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ORIGINAL ARTICLE

Tissue interface pressure and skin integrity in critically ill, mechanically ventilated patients☆

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Summary
Objective: To describe tissue interface pressure, time spent above critical pressure levels and the effect on skin integrity at seven anatomical locations.
Design, setting, patients: Descriptive, longitudinal study in critically ill mechanically ventilated adults, from Surgical Trauma ICU-STICU; Medical Respiratory ICU-MRICU; Neuroscience ICU-NSICU in a Mid-Atlantic urban university medical centre. Subjects were enroled in the study within 24 hours of intubation.
Measurements: Tissue interface pressure was measured continuously using the XSENSOR pressure mapping system (XSENSOR Technology Corporation, Calgary, Canada). Skin integrity was observed at all sites, twice daily, using the National Pressure Ulcer Advisory Panel staging system, for the first seven ICU days and at day 10 and 14.
Results: Of the 132 subjects, 90.9% had no observed changes in skin integrity. Maximum interface pressure was above 32 mmHg virtually 100% of the time for the sacrum, left and right trochanter. At the 45 mmHg level, the left and right trochanter had the greatest amount of time above this level (greater than 95% of the time), followed by the sacrum, left and right scapula, and the

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left and right heels. Similarly, at levels above 60 mmHg, the same site order applied. For those six subjects with sacral skin integrity changes, maximum pressures were greater than 32 mmHg 100% of the time. Four of the six sacral changes were associated with greater amounts of time above both 45 mmHg and 60 mmHg than the entire sample.
Conclusions: Maximum tissue interface pressure was above critical levels for the majority of the documented periods, especially in the sacrum, although few changes in skin integrity were documented. Time spent above critical levels for mean pressures were considerably less compared to maximum pressures. Maximum pressures may have reflected pressure spikes, but the large amount of time above the critical pressure levels remains substantial.

Implications for clinical practice

- Pressure ulcers develop as result of a complex, multi-factorial process.
- Although high tissue interface pressure over extended periods of time are contributory to this process, other factors also place patients are risk.
- Time spent above critical pressure levels in this sample was considerable.
- For those with changes in skin integrity, trends toward greater pressures during the period preceding changes in skin integrity, especially for the sacral and trochanter sites, were identified.

Introduction

In mechanically ventilated, critically ill patients, pressure ulcer risk is high and may result in negative patient outcomes and increased health care costs (Alderden et al., 2011; Anon, 2016; Shahin et al., 2009a). Pressure ulcers, any lesion caused by unrelieved pressure resulting in damage to the underlying tissue, are a serious complication of impaired mobility (Anon, 2016; Cox and Cwocn, 2011). Repositioning is one strategy to mitigate the effects of immobility in pressure ulcer development. Recommendations to reduce pressure ulcer (PrUl) risk place patients in backrest positions of less than 30° to reduce pressure on bony prominences that are most at risk for the development of pressure ulcers (Burk and Grap, 2012; Shahin et al., 2009b).

The magnitude and duration of pressure affects PrUl development with increasing tissue interface pressure and time contributing to tissue damage (Bennett et al., 1979; Daniel et al., 1981; Dinsdale, 1974; Kosiak, 1959). The critically ill, with their unstable physiologic status are especially at risk. In healthy individuals, an external pressure of at least 120 mmHg is required for blood flow occlusion, compared with 11—30 mmHg in geriatric hospitalised patients (Ek et al., 1987; Frantz and Xakellis, 1989). Although low levels of external pressure may increase dermal flow, this flow response in critically ill patients is not consistent (Frantz et al., 1993; Herrman et al., 1999; Xakellis et al., 1993), resulting in an impaired and delayed tissue recovery compared with healthy individuals (Aoi et al., 2009; Bader, 1990). Early studies found that a primary cause of PrUls is ischaemia produced by external pressures greater than capillary pressure (12—32 mmHg) and a constant pressure of 70 mmHg applied for two hours produced ischaemic changes (Dinsdale, 1974; Kosiak, 1959). Subsequent studies have supported pressure as a primary culprit in PU development (Bennett et al., 1979; Kottner et al., 2015; Lahmann and Kottner, 2011).

Although use of lower backrest elevation are recommended for pressure ulcer prevention, for critically ill patients who are mechanically ventilated, higher backrest positions are recommended to reduce the risk of ventilator associated pneumonia (VAP) (Guidelines for Prevention of Nosocomial Pneumonia, 1997; Tablan et al., 2004). Since pressure is a primary mechanism in the formation of PrUls, higher backrest elevation positions used for VAP prevention may have deleterious effects on skin integrity (Linder-Ganz et al., 2008). Recently in the parent study for the present, secondary analysis, we found in critically ill, mechanically ventilated patients, that overall, mean tissue interface pressures were less in the scapula and heel than in trochanter and sacral area (Grap et al., 2016). We also found that interface pressure decreased as backrest elevation increased in the scapula, but not in the sacrum, heels or trochanter (Grap et al., 2016). However, there are few data that fully describe tissue interface pressure over time and the effect on skin integrity in critically ill, mechanically ventilated patients (Lippoldt et al., 2014; Sprigle and Sonenblum, 2011; van Nieuwenhoven et al., 2006). Therefore, the purpose of this secondary, descriptive, longitudinal study in critically ill mechanically ventilated adults, was to describe tissue interface pressure, time spent above critical pressure levels and the effect on skin integrity at seven anatomical locations with high risk for development of pressure ulcers.

Methods

Setting and sample

The parent study, from which this analysis is derived, was a descriptive, longitudinal study of skin integrity of 150