This experience demonstrates that, in the setting of resource limitations, the benefits of mAb administration for patients with COVID-19 can be optimized with a triage protocol that groups patients by risk. Notably, the NNT for our second priority category—comprised of fully vaccinated patients, most of whom were either ≥65 years of age or had a BMI ≥35—was still quite small at 8.5, although it was nearly double the NNT for the group that included the high-risk unvaccinated and heavily immunosuppressed patients.

Regarding the relative efficacy of subcutaneous vs intravenous administration, our data suggest that subcutaneous administration might be equally as effective as intravenous infusion in preventing hospitalization. This is an important finding, as the barriers to intravenous infusion are significantly higher than they are for subcutaneous injection, and subcutaneous administration may allow more patients to be treated in many health systems.

The study had several limitations. It was conducted within a single health system, which may limit its generalizability. It was a retrospective study and was limited by the information available in the EHR. Some hospitalizations or administrations of monoclonal antibody therapy outside of our system may have been missed. Some health conditions are likely not listed in the EHR, which could have affected our evaluation of risk factors for severe disease. Regarding the analysis of whether the route of administration was associated with rate of hospitalization, notwithstanding the IPTW weighting, unmeasured variables

Table 4. IPTW Analysis of Hospitalization vs Treatment Type

	Hospitalization			Weighting Model 1 (MASS Score)[a]		Weighting Model 2 (Individual Factors)[b]	
	No (n = 555), No. (%)	Yes (n = 28), No. (%)	Overall (n = 583), No. (%)	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
SQ	293 (52.8)	11 (39.3)	304 (52.1)	Ref		Ref	
IV	262 (47.2)	17 (60.7)	279 (47.9)	1.26 (0.56–2.8)	.58	1.28 (0.56–2.92)	.55

Abbreviations: IPTW, inverse probability of treatment weighting; IV, intravenous; MASS, Monoclonal Antibody Screening Score; OR, odds ratio; SQ, subcutaneous.

[a]IPTW weighting: treatment type, vaccination status, gender, race/ethnicity, Monoclonal Antibody Screening Score.

[b]IPTW weighting: treatment type, vaccination status, gender, race/ethnicity, age, BMI category, heavy immunosuppression, chronic kidney disease, diabetes mellitus, chronic lung disease, cardiovascular disease, hypertension.

may confound the analysis of the effectiveness of subcutaneous vs intravenous administration of mAbs. Finally, the sample size is small, and only 28 events occurred in the group of treated patients, which limits the analysis of the effectiveness of the 2 modes of treatment. The analysis was performed during the Delta wave, and these results may not be applicable to mAB therapies reactive against the Omicron variant.

CONCLUSIONS

Our health system's experience implementing a triage protocol for monoclonal antibodies for patients with COVID-19 in a time of scarcity suggests that prioritization by risk can be executed in a way that optimizes the use of scarce resources by identifying groups of patients at highest risk of hospitalization. It also suggests that subcutaneous administration of mAb might be equally as effective as intravenous infusion in lowering the rates of hospitalization in patients at high risk of severe disease, although the sample size was small and studies of larger patient populations will be necessary to adequately compare the efficacy of the 2 routes of administration.

Acknowledgments

Financial support. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Potential conflicts of interest. M.D. has received research funding from Novartis and Eli Lilly, has served as a consultant for Roche-Genentech, Tillotts Pharma, ORIC Pharmaceuticals, Partner Therapeutics, SQZ Biotech, AzurRx, and Moderna, and is a member of the Scientific Advisory Board for Neoleukin Therapeutics. All other authors report no potential conflicts. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

Author contributions. Dr. Rubin had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: E.B.R., A.G.H., M.L., M.D. Collection, management, analysis, and interpretation of the data: E.B.R., L.A.H., K.S., C.E.K., A.G.H., M.L., M.D. Drafted or critically revised the manuscript for important intellectual content: E.B.R., A.G.H., M.L., M.D.

Patient consent. The study was approved by the Institutional Review Board. The study does not include factors necessitating patient consent.

References

1. Food and Drug Administration. Fact sheet for healthcare providers: Emergency Use Authorization (EUA) of casirivimab and imdevimab. Available at: https://www.fda.gov/media/145611/download. Accessed 14 December 2021.
2. Food and Drug Administration. Fact sheet for health care providers: Emergency Use Authorization (EUA) of bamlanivimab and etesevimab. Available at: https://www.fda.gov/media/145802/download. Accessed 14 December 2021.
3. Food and Drug Administration. Fact sheet for health care providers: Emergency Use Authorization (EUA) of sotrovimab. Available at: https://www.fda.gov/media/149534/download. Accessed 14 December 2021.
4. Dougan M, Nirula A, Azizad M, et al. Bamlanivimab plus etesevimab in mild or moderate Covid-19. N Engl J Med **2021**; 385:1382–92.
5. Weinreich DM, Sivapalasingam S, Norton T, et al. REGEN-COV antibody combination and outcomes in outpatients with Covid-19. N Engl J Med **2021**; 385:e81.
6. Gupta A, Gonzalez-Rojas Y, Juarez E, et al. Early treatment for Covid-19 with SARS-CoV-2 neutralizing antibody sotrovimab. N Engl J Med **2021**; 385:1941–50.
7. Ganesh R, Philpot LM, Bierle DM, et al. Real-world clinical outcomes of bamlanivimab and casirivimab-imdevimab among high-risk patients with mild to moderate coronavirus disease 2019. J Infect Dis **2021**; 224:1278–86.
8. Rubin EB, Boiarsky JA, Canha LA, et al. Bamlanivimab efficacy in older and high-BMI outpatients with COVID-19 selected for treatment in a lottery-based allocation process. Open Forum Infect Dis **2021**; 8:XXX–XX.
9. O'Brien MP, Forleo-Neto E, Musser BJ, et al. Subcutaneous REGEN-COV antibody combination to prevent Covid-19. N Engl J Med **2021**; 385:1184–95.
10. Sakata T, Brunisholz KD, Andersen C, Davie D, Srivastava R, Webb BJ. The MAb Squad: delivering Covid-19 monoclonal antibody therapy across a large geographic region. NEJM Catal Innov Care Deliv. 2021; 09. doi:10.1056/CAT.21.0154.
11. National Institutes of Health. Updated COVID-19 treatment guidelines panel's statement on the prioritization of anti-SARS-CoV-2 monoclonal antibodies for the treatment or prevention of SARS-CoV-2 infection when there are logistical or supply constraints. Available at: https://www.covid19treatmentguidelines.nih.gov/therapies/updated-statement-on-the-prioritization-of-anti-sars-cov-2-mabs/. Accessed 14 December 2021.
12. Bierle DM, Ganesh R, Tulledge-Scheitel S, et al. Monoclonal antibody treatment of breakthrough COVID-19 in fully vaccinated individuals with high-risk comorbidities. J Infect Dis **2022**; 225:598–602.
13. Bierle DM, Ganesh R, Wilker CG, et al. Influence of social and cultural factors on the decision to consent for monoclonal antibody treatment among high-risk patients with mild-moderate COVID-19. J Prim Care Community Health. 12 (2021): 21501327211019282.