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A vital parameter? Systematic review of spirometry in evaluation for intensive care unit admission and intubation and ventilation for Guillain-Barré syndrome

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ABSTRACT

Background: Patients with Guillain-Barré syndrome (GBS) may require intensive care unit (ICU) admission for intubation and ventilation (I + V). The means to predict which patients will require I + V include spirometry measures. The aims of this study were to determine, for adult patients with GBS, how effectively different spirometry parameter thresholds predict the need for ICU admission and the requirement for I + V; and what effects these different parameter thresholds have on GBS patient outcomes.

Method: A systematic review was conducted of the databases PubMed, EMBASE, and Cochrane library in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The systematic review was registered prospectively on PROSPERO.

Results: Initial searches returned 1011 results, of which 8 fulfilled inclusion criteria. All included studies were observational in nature. Multiple studies suggest that a vital capacity below 60% of predicted value on admission is associated with the need for eventual I + V. No included studies evaluated peak expiratory flow rate, or interventions with different thresholds for ICU or I + V.

Conclusions: There is a relationship between vital capacity and the need for I + V. However, there is limited evidence supporting specific thresholds for I + V. In addition to evaluating these factors, future research may evaluate the effect of different patient characteristics, including clinical presentation, weight, age, and respiratory comorbidities, on the effectiveness of spirometry parameters in the prediction of the need for I + V.

1. Introduction

Guillain-Barré syndrome (GBS) is a neurological disorder characterised by an acute autoimmune polyneuropathy, which may result in life-threatening neuromuscular weakness [1]. The severity of GBS can range from a mild case with brief weakness to paralysis, leading to respiratory failure. Immunomodulatory treatment with intravenous immunoglobulin (IVIg) or plasma exchange (PLEX) can influence the disease course of GBS [4]. However, despite these treatments, intubation and ventilation (I + V) is required in up to 30% of patients [5]. Indications for I + V, and associated intensive care unit (ICU) admission, in patients with GBS include both respiratory failure and bulbar dysfunction [5]. Given the scarcity of ICU resources, the ability to predict which patients are likely to require I + V due to respiratory failure would assist with the allocation of resources to monitor those most at risk. Spirometry parameters, such as forced vital capacity (FVC), are commonly used for this reason. However, the thresholds that should prompt escalation in monitoring for derangements in these parameters may be debated.

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The evaluation of respiratory failure in patients with GBS requires careful consideration of the neuromuscular characteristics of the condition. Signs such as increased work of breathing may not be present until late in the course of respiratory failure [6]. Similarly, pulse oximetry readings may not be altered until late in the course of respiratory failure [7]. While arterial blood gasses provide a means of monitoring respiratory function, these tests are invasive and, when recurrent, typically require an arterial line. In view of these limitations, bedside spirometry (including the measurement of FVCs) is often employed in the evaluation of pulmonary function and respiratory muscle weakness. There are generally accepted practices relating to a threshold for ICU monitoring below an FVC of 20 mL/kg and consideration of I + V below an FVC of 15 mL/kg [8,9]. A "20/30/40" rule referring to vital capacity < 20 mL/kg, maximal inspiratory pressure < 30 cmH_2O, or maximal expiratory pressure < 40 cmH_2O may also be cited regarding prediction of respiratory failure and warranting ICU admission [7,9]. However, there may be uncertainty in circumstances involving patients who may not have been included in previous studies, such as those with obesity, advanced age, or respiratory comorbidities [10].

The aims of this study were: to determine, for adult patients with GBS, how effectively different spirometry parameter thresholds (including FVC) predict the requirement for ICU admission and the requirement for I + V; and to determine the effects of these different parameter thresholds on GBS patient outcomes.

2. Materials and methods

2.1. Study design, search strategy, and selection criteria

The development and reporting of this systematic review were in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (see checklist in Supplementary Information 1) [11]. Registration with the PROSPERO registry was completed (PROSPERO CRD42022356681). The databases PubMed, Cochrane Library, and EMBASE were searched from inception to 30.11.2022. The search employed was based upon the following terms: *(Guillain-Barre syndrome OR Guillain*) AND (Intubation OR ventilation OR respiratory failure OR intensive care OR critical care OR crisis OR acute care OR high dependency OR emergency OR death OR mortality) AND (Forced vital capacity OR maximum inspiratory pressure OR maximal inspiratory pressure OR negative inspiratory force OR maximum expiratory pressure OR maximal expiratory pressure OR peak expiratory flow rate OR spirometry OR pulmonary function OR respiratory function OR prediction OR predictors OR anticipat* OR bedside)*. Supplementary Information 2 provides the search strings employed for the respective databases.

Eligibility determination was undertaken in duplicate (R.M., N.D., T. M., L.Z., S.B.), and instances of disagreement were resolved through discussion with a third reviewer. This evaluation was firstly conducted based on titles and abstracts, prior to full-text review, using a standardised form. The inclusion criteria applied were: (1) English-language; (2) primary peer reviewed publication (abstracts, posters, reviews, and editorials were excluded); (3) presented results specifically for adult (≥18 years of age) patients with GBS; (4) presented spirometry parameters (namely FVC, peak expiratory flow rate, maximal inspiratory pressure, or maximal expiratory pressure) prior to requirement for ICU admission or I + V, specifically for both the groups that did and did not require these interventions; (5) described these desired parameters in ≥ 10 patients with GBS; and (6) available in full-text.

3. Data extraction and analysis

A standardised form was used for the data extraction of included studies. Data of interest included patient factors (number of patients, age, gender, weight, key comorbidities, and duration of follow-up), GBS factors (proportion of subtypes, severity as evaluated with any standardised scale, treatments received, proportion that required ICU, reasons for requiring ICU, proportion that required I + V, reasons for requiring I + V, and proportion that suffered mortality), spirometry parameters (parameters assessed, timing of parameter assessment, repeated assessments, equipment used for assessment, and method for assessment), performance of spirometry parameters as predictors (performance of respiratory parameters in predicting ICU admission and I + V, effect on outcomes in interventional studies, and performance in predicting other outcomes), and performance of other predictors (predictors of ICU admission and I + V). The Joanna Briggs Institute Critical Appraisal Checklists for cohort studies was used [12]. This risk of bias analysis was also performed in duplicate.

4. Results

4.1. Search results and study characteristics

The search strategy provided 1011 results (see Fig. 1). Following the screening of titles/abstracts, there were 66 studies that underwent review in full-text. The number of studies that were found to meet the inclusion criteria were 8 (see Table 1 and Table 2). The included studies were all cohort studies. Risk of bias analysis of the included studies showed that they were of low-moderate risk of bias (see Supplementary Information 3). The most frequent study limitation was that confounding variables with respect to respiratory comorbidities were not discussed. Additionally, it is noteworthy that a high proportion (6/8) of the studies were from a single country (France), and often from a single centre.

There was one study [13], which met the inclusion criteria that likely presented a subset of the same population represented in another included study [14], and therefore the results of this study will not be presented separately. There were also studies that had possible overlapping cohorts; however, these cohorts had unique patients and will therefore be presented separately. Examples of these studies include Ogna et al. and Sharshar et al. [15,16], and Orlikowski et al. and Durand et al. [14,17].

4.2. Spirometry parameters used to predict intensive care unit admission

There were no studies identified that examined the association between spirometry results and ICU admission.

4.3. Spirometry parameters used to predict requirement for intubation and ventilation

Spirometry parameters that were evaluated in the identified studies included: FVC, vital capacity (VC), FEV1, FEV25-75, maximal expiratory pressure (MEP), maximal inspiratory pressure (MIP), peak cough flow and minute ventilation. FVC is the total volume of air exhaled with maximal forced effort after a maximal inspiration, while VC is calculated when the manoeuvre is not forced, except near end-inspiration and end-expiration. FEV1 is the maximum amount of air that can be exhaled in one second. FEV25-75 is the average forced expiratory flow rate at 25–75% of the FVC. MEP and MIP measure the highest pressure that can be developed during maximal inspiration and expiration respectively, against an occluded airway. Peak cough flow is used to assess cough strength. Minute ventilation is the product of respiratory rate and tidal volume, and indicates the volume of air that enters the lungs per minute.

All 8 studies evaluated VC or FVC. The majority of these studies found a relationship between VC and I + V [10,14,15,18,19]. Several of these studies examined a threshold of 60% of predicted VC. For example, Durand et al. 2006 reported that the mean VC of the group that did not require I + V was 81% of the predicted value, which was significantly different from the VC of the group which did require I + V, which was 61% of the predicted value ($P < 0.0001$) [14]. Likewise, Sharshar et al. 2003) provided support for a VC threshold of 60% of the predicted value, with those falling below this threshold being significantly more

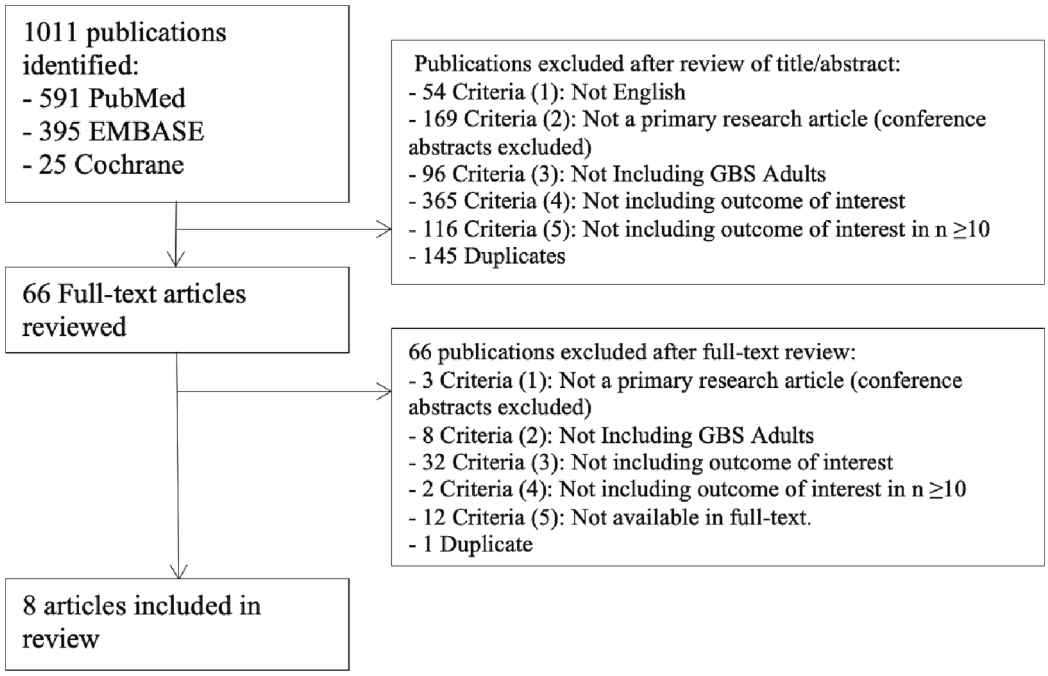

Fig. 1. Study selection.

likely to require I + V (odds ratio 2.86, 95% confidence interval 2.43 to 10.00, P = 0.0001) [19]. Conversely, Ogna et al. reported that a VC < 60% of the predicted value did not reach statistical significance with respect to an association with I + V (odds ratio 4.5, 95% confidence interval 0.89 to 22.7, P = 0.11), although this result was in the setting of low sample size (n = 30) [15].

With respect to other VC thresholds, the study by Chevrolet et al. of 10 patients with GBS provided evidence to support the canonical 15 mL/kg threshold for I + V [10]. In this study, VC was noted to decline up to 48 h prior to the need for I + V. In particular, a fall of > 50% in the VC was predictive of I + V in the following 24 h. I + V was required at the point when VC reached 15.2 +/- 3.7 mL/kg. In this study, it was not specified whether the ideal or actual body weight was used; however, the weights of the included patients ranged from 43.0 kg to 64.5 kg. Although heights were not provided, this weight range reduces the likelihood of the inclusion of morbidly obese patients. The study by Kanikannan et al. reported that all patients who required I + V had an FVC < 15 mL/kg on admission [18].

Several studies evaluated VC as a continuous variable. When VC was evaluated as a continuous variable in Ogna et al. it marginally reached statistical significance with respect to I + V (odds ratio 0.95, 95% confidence interval 0.91 to 1.00, P = 0.03) [15]. Kanikannan et al. reported that there was a significant difference in FVC between those who did and did not require I + V (0.88 L vs 1.7 L, P < 0.001) [18]. In this study, FVC was also presented as a receiver operator characteristic and an area under the curve was calculated, which was 0.934 (95% confidence interval 0.88 to 0.99) [18]. One study of 110 patients found no relationship between VC and requirement for I + V [16]. Orlikowski et al. evaluated FVC at the time of intubation as a threshold of meeting 30% of the predicted value; however, this study did not present the statistical significance of these results (61% vs 39%) [17].

In the study that examined a subset of the patients described in Durand et al., mean MIP (64 vs 35 cmH_2O, P = 0.002) and mean MEP (72 vs 31 cmH_2O, P = 0.0001) at the time of inclusion were lower in the group that subsequently required I + V [13]. This finding was supported by another study, which found that both lower MIP and lower MEP were associated with subsequent requirement for I + V (P = 0.03, and P = 0.03) [15]. FEV1 (no intubation vs intubation groups had mean 1.7 vs 0.86 L, P < 0.001) and FEV25-75 (no intubation vs intubation groups had mean 2.6 vs 1.4 L, P < 0.001) were both evaluated in one study, and found to be predictive of the need for I + V [18]. The one study that evaluated peak cough flow did not find this parameter to be associated with the subsequent need for I + V (P = 0.16) [15].

4.4. Interventional studies that employed different thresholds for intensive care unit admission or intubation and ventilation

No interventional studies were identified that evaluated the impact of implementing different spirometry-based thresholds for ICU or I + V.

5. Discussion

This review has shown that there is evidence from observational cohort studies to support the use of spirometry, namely VC and FVC, in the prediction of which patients with GBS will require I + V. With respect to specific thresholds, the most commonly described was a VC of < 60% of the predicted value being associated with subsequent requirement for I + V. However, these studies have noteworthy limitations, including largely having been conducted at a single centre. There is limited evidence to support the use of other spirometry parameters including MIP, MEP, FEV1, and FEV25-75. There have been no studies identified that evaluated the impact of implementing a specific spirometry threshold-based criteria for ICU admission, or I + V, on patient outcomes.

There is a noteworthy study by Melone et al. that did not meet the inclusion criteria for this review but requires discussion [20]. This randomised controlled trial of 50 patients with GBS trialled an early mechanical ventilation approach if the patients had the following risk factors for intubation: (1) time from onset to admission<7 days, (2) unable to lift their head and (3) FVC<60% of predicted value. This differed from the standard approach, which employed usual I + V criteria including an FVC of<20% of predicted value or<15 mL/kg. This study did not meet inclusion criteria because FVC were presented for the intervention group, which included both those who had I + V *and* those who had non-invasive ventilation. In this study there were no significant differences in the number of patients who had pneumonia, a tracheostomy, more severe neurological impairment, length of stay, or death. Although this study employed non-invasive ventilation, given the lack of

Table 1
Study participant characteristics.

	General Type of study	Location	Patient characteristics Number (n)	Age (years)	Gender %F	Weight	Duration of follow up after admission	GBS characteristics Treatments received (e.g., IVIg, PLEX)	Proportion that required ICU %	Proportion that required I + V
Durand et al. 2006	Prospective cohort	Raymond Poincaré Teaching Hospital, Garches, France	154	45 people < 40 105 people ≥ 40	51	Not specified	Every other day for the first 8 days, then every third day for 29 days, then one follow up at 6 months	72 patients (47%) had received IVIg at inclusion65 patients (42%) had received PLEX at inclusion	Uncertain	34/154 (22.1%)
Kannan Kanikannan et al. 2014	Prospective Cohort	Tertiary hospital in South India	68	37 ± 16	30.8	Not specified	Not specified	Not specified	100	22/68 (32.4%)
Sharshar et al. 2003	Retrospective cohort	Not specified	722	Not specified	Not specified	Not specified	Not specified	PLEX at inclusion	Not specified	313/722 (43%)
Ogna et al. 2017	Prospective cohort	Raymond Poincaré Teaching Hospital, Garches, France	30	57, (range 32–65)	46.7	BMI.26.3 (22.5–30.4)	Not specified	23 patients (77%) received IVIg and9 patients (30%) received PLEX at an average of 5.6 ± 4.6 days after GBS symptoms. .	100	10/30 (33.3%)
Orlikowski et al. 2006	Prospective cohort	Raymond Poincaré Teaching Hospital, Garches, France	81	25 patients < 45 29 patients 45–64 27 patients > 65	Not specified	Not specified	28 days	4 received IVIg prior to intubation 28 received PLEX prior to intubation	100	81/81 (100%)
Sharshar et al. 2012	Prospective cohort	Raymond Poincaré Teaching Hospital, Garches, France	110	Median age 49.6 IQR 16.7	38	Not specified	Every other day during the first 8 days, then every third day until 29 days	57 patients (32%) had received PLEX, and 53 patients (48%) had received IVIg at inclusion	Not specified	25/110 (22.7%)
Chevrolet et al. 1991	Prospective cohort	Geneva University Hospital, Geneva, Switzerland	10	(range 21–63)	60	F: 43–57.5 kg M: 50–64.5 kg	Follow up varied between patients from 43 to 78 days	4/5 intubated patients received plasmapheresis	Not specified	5/10 (50%)

Table 2
Study spirometry parameters.

	Respiratory parameters				Performance of respiratory parameters as predictors
	Parameters assessed	**Timing of parameter assessment**	**Repeated assessments described**	**Method of parameter assessment**	**Performance/association of respiratory parameters in predicting I + V**
Durand et al. 2006	VC	Not specified	VC was assessed every other day during the first 8 days, then on third day until day 29.	Slow inspiratory VC measured in triplicate with spirometer. Patient seated with back reclined ($30^\circ - 60^\circ$), wearing a nose clip, and breathing through a flange-type mouthpiece.	Mean VC was at 61% of predicted value for the ventilated group (n = 34) and at 81% (n = 120) for the non-ventilated group
Kannan Kanikannan et al. 2014	FVC FEV1 FEV25-75	At time of admission	No	FVC was recorded in supine and measured in triplicate	All patients who required I + V had FVC<15 mL/kg on admission. AUC FVC: 0.934 [95% C.I 0.88 to 0.99] AUC FEV1: 0.929 [95% C.I 0.87 to 0.99] AUC FEV25-75%- 0.882 [95% C.I 0.79 to 0.97]
Sharshar et al. 2003	VC	At time of admission	No	Not specified	VC < 60% of predicted value (Odds ratio 2.86 CI 2.43–10.00, P < 0.0001) was a factor which predicted I + V
Ogna et al. 2017	VC (sitting, supine) MIP MEP Peak cough flow	At time of admission	No	Slow inspiratory VC measured in triplicate with spirometer, both sitting and supine. For MIP and MEP at total lung capacity, patients breathed into a mouthpiece connected to a manometer, with triplicate repeat measures until two identical readings were obtained.	VC (% predicted value) had odds ratio of 0.95 (95% C.I 0.91 to 1.00, with a p value of 0.03) in predicting intubation. VC < 60% had odds ratio of 4.50 (95% C.I 0.89 to 22.7, with a p value of 0.11) in predicting intubation MIP (cmH2O) had odds ratio of 0.92 (95% C.I 0.84 to 1.00, with a p value of 0.03) in predicting intubation MEP (cmH2O) had odds ratio of 0.94 (95% C.I 0.88 to 1.00, with a p value of 0.03) in predicting intubation. Peak cough flow (l/min) had odds ratio of 0.99 (95% C.I 0.98; 1.00, with a p value of 0.16) in predicting intubation
Orlikowski et al. 2006	VC	At time of admission At time of intubation	VC done daily from admission until start of I + V	Not specified	At admission, 36 patients (47%) have a VC of ≥ 60% of predicted and 40 (53%) have a VC of < 60% of predicted. At intubation, 44 patients (61%) had a VC of ≥ 30% of predicted and 28 (39%) had a VC of < 30% of predicted.
Sharshar et al. 2012	VC	Within 24 h of admission Median time of 3 days from inclusion to I + V	VC was assessed every other day for the first 8 days and then on every 3rd day until day 29	VC measured in triplicate with patient seated with back reclined ($30^\circ - 60^\circ$), wearing a noseclip and breathing through a flange-type mouthpiece.	Non-ventilated patients had a VC of 71.6% (n = 85) on admission, ventilated patients had a VC of 70.7% (n = 25) on admission I + V was not associated with VC VC was not significantly different between patients who did or did not require I + V subsequently
Chevrolet et al. 1991	VC FEV1 Minute Ventilation	3 times per day, from time of admission (more often as required if unstable)	3 times per day	On the ward, 3 daily measurements were performed by trained respiratory therapists using standard techniques. In ICU, tests were performed by nurses	In intubated patients, VC was 15.2 ± 3.7 mL/kg body weight. In non-intubated patients, VC was stable and > 40 mL/kg body weight. VC

(*continued on next page*)

Table 2 (*continued*)

	Respiratory parameters				Performance of respiratory parameters as predictors
	Parameters assessed	Timing of parameter assessment	Repeated assessments described	Method of parameter assessment	Performance/association of respiratory parameters in predicting I + V
		Immediately before intubation.		"who were accustomed to treating patients with respiratory failure"	tended to have a steady decrease prior to intubation. A 50% decline of VC from the first recorded value predicted the need for subsequent ventilation<24 h prior to intubation

randomised or interventional studies examining FVC thresholds for ICU or I + V, the findings of this study are relevant to consider.

There is a component of the results in the included studies which could be considered a "self-fulfilling prophecy". For example, if FVC is in the criteria for I + V, in studies examining I + V, a lower FVC will likely be associated with I + V. For example, Durand et al. reported that patients with a VC < 15 mL/kg was a major criterion in the determination to commence I + V [14]. Therefore, since it is defined in the criteria for the indication of I + V, it can be seen that a lower VC will be associated with I + V.

It should be noted that respiratory failure in GBS can develop through multiple mechanisms, including inspiratory/expiratory muscle weakness, bulbar dysfunction, and respiratory complications of the condition (such as pneumonia) [21]. Additionally, respiratory failure is only one indication for ICU and I + V in patients with GBS. For example, bulbar dysfunction and significant respiratory distress may play a role in the decision to proceed with I + V independent of the presence of respiratory failure. ICU admission may also be required for non-respiratory issues, such as autonomic dysfunction [9].

Bulbar dysfunction can also limit the accuracy and utility of spirometry. In order to perform spirometry effectively, patients must be able to make a 'seal' on the mouthpiece. Accordingly, those with facial diplegia may be precluded from performing this task accurately, and the use of a facemask is considered a better alternative [22]. Therefore, it remains necessary to have a suite of techniques to evaluate the likelihood of respiratory deterioration in these patients.

A multitude of factors have been investigated in the prediction of respiratory failure and the requirement for I + V in patients with GBS. For example, neck flexion was found to be an independent predictor of I + V [18]. In particular, neck flexion ≤ grade 3 on Medical Research Council Scale has previously been demonstrated to identify 100% of patients who require I + V, although only in small studies [23]. The single count breath has been found to be a moderately accurate surrogate for pulmonary function tests [18,24,25]. Nerve conduction studies have a role to play in the diagnosis of GBS; however, existing studies suggest that their role in the prediction of respiratory failure may be more limited [13,25-28]. A variety of laboratory tests have also been investigated in the prediction of GBS severity and respiratory failure, including inflammatory markers and hyponatraemia, with moderate performance described [29-31].

It was not possible to examine a relationship between initial respiratory parameters and time to ICU admission or duration of ICU admission. While multiple articles presented information on the time between onset of GBS symptoms and the likelihood of ICU admission or I + V, these analyses did not focus on associations between respiratory parameters and the timing or duration of ICU admission [14-17,19]. In these studies, it was found that hospital admission<7 days from the onset of disease was an early predictor of the need for mechanical ventilation. For example, in Sharshar et al. it was found that time from a symptom onset to admission duration of<7 days was significantly associated with an increased likelihood of I + V (odds ratio 2.51, 95% confidence interval 1.68 – 3.77, p = 0.0001) [19]. Further evaluation of the relationship between respiratory parameters and time to, or duration of, ICU admission would be a useful topic for further research.

The prediction of respiratory failure in paediatric patients was beyond the scope of this review. Therefore, studies that presented results for both adults and paediatrics collectively were excluded. These excluded studies may have relevance to adolescents who present to adult hospitals in an emergency. For example, in a study by Lawn et al., 114 patients with GBS (aged from 4 to 87 years) were evaluated in a retrospective study. This study demonstrated that VC < 20 mL/kg, or a reduction of > 30% in VC, were associated with progression to respiratory failure [9]. Another study that included both paediatrics and adults was one of few studies that presented data regarding peak expiratory flow rate, with results indicating that values < 250 mL/min were associated with an increased likelihood of requiring I + V [32]. While not included in this review, these studies provide some evidence for commonly employed thresholds (see Table 3). Even so, the performance of these thresholds in predicting respiratory failure is relatively poorly defined.

The studies included in this review had several limitations. For example, a limitation of the studies included in this review is the potential for a perceived indication for I + V to prompt intervention, and thereby create a self-fulfilling prophecy with respect to indications for I

Table 3
Evidence for commonly used thresholds.

Parameter	Threshold	Performance*	Supporting studies
Always consider alternative indications for I + V, including bulbar dysfunction			
VC	< 20 mL/kg	Patients who required I + V were more likely to have a VC < 20 mL/kg at some time after admission (P < 0.001).	Lawn et al. 2001*
FVC	< 15 mL/kg	All patients who required I + V had FVC < 15 mL/kg on admission	Kanikannan et al. 2014
			Chevrolet et al. 1991
		VC was 15.2 ± 3.7 mL/kg in intubated patients	
VC	< 60% predicted	VC < 60% of predicted at admission was associated with eventual I + V (OR 2.86 CI 2.43–10.00, P < 0.0001)	Sharshar et al. 2003
			Durand et al. 2006
		VC was on average 61% of predicted value for the ventilated group.	
Peak Expiratory Flow Rate	Any	Peak Expiratory Flow Rate < 250 mL/min increased the likelihood of requiring I + V.	Gonzalez-Suarez et al. 2013*

*Included paediatric patients and therefore study was not included in systematic review.

+ V. Few studies provided details on the GBS subtypes included in their cohorts [14,18]. Similarly, few details were provided regarding the criteria which patients fulfilled to arrive at a diagnosis of GBS. Additionally, a significant limitation of the included studies is that facial weakness may limit the accuracy of spirometry evaluation. The methods of spirometry assessment were not described in all studies, and differed between the studies, which limits the inferences about the generalisability of measurements. Another potential confounding factor is the fact that some patients may have received more timely disease-modifying treatment than others, which may have influenced the subsequent likelihood of requiring ICU admission and I + V.

The present systematic review has several limitations. Only articles available in English were included in the systematic review. Another limitation is the exclusion of studies due to an inability to be retrieved in full-text. It is also possible that publication bias may have influenced the results of the review.

Future multi-centre studies may help establish the external generalisability of the commonly used thresholds for spirometry parameters in GBS. Studies specifically examining patients with obesity, advanced age, and respiratory comorbidities may aid in the interpretation of these results. Future studies should also investigate whether spirometry parameter thresholds may have differing implications for subtypes of GBS, such as axonal forms of GBS as compared to acute inflammatory demyelinating polyradiculoneuropathy.

Furthermore, additional research characterising the trends in spirometry, and how these trends may predict the requirement for I + V may be beneficial. Finally, studies implementing protocols and specific thresholds for ICU admission and/or I + V, aiming to improve patient-centred outcomes, would be useful in the future.

6. Conclusion

Patients with GBS may require ICU admission and I + V due to respiratory failure. The results of this systematic review indicate that a lower VC on admission predicted the need for I + V, but the evidence on thresholds for I + V is limited. Therefore, future research could be directed towards identifying the specific thresholds for ICU admission and I + V based on respiratory parameters and patient characteristics.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jocn.2023.04.022.

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