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The risk of pressure ulcers in a proned COVID population

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**Abstract**

The utilisation of prone positioning has been vital during the COVID-19 pandemic, however risks the development of anterior pressure ulcers. An observational study was performed to examine the prevalence of pressure ulcers in this population and define risk factors. Eighty-seven patients admitted to critical care were studied. Of 62 patients with >1 day in prone position, 55 (88.7%) developed anterior pressure ulcers, 91% of which were anterior. The most commonly affected site were the oral commissures (34.6%), related to endotracheal tube placement. Prone positioning (p < .001) and the number of days prone (OR 3.11, 95% CI 1.46–6.62, p = 0.003) were a significant risk factors in development of an anterior ulcer. Prone positioning is therefore a significant cause of anterior pressure ulcers in this population.

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**Introduction**

The SARS-COVID-19 pandemic has strained resources within healthcare systems and forced us to change how we treat large number of critically ill patients at any one time. Severe COVID-19 infections can result in a clinical picture similar to Acute Respiratory Distress Syndrome (ARDS). A recognised strategy to manage these sequelae of COVID-19 is the utilisation of prone positioning; this has been employed to good effect with improved outcomes.

At the time of writing, 21,084 patients have been managed in critical care units in England, Wales and Northern Ireland. Critical care patients are recognised for having higher risk for developing pressure ulcers (PrU) due to their immobility, reliance on regular position changes and pressure relief devices. Prone positioning and the use of invasive medical devices such as feeding tubes, urinary catheters and central venous- and arterial lines may increase this risk.

Our study aimed to examine the prevalence of pressure ulceration in a prone positioned population and identify associated risk factors.

**Methods**

**Data collection**

A retrospective cohort study was performed in accordance with Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. All patients admitted to the Intensive Care Unit at the Queen Elizabeth Hospital, Birmingham on 19th April 2020 were recruited. Data collected included patient demographics, number of days in prone position, methods of Endotracheal (ET) tube fastening and the presence and distribution of PrUs. Age was categorised as per the Intensive Care National Audit and Research Centre (ICNARC) data, for comparison, and Body Mass Index (BMI) categorised as per the NHS classification (https://www.nhs.uk/conditions/obesity) to allow comparison and generalisation. BMI was estimated based on previous measurements.

All patients admitted to critical care had ET tubes, nasogastric (NG) tubes, urinary catheters, and central venous access. Patients were positioned prone with a PaO2/FIO2 ratio <15 kPa, equating to severe ARDS, by the Berlin Definition.
PrUs were divided into anterior and posterior, with anterior PrUs more likely to be related to proning due to the pressure on the anterior surface. Acute Physiology And Chronic Health Evaluation II (APACHE II), Sequential Organ Failure Assessment (SOFA), CURB-65, Waterlow, serum albumin and serum haemoglobin (Hb), were recorded at the time of identification of pressure injury. APACHE II and SOFA tools estimate Critical Care mortality risk, and CURB-65 is a tool used to estimate mortality risk in community-acquired pneumonia. Waterlow gives an estimated risk of developing a PrU in a given patient. For patients without PrUs, these parameters were recorded 7 days post-admission; this was the mean number of days between admission and development of PrU.

Data was extracted from electronic noting, and calculations performed using MDCalc (www.MDCalc.com). Ethical approval was not needed, as this was an observational study.

Data analysis

Data was analysed using Stata 15 (Statacorp LLC, Texas, USA). A univariable analysis was performed using a Chi-squared test to determine an associated between proning and development of anterior PrU. A subsequent multivariable logistic regression was developed in order to consider factors associated with development of an anterior PrU (include variables); proning sessions indicates the number of 16-h sessions the patient spent in the prone position, prior to development of a PrU. The p value of <0.05 was taken as the statistical significant threshold.

Results

Demographics

Demographic data is summarised in Table 1. Eighty-seven patients were included in the study. Male sex was statistically significant in the development of an anterior PrU (p = 0.044 95% CI 1.05–40.48), 55 males developed PrUs, compared to 11 females in any anatomical location.

The most common age category for both sexes combined was 60–69 (n = 26), whereas for females was 50–59 (n = 8). The mean age amongst all age categories was 54.

Pressure ulcers

Sixty-six (75.8%) patients developed a PrU of any kind. Fifty-three patients had only anterior PrUs, 4 patients had only a posterior PrU, whilst 9 patients had at least one of each type. Sixty-two patients had 111 separate PrUs. The mean time from admission to diagnosis of a PrU was 7 days.

Ulcers located on the head and neck totalled 101, 77.7% of all anterior and posterior PrUs, and 88.3% of all those on the anterior surface. The remaining anterior PrUs occurred on the genitalia (n = 8), finger (n = 1) and anterior torso (n = 4). The most common site (34.6% of all PrUs) of PrUs was of the oral commissures. Other common areas included nose – including nasal ala and columnella (11.5%), central lip (8.5%), ears (6.9%) and cheeks (5.4%) (Fig. 1). Of all documented lesions, 40% were grade 2, 30% were deep tissue injuries (DTI), the rest were recorded as unstageable, as per National Pressure Ulcer Advisory Panel (NPUAP) 2016 criteria7 (Table 2).

Table 1 – Demographic Data

| Age range | All patients n = 87 | Patients with Anterior Pressure Ulcers n = 62 |
|-----------|-------------------|------------------------------------------|
| 16–29     | 3                 | 2                                        |
| 30–39     | 6                 | 4                                        |
| 40–49     | 21                | 17                                       |
| 50–59     | 25                | 17                                       |
| 60–69     | 26                | 20                                       |
| 70–79     | 6                 | 2                                        |

| Sex (n (%)) | All patients | Patients with Anterior Pressure Ulcers |
|-------------|--------------|---------------------------------------|
| Male        | 69 (79.3)    | 52 (83.9)                             |
| Female      | 18 (20.7)    | 10 (16.1)                             |

| BMI (n %) | All patients | Patients with Anterior Pressure Ulcers |
|-----------|--------------|---------------------------------------|
| 18.5–24.9 – healthy weight | 10 (11.5) | 4 (6.5) |
| 25.29.9 – overweight | 35 (40.2) | 25 (40.3) |
| 30.39.9 - obese | 30 (34.5) | 24 (38.7) |
| >40 – severely obese | 12 (13.8) | 9 (14.5) |

| Prone to lesion sessions (Median (IQR)) | All patients | Patients with Anterior Pressure Ulcers |
|----------------------------------------|--------------|---------------------------------------|
| Presence of posterior pressure ulcer (n %) | 13 (14.9) | 9 (16.9) |

Mean Physiological Parameter (Median (IQR))

| Albumin (g/L) | All patients | Patients with Anterior Pressure Ulcers |
|--------------|--------------|---------------------------------------|
| 17 (15.5–20) | 17 (16–20)   |

| Haemoglobin (g/L) | All patients | Patients with Anterior Pressure Ulcers |
|-------------------|--------------|---------------------------------------|
| 93 (82–105.5)     | 93 (80.25–109) |

| Waterlow | All patients | Patients with Anterior Pressure Ulcers |
|---------|--------------|---------------------------------------|
| 27 (23.5–30) | 26.5 (23–29) |

| CURB-65 | All patients | Patients with Anterior Pressure Ulcers |
|---------|--------------|---------------------------------------|
| 1 (1–2) | 1 (1–1.75) |

| APACHE-II | All patients | Patients with Anterior Pressure Ulcers |
|-----------|--------------|---------------------------------------|
| 14 (12–19) | 14 (11.25–19) |

| SOFA | All patients | Patients with Anterior Pressure Ulcers |
|------|--------------|---------------------------------------|
| 7 (5–8) | 6 (5–8) |

Prophylaxis positioning

A total of 62/87 (70.5%) patients were prone for a median of 4 sessions (IQR 3–7) and 57/62 (91.9%) developed a PrU. The remaining 25 had no sessions prone between admission and study date.

Using a Pearson chi-squared test, proning was a statistically significant cause of anterior PrUs (p = 0.044 95% CI 1.05–40.48), 55 males developed PrUs, compared to 11 females in any anatomical location.

A Kaplan–Meier survival curve for development of an anterior PrU, comparing prone and non-prone cohorts (Fig. 2), shows that all patients prone positioned (red dotted line) will develop a PrU by 20 days.

Other risk factors

Neither Age, BMI, presence of concurrent posterior PrU nor the physiological parameters proved an increase risk for development of an anterior PrU (Table 2).
Discussion

Pressure ulcers occur when the pressure exerted on tissues exceed their perfusion pressure, resulting in ischaemic necrosis. Critical care patients are high risk due to the inability to reposition themselves to a position of comfort. Ulceration and tissue damage are common in this COVID population due to the prone positioning and use of medical devices to assist and supplement care. The use of vasopressors reduces peripheral tissue perfusion, and wound healing potential significantly decreases due to the systemic inflammatory response. Pre-existing preventative and management strategies include regular repositioning, correct mattresses and pressure redistribution, however gel pads and high-specification mattresses were in short supply due to unprecedented demand.

Our study demonstrates a significant causation of anterior PrUs in prone patients, in different anatomical locations compared to typical PrUs seen in a critical care setting. This risk was increased per session prone. Compared to the national ICNARC data, our study population was similar in age (mean 54.0 vs. 58.7) and gender (79.3% males vs. 70.7). The most common age range in both was 60–69 (26 vs. 21.1). Our population had less in the 70–79 age group category, possibly due to stricter admission criteria to critical care compared to other units. Risk factors including age, BMI and physiological status were not significant in the development of PrUs opposed to studies indicating that age and BMI does have an influence on the risk profile.

Previous studies highlighted the incidence of PrUs in the prone population in patients with ARDS between 11 and 65%, regardless of anatomical distribution. Our study demonstrates a higher incidence of 75.8%. These studies were performed on ARDS patients of any cause. The key difference in our population is it was performed on COVID-19 patients during a pandemic. This led to huge demand on medical and nursing staff, whereas the other studies were performed in controlled environments with normal staffing levels.

The PROSEVA trial, demonstrated a significant reduction in 28-day and 90-day mortality in prone patients compared to control. This positioning improves both oxygenation and reduces airway opening pressures in the dorsal aspects of the

Table 2 – NPUAP 2016 classification of Pressure Ulcers.

| Stage | Description |
|-------|-------------|
| Stage 1 Pressure Injury | Non-blanchable erythema of intact skin |
| Stage 2 | Partial thickness skin loss with exposed dermis |
| | May present as intact fluid filled blister. Adipose tissue not visible at base of wound |
| Stage 3 | Full thickness skin loss |
| | Adipose tissue exposed. Muscle, tendon or bone are not exposed. If slough or eschar obscures extent of tissue loss, this is Unstageable Pressure Injury |
| Stage 4 | Full thickness skin and tissue loss |
| | Exposed or directly palpable fascia, muscle, cartilage, tendon or bone. |
| Unstageable Pressure Injury | Obscured full-thickness skin and tissue loss |
| | Tissue loss in which extent of damage cannot be confirmed due to slough/eschar. When removed stage 3 or 4 injury will be revealed |
| Deep Tissue Injury | Persistent non-blanchable deep red, maroon or purple discolouration |
| | Persistent sheath/friction at bone-muscle interface resulting in intact, discoloured skin. May rapidly evolve to reveal actual extent of tissue injury |

Fig. 1 – Anatomical distribution of facial PrUs n (%).
Multivariable analysis of risk factors.

| Sex       | Baseline | P > z | 95% Conf. Interval |
|-----------|----------|-------|--------------------|
| Male      | 7.17     | 0.083 | 0.77               |
| Age       | Baseline |       |                    |
| 30–39     | 3.62     | 0.660 | 0.01               |
| 40–49     | 9.42     | 0.218 | 0.27               |
| 50–59     | 3.16     | 0.488 | 0.12               |
| 60–69     | 10.02    | 0.210 | 0.27               |
| 70–79     | 1.56     | 0.836 | 0.02               |
| BMI       | Baseline |       |                    |
| 18.5–24.9 | 2.08     | 0.526 | 0.22               |
| over/weight| 1.54     | 0.699 | 0.17               |
| severely obese | 1.66 | 0.736 | 0.09               |
| Posterior Ulcer | Baseline no post pressure sore | 1.07 | 0.956 | 0.09 | 12.29 |
| Prone to lesion | 3.11 | 0.003 | 1.46 | 6.62 |
| Albumin   | 0.94     | 0.611 | 0.74               |
| Hb        | 0.99     | 0.762 | 0.95               |
| Waterlow  | 1.06     | 0.539 | 0.88               |
| CURB-65   | 0.53     | 0.269 | 0.17               |
| APACHE-II | 0.78     | 0.052 | 0.61               |
| SOFA      | 0.90     | 0.634 | 0.58               |

Odds Ratio: Prone to lesion | 3.11 | P > z: 0.003 | 95% Conf. Interval: 1.46 – 6.62

**Fig. 2** – Kaplan–Meier Survival Curve. End point is development of Pressure Ulcers.

Multivariable analysis of risk factors.

Table 3

| Risk Factor | Odds Ratio | P > z | 95% Conf. Interval |
|-------------|------------|-------|--------------------|
| BMI         | 2.08       | 0.526 | 0.22               |
| overweight  | 1.54       | 0.699 | 0.17               |
| severely obese | 1.66 | 0.736 | 0.09               |
| Posterior Ulcer | 1.07 | 0.956 | 0.09 | 12.29 |
| Prone to lesion | 3.11 | 0.003 | 1.46 | 6.62 |
| Albumin     | 0.94       | 0.611 | 0.74               |
| Hb          | 0.99       | 0.762 | 0.95               |
| Waterlow    | 1.06       | 0.539 | 0.88               |
| CURB-65     | 0.53       | 0.269 | 0.17               |
| APACHE-II   | 0.78       | 0.052 | 0.61               |
| SOFA        | 0.90       | 0.634 | 0.58               |

Risk analysis of lenses.

Lungs, a decrease in shunting, and reduction in barotrauma and ventilator induced lung injury (VILI). The lower staff to patient ratios and addition of ancillary staff unfamiliar with critical care and its procedures leaves patients in this position at risk of significant complications.

Prone positioned patients in particular are at increased risk due to the presence of ET tubes, tapes, NG tubes and urinary catheters, all of which the patient will be repositioned onto, and must be sited accordingly to prevent tissue damage. Prolonged prone positioning during spinal surgery with associated hypoxia and hypotension risks posterior ischaemic optic neuropathies, and direct pressure on the orbit can lead to raised intraocular pressures and retinal artery occlusion for which prognosis of recovery is poor, therefore long periods in this position in critical care also carry this risk.

In our unit, specially trained teams led the protocol driven procedure paying careful attention to pressure areas and airway maintenance. The head is placed in a lateral position, with the contralateral arm above the head, and the ipsilateral arm by the patient’s side. The NPIAP has published guidance on preventing pressure injury in prone patients.

Patients are ideally repositioned every 2 h when prone, by way of lateral rotation of the head, and alternating arm positions with care to prevent shoulder dislocation and brachial plexus injury. Due to staffing ratios and the availability of an airway trained professional to maintain position of the ET tube, this may be less regular. Neck stiffness prevents complete rotation, causing further pressure on the central face.

On admission to the critical care unit, ET tubes are fixed with tapes, as this is more secure when the patient is to be repositioned. When the patients improve clinically and prone positioning is no longer required, they are converted to an AnchorFast (Hollister, Ltd, UK). This adheres to the cheeks, and prevents direct pressure to the lips from the ET tube, with the aim of reducing the risk of pressure on the oral commissures. Ideally tapes are changed daily, however with higher demands on intensive care nursing staff and a short window between prone sessions, this is not always achievable. The moisture retained by the tape contributes to worsening pressure injury, and increases risk of bacterial or fungal infection.

A small number of patients developed anterior PrUs without being prone positioned. This was due to the use of invasive lines such as ET tubes, NG tubes and urinary catheters, well described risk factors for the development of PrUs. Black et al. found patients with medical devices were 2.4 times more likely to develop a pressure injury. In our study, all patients admitted to the Intensive Care Unit studied had a minimum of an ET tube, urinary catheter, arterial and central venous line, and NG tube, and therefore the increased risk of these devices cannot be compared to a control.

Swift recognition of pressure injury is important in prevention of deterioration. Nutrition should be optimised, and referral to tissue viability services is mandatory. Medical devices should be kept to a minimum and position checked carefully during the proning process. Moisture and friction should be prevented by regular changing of tube tapes. Close monitoring for infections, especially fungal, should be undertaken around the perioral area.

The mainstay of treating PrUs aims to optimise wound healing. Many wounds heal with non-operative intervention; the remainder are considered for reconstructive surgery. All patients in this study were managed conservatively, and surgical treatment was not required. Deep injury to the oral commissures may lead to microstomia and require future management. Eyelid injury could progress to lid shortening and ectropion resulting in exposure keratitis. Urethral damage may require referral to urology if the patient experiences difficulty with micturition following catheter removal.

A number of limitations of the study are as follows. This study used a small sample size. However, we believe this studied population can be used as a representative sample of a wider population due to similarities in the demographic split. BMI was estimated based on previous measurements as up to
date weights were not feasible to obtain in these patients; whilst the BMI for patients may have different, estimated BMI provides a reasonable approximation of patient body habitus. Ethnicity is poorly recorded in general, and was not included but our urban population may differ from smaller units. Fitzpatrick skin type may have simplified the stratification.23

This cohort of patients clearly has a significant threat to life, therefore these wounds are not prioritised. Prone positioning is a strong risk factor for development of anterior PrUs and changing such processes to prevent pressure injury is not recommended, however timely recognition and small positional adjustments may prevent worsening and when the clinical picture improves, they can be further managed as appropriate.

**Author contribution**

All authors have contributed to the study design, data collection, analysis and the final approval of the manuscript.

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**Declaration of competing interest**

There are no conflicts of interest.

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