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QUALITY IMPROVEMENT REPORT

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Reducing neuropathies between the 2020 and 2021 Covid-19 surges in a large UK intensive care unit: A quality improvement project

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Abstract

Background: Peripheral nerve injuries (PNIs) can be acquired by patients in intensive care unit (ICU) who are critically unwell with Covid pneumonitis. Prone position ventilation has been linked to this life-changing complication.

Aim: To reduce the occurrence and severity of PNIs for patients with Covid pneumonitis requiring prone positioning whilst sedated and ventilated in ICU.

Study Design: This study is a quality improvement project that evolved over the course of the first two surges of Covid pneumonitis admissions within the ICU at the Queen Elizabeth Hospital Birmingham (Surge 1: March 2020–July 2020, 93 prone ventilation survivors; Surge 2: September 2020–May 2021, 309 prone ventilation survivors). Implementation of updated prone positioning guidelines that aimed to reduce the risk of PNI. This was supplemented by face-to-face teaching for ICU professionals. The number of patients who sustained PNI and the severity of such injuries were recorded.

Results: During the first surge 21 patients (22.6%) had at least one high grade PNI. During the second surge there were 12 patients (3.9%) sustaining an intermediate or high grade PNI. For PNI patients, there was an increase in the mean proning episodes (6–13) and duration (17.8–18.6 h). This represents an 82% reduction in PNI cases. High grade injuries reduced from 14/21 (66%) to 4/12 (33%).

Conclusions: Optimizing the position of patients in the prone position in ICU with Covid pneumonitis may be key in reducing the development of PNI. Changes to pharmacological management may have influenced the results seen in this study.

Relevance to Clinical Practice: Clinicians working within ICU with acutely unwell patients with Covid pneumonitis should acknowledge the heightened risk of PNI and take relevant steps to reduce the risk of injury acquisition.

KEYWORDS
Covid-19, intensive care, nerve injury, prone positioning, quality improvement

1 | INTRODUCTION

1.1 | Problem description

The use of the prone position in intensive care units (ICU) has been well established as an effective treatment for patients who are acutely unwell with Covid Pneumonitis.[1] Despite the benefits of proning, placing a patient into the prone position in ICU offers many challenges, including having enough people to carry out the procedure safely, negotiating critical attachments and positioning patients who in many instances present with very high body mass index.

Several neuromusculoskeletal complications from proning have been reported in the literature. These include peripheral neuropathies affecting the upper and lower limb,[2–5] the development of multifactorial musculoskeletal shoulder pain[6] and even cervical spine injury.[7]

Peripheral nerve and brachial plexus injuries can be devastating and are associated with reduced quality of life, impaired activity participation, persistent pain, and psychological morbidity.[8,9] Severe cases often require reconstructive nerve surgery. Added to the wider complex rehabilitation burden that Covid-ICU survivors face, this can result in significant disability for this particular patient group.

What is known about the topic

- The prone position is used to help ventilate critically ill patients with Covid pneumonitis.
- Peripheral nerve injury has been reported as an adverse effect of the prone position, causing significant disability.
- Guidelines have been developed to help minimize neuromusculoskeletal complications of prone positioning but their effectiveness is unknown.

What this paper adds

- This work details how many nerve injuries (including severity) were seen in both pandemic surges at one large critical care unit.
- This work demonstrates how a reduction in the frequency and severity of peripheral nerve injuries was observed between two surges of the Covid pandemic. This reduction may have been influenced by the implementation of revised positioning guidelines and critical care staff education.
- Considerations for the positioning of the critically ill prone-positioned patient are described and illustrated.

1.2 | Available knowledge

The pathoaetiology of proning related peripheral nerve and brachial plexus injury is likely to be multifactorial. Elements of direct nerve compression/traction in addition to global inflammatory state which Covid-19 promotes may be potential contributors to the injury. A useful overview of potential neurological mechanisms is put forward by Fernandez et al.[10]

Prior to the initiation of this improvement project, local prone position guidelines taken from the FICM[11] were used, however, no mention of peripheral nerve injury (PNI) is made within this document. Further guidance proposed by Quick and Brown[12] described methods to reduce traction on peripheral nerve structures and reduce injury.

1.3 | Rationale and specific aims

Our team noticed an influx of referrals to the peripheral nerve service during the first surge of the pandemic observing many patients develop peripheral neuropathies.[13] We identified a potential causal link to patients being prone ventilated and sustaining PNI.

At our centre pre-existing proning guidelines advocated the classic swimmer's position for all patients. During the first surge of Covid-19 admissions, reducing harm from prone positioning mainly focused on reducing pressure damage to the skin around the head and neck. Following the first surge of the pandemic we rapidly commenced a quality improvement project with the aim of reduce the number and severity of peripheral neuropathies identified following Covid-19 ICU admission by changing local proning guidelines. This report will present the methods and results of the service evaluation and conclude with a discussion and limitations of our findings.

This manuscript has been created using the revised Standards for Quality Improvement Reporting Excellence (SQUIRE 2.0).

2 | METHODS

2.1 | Context

Like many hospitals, our centre saw a huge increase in critical care admissions for people critically unwell due to Covid-19 pandemic. This period saw a massive change in how the majority of hospital (and community) services were being. Many health professionals from diverse health roles were redeployed to critical care from non-critical care teams. This is an important contextual factor to bear in mind when reading and potentially implementing the findings of the evaluation.

Factors that effected staffing, that is, mandatory isolation, high stress and a lack of specialist knowledge and skills were taken into consideration when delivering this project, but also factored in when data were collected and analysed—for example, clinical noting may

Head and neck	Make sure head is **turned towards the flexed arm**
	Neck is not overly rotated
	Neck is not overly side flexed (keep the neck in a straight alignment)
	Neck is not overly extended (not tilted back too far)
Shoulder girdle	Shrug the shoulder girdle to offload the brachial plexus (avoid stretch on the muscle between the shoulder and neck)
Shoulder	Shoulder joint is abducted to less than 90°, ideally less than 45°
	Shoulder joint is forward flexed (not extended) — support at chest
Elbow	Elbow is flexed less than 90°, ideally less than 45°
Knees	Support legs to avoid prolonged periods of loaded extension/hyperextension at the knees (use pillows to offload back of knee and avoid legs hanging off edge of bed)
Compression	Minimise direct compression at medial elbow
	Minimise direct compression to the medial upper arm
Arm and head cycling	Cycle arms and head every 2 — 4 h Head should always be facing the flexed arm. Do not cycle the arms if unable to perform head turn.

FIGURE 1 Head and limb positioning guidance for patients in the prone position on the intensive care unit

have been incomplete or not detailed enough to collect data on proning data or when patients were repositioned. Despite this, a culture of teamwork grew. Rapid collaboration between unusual team members spanning across the patient journey from admission to discharge was fostered. In terms of nerve (and other musculoskeletal) injury prevention, interest from medical, nursing, and therapy colleagues was coordinated into a team that focused on reducing harm from prone positioning.

2.2 | Patient identification

Between March 2020 and May 2021, patients who sustained peripheral neuropathies during their inpatient stay on Covid-ICU were identified by the dedicated peripheral nerve therapy team. We experienced two distinct surges of patients being admitted with acute Covid pneumonitis. The first surge at our centre was

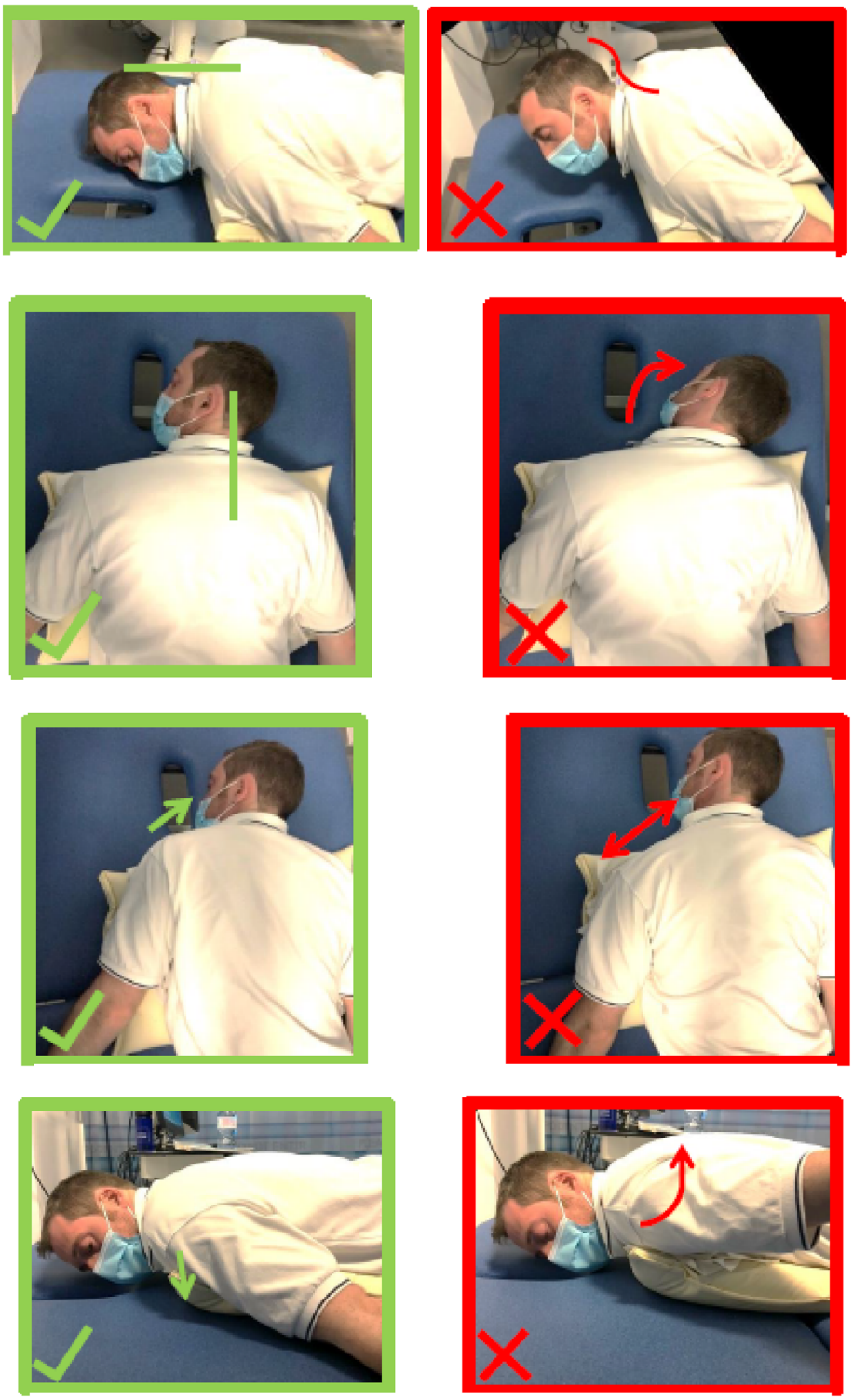

FIGURE 1 (Continued)

defined as taking place between March 2020–July 2020 and the second surge defined as taking place between September 2020 and May 2021.

The peripheral nerve therapy team was available for any member of therapy staff within the ICU or acute rehabilitation wards to refer potential patients to for inpatient-based assessment. Some patients were also identified in post-ICU outpatient clinics, perhaps due to specific residual nerve injuries becoming evident only once globalized intensive care associated weakness resolved.

FIGURE 1 (Continued)

2.3 | Interventions

The early data of the first 15 patients with PNI from the first surge are detailed in our initial retrospective case series.[13] We used this data and further experience gained during the first surge to modify previous prone positioning guidelines highlighted in the introduction of this article.[10,11] This was done to reflect the changes we felt needed to be included, such as making reference to lower limb positioning, further reducing the degree of shoulder abduction, and making key reference to avoiding deep elbow flexion.

The guideline we developed is shown in Figure 1. The guidelines were made available to all staff on Covid-ICU in paper format and via email. The ICU consultant responsible for reducing harm in ICU as well as key nursing educational leads were involved in the development

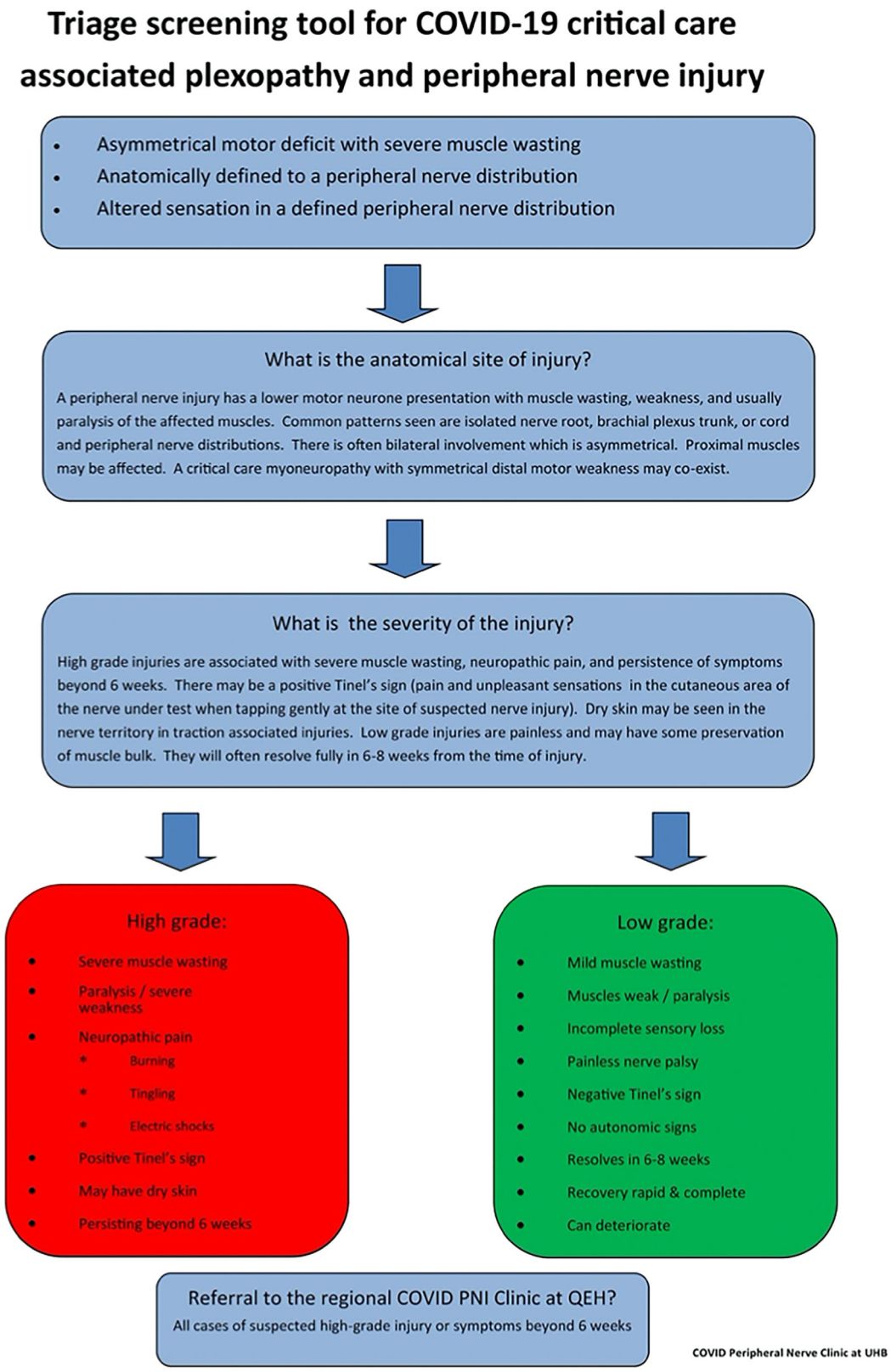

FIGURE 2 Nerve injury triage screening tool

and implementation of the new guidelines. This collaboration of ICU nursing and medical leads (who were experts on environmental factors and the proning process itself) and specialist therapists (with relevant anatomy and musculoskeletal care skills) working on this guidance was felt to be important.

General attention to keeping the neck and shoulder in neutral, non-stretch positions was encouraged, particularly to avoid traction to the brachial plexus and to keep the shoulder from dislocation and thus injuring the axillary nerve. During busy periods, it was noted that the position of the head *or* arms would be cycled during the first surge,

Surge period	March – July 2020	September 2020 – May 2021	Key % changes between surges
Number of survivors of Covid ICU	93	309	
Number of survivors who sustained any PNI	21 (22.58%)	12 (3.88%)	82% Reduction
Number of severe PNI	14 (66%)	4 (33%)	50% Reduction
Number of patients with tibialis anterior weakness	3 (3.2%)	6 (1.9%)	41% Reduction
Proning duration (median) (interquartile range)	17.34h 1.94	18.55h 1.1125	
Proning frequency (median) (interquartile range)	6 6	13.5 12	
Age (median) (interquartile range)	59 12	53 14.25	
Glenohumeral joint dislocations (confirmed radiographically)	3	0	100% Reduction
Initial outpatient DASH (number completed) (median) (interquartile range)	*n* = 12 73.5 20.125	*n* = 10 73.3 22.675	
Number of patients listed for surgery	7	4	

FIGURE 3 Results table demonstrating patient outcomes for nerve injury occurrence/severity and proning frequency/duration during the 2020 and 2021 pandemic surges at our centre. ICU, intensive care unit; PNI, peripheral nerve injury

resulting in the head being turned away from the outstretched arm, further putting traction on the brachial plexus. This was a key acknowledgment in the new guideline. With the most common injury seen in the first surge being ulnar neuropathy at the cubital tunnel, minimizing the degree of elbow flexion was also an important consideration.

Although much attention was focused on the upper limbs, the first surge saw a number of patients develop foot-drop, with total loss of activity at tibialis anterior (the prime ankle dorsiflexor muscle). As a result, the position of the lower limbs featured within the guideline. The aim here was to reduce traction on the common peroneal nerve as it crosses the posterolateral knee joint which was felt to be caused by heavy, often oedematous legs hanging over the edge of the bed.

2.4 | Intervention dissemination and change of practice

ICU physiotherapy staff participated in a practical seminar training session on how to identify PNI and optimize prone positioning. Whilst unable to deliver this training in the same way to the nursing and medical teams on the ICU, 'on the floor' training was provided over the course of three 2-h sessions to capture as many nursing and medical staff working in ICU as possible early on in the second surge. This ensured that the development of the guideline in the early stages was an iterative process whereby nursing staff were able to give their thoughts on the new guideline, for example in

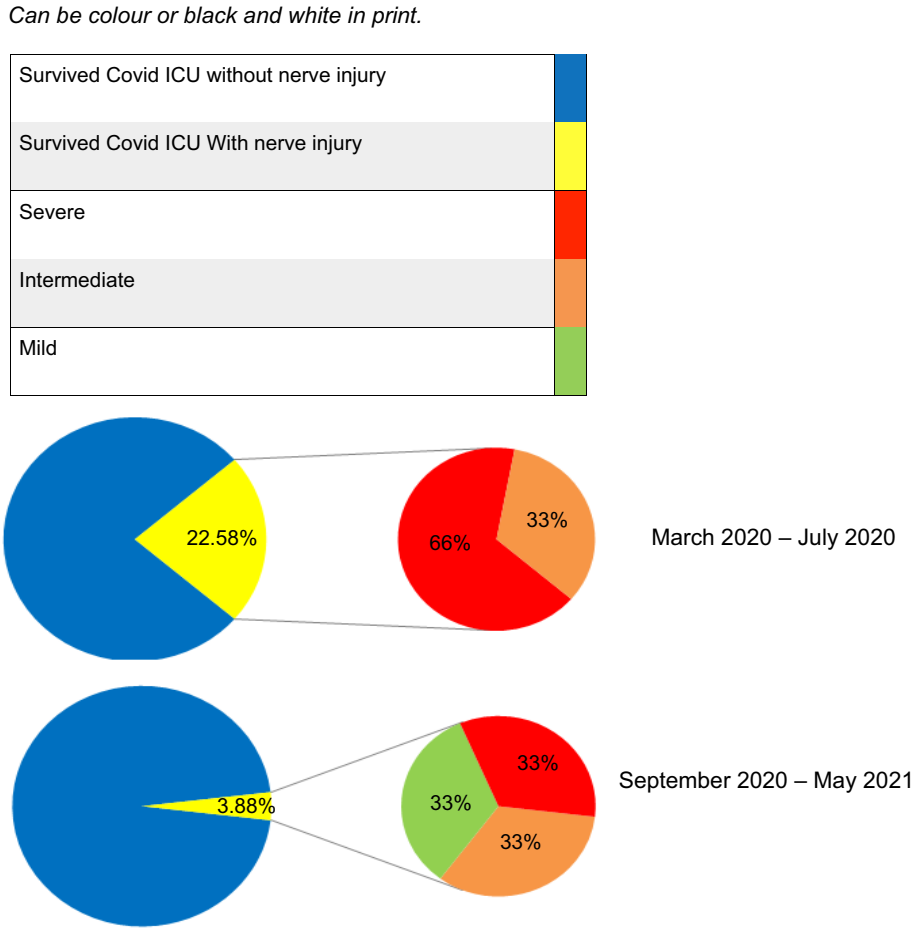

FIGURE 4 Pie chart illustrating the proportion of patients who acquired nerve injury between the 2020 and 2021 pandemic surges including a breakdown of severity classification. ICU, intensive care unit

ensuring that the recommendations and the images used were easy to interpret.

During these training sessions, key messages included the existence of proning injuries as an entity and their impact, the potential mechanisms of injury and potential suggestions of improving positioning with reference to the new guideline. More pertinently our aim was to empower staff to position patients in a way that made sense for the patient as an individual, considering their specific habitus and premorbid joint mobility and therefore often taking them away from the classic swimmers position demonstrated within previous guidelines.

2.5 | Study of the interventions

We assessed the impact of the intervention by identifying the number of nerve injuries acquired between each surge, the severity of these injuries by use of a simplified nerve injury grading system, the number of glenohumeral joint dislocations, and patient reported disability at first outpatient follow up.

The nerve injury grading system categorized observed PNIs into severe, intermediate, and mild.[14] Data about the presence of neuropathic pain, degree of motor loss, muscle wasting, sensory loss, and presence of Tinel's sign (tingling and/or pain when the skin over the course of a nerve(s) is percussed, signifying an area of nerve irritation) were collected in order to grade injury severity. This simplified grading system based off the Seddon system[15] was used to facilitate effective simple communication between specialist and non-specialist health care workers working in redeployed roles and also negated the need for electrophysiology studies in order to classify grade of PNI for all patients (Figure 2).

To establish whether other factors may have accounted for a change in outcome, data on length of time proned, and frequency of proning was also collected. However, pharmaceutical interventions may have changed for this second cohort impacting on the outcomes. It was outside the scope of this service evaluation to control these factors.

Once transferred to the outpatient follow up setting, the majority of patients completed the Disability of the Arm, Shoulder, and Hand (DASH) questionnaire to help assess the impact upon patient function. The DASH score can range from 0%–100%, whereby a higher percentage score represents higher patient reported disability.

2.6 | Data collection and measures

Electronic ICU clinical noting was examined to identify the frequency and duration of each proning episode for each patient who presented with PNI. The clinical data were collected by senior therapists with over 10 years of experience working in nerve injury care. A framework was used to ensure that data were complete and as accurate as possible. We held regular team meetings to discuss ongoing data collection and any issues were raised, discussed, and consensus reached

when uncertainty on any data. The proning procedure checklist was updated to include acknowledgment that the positioning guidance had been considered for each patient per proning.

2.7 | Analysis

Data were analysed using descriptive statistics. Our centre's health informatics team deduced the number of patients who survived critical care per surge period. We used our data on how many limbs acquired PNI (*limbs* vs. *number of patients* acquiring PNI to account for the fact that some individual patients had multiple limbs affected) to then find the percentage of those affected for each surge. Severity scores were compared between surges by way of working out as percentages for both surges. The raw number of shoulder dislocations and cases of foot-drop were collected during both surges and then compared directly.

2.8 | Ethical considerations

This retrospective study was registered and approved by the University Hospitals Birmingham National Health Service Foundation Trust Clinical Audit Registration Management System (CARMS-16211). Research ethics committee review was not sought or required for this project, due to the data being collected as part of normal clinical pathways. This was confirmed via completion of a National Health Service Health Research Authority research decision tool, confirming that this project would not be deemed research by the National Health Service. Therefore, patient consent for holding anonymised data was not required.

3 | RESULTS

No modifications to the intervention were made during the project.

Figures 3 and 4 illustrate the findings of this service evaluation.

For PNI patients, there was an increase in the mean proning episodes (6–13) and duration (17.8–18.6 h) between the first and second surges respectively. During the first surge, 21 out of 93 ICU survivors (22.6%) had at least one PNI.

Despite the increase in proning, during the second surge there were 12 out of 309 survivors (3.9%) sustaining a PNI. This represents an 82% reduction in PNI cases.

With respect to PNI severity, those who sustained high grade injuries reduced from 14/21 (66%) to 4/12 (33%). There were no shoulder dislocations in the second surge as opposed to three in the first surge.

The cases of acute foot-drop changed from 3/93 (3.2%) to 6/309 (1.9%) representing a 41% reduction between surges.

Patients who were listed for surgery (nerve decompression and/or nerve transfer/reconstruction) reduced between surges—7 listed from the first surge and 4 listed from the second surge.

The mean first outpatient DASH questionnaire scores were 73.5% for patients seen from the first surge and 73.5% from the second surge, representing no real change in patient reported upper limb disability at first assessment.

In terms of demographics, the mean age of PNI patients was 59 in the first surge and 53 for the second surge. There was a similar spread of co-morbidities (namely diabetes mellitus, obesity, and hypertension) across the patients who sustained PNI during both surges.

Many patients were unable to be positioned into a position that perfectly met all of the recommendations within the guidelines. This was especially an issue with bariatric patients. Some staff were concerned that patients were therefore at risk and were unsure about what parts of the recommendations to prioritize—this was an unintended consequence. To offset this, the Multidisciplinary team were reassured during the roll out of the updated guidelines to use own clinical judgement and to choose what seemed right for each patient.

Some patients did not complete the DASH as they did not attend their first outpatient clinic appointment. Furthermore, some were not asked to complete the DASH during the early first wave period, as they could only be offered virtual appointments due to restrictions on footfall within the hospital setting; completion of the DASH this way would be too time consuming. Some of these patients also needed different language versions of the DASH which could not be completed via telephone consultation. One patient during the first wave did not attend their first outpatient appointment and later died before any other follow up reviews to assess their progress and collect data could be offered.

4 | DISCUSSION

4.1 | Summary

To our knowledge this is the first reported project looking into reducing Covid-ICU proning related neuropathies. The results reflect an improvement upon PNI occurrence and severity following the implementation of our prone positioning guideline.

The DASH scores recorded show that at initial contact following discharge from intensive care there were high levels of disability seen across the patient groups following both surges. This demonstrates that even with less severe grades of PNI (i.e., a neuropraxia lasting less than 3 months), initial disability was still significant.

Other experts in nerve injury acknowledge that each patient will have different needs when it comes to positioning and that there is no one single perfect position.[16] Maintaining a patient centred approach by considering individual physical restrictions and body habitus remains paramount. The guidance we used is not a strict protocol. It includes useful practical considerations but all those caring for this patient group should be empowered to modify positioning as indicated on a person-by-person basis.

4.2 | Interpretation

Whilst our findings suggest that the implementation of updated positioning guidance and training may have had a positive effect, there

may also be other factors at play. Covid-19 infection causes systemic inflammation[17] and this has been suggested as a potential mechanism of PNI in this patient group as previous discussed in this article. During the second surge the use of dexamethasone, tocilizumab, and remdesivir was implemented. This significant change in pharmacological management may also have influenced our results. Of relevance here is that only during the second surge did we have no cases of heterotypic ossification and frozen shoulder referred to our service. These conditions have inflammatory mechanisms as part of their aetiology[18,19] and perhaps this suggests that the general inflammatory environment was not enough for certain pathologies to develop during the second surge.

No shoulder dislocations were reported or referred to our team during the second surge. This may be solely related to the standard of proning and patient handling and not related to any pharmaceutical changes. Considering the increased number of patients admitted to the ICU during the second surge, it could be argued that the number of dislocations may have been higher if our guidance had not been implemented.

Whilst we found significant improvements in upper limb PNI, we found a more modest improvement in the number of those developing foot-drop between the first and second surges. Offloading of the knees may have a beneficial effect on the development of common peroneal nerve palsy, but the numbers seen in this study are two small to make any firm conclusions.

4.3 | Limitations

We were unable to collect data on patients who survived Covid-ICU without PNI due to lack of time. As a result, we cannot develop a clearer understanding of how the duration and frequency of proning itself had upon the development of nerve injury at this stage. Despite this it is felt that an appropriate balance was found between data richness and the need to rapidly change practice and disseminate findings during this quality improvement project. We did not collect data on repositioning of arms and head position as this procedure may not have always been routinely documented during times where the unit was under extreme pressure, especially whilst being staffed by many redeployed health care workers who were responsible for documentation. Some mild and intermediate nerve injuries may not have been identified from patients who were sedated and/or unable to participate in meaningful assessment before they resolved. However, to date we have not had any more patients (treated at our ICU) referred to our service, that is, from outpatient clinics, since data collection stopped in September 2021.

Finally, the use of the DASH questionnaire proved useful in planning rehabilitation and understanding the impact of upper limb impairments, however the items on the DASH questionnaire were not answered purely within the context of nerve injury; confounding impairments such as cognitive issues, global de-conditioning and fatigue would likely affect how the patients rated their ability to perform many functional tasks. It could be argued that a brachial plexus specific outcome measure such as the Brachial Assessment Tool[20] could have been used in addition.

5 | CONCLUSIONS

Optimizing positioning of the proned ventilated patient may have reduced the incidence of nerve injury at our centre. Changes to the pharmacological management of these patients may have also played a significant role.

Individuals from the second surge still developed severe injury despite this change in practice, some going on to have reconstructive nerve surgery. Individual risk factors and other methods of optimizing the prone positioning in ICU should be investigated further in order to reduce the impact of this potentially life-changing impairment.

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