Incidence of Pressure-Related Skin Injuries in Patients Operated for Spine Surgery in Prone: A Retrospective Analysis of 307 Patients

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Abstract

Background: Spine surgery in prone position frequently results in pressure skin lesions (PSLs). No study from Arabic world has published their incidence in literature. Methods: We retrospectively analyzed patients who underwent prone position spine surgery from December 1, 2017, to November 30, 2018. They received standardized anesthesia care and were made prone on Jackson table. The face was supported on a nonface contoured foam device, whereas the chest and pelvis were supported on soft cushions. Following completion of surgery, they were turned supine and their skin was inspected for any skin lesions. The lesions were categorized into five grades depending on severity. Results: Data of 307 patients were analyzed. Their mean age and weight was 41.5 years and 71 kg, respectively. The mean duration of prone positioning was 470 min. One hundred and three PSLs were observed in 45 patients (14.7%), giving a PSL incidence of 43.7% in affected patients. Majority of patients (18, 40%) with lesions remained in prone position between 421 and 600 min. Multiple lesions were observed in 53.3% of the affected patients. The highest number of patients (21, 46.7%) had one lesion only and it was restricted to face. All lesions were of Grade I, II, or III. Body weight >71 kg was more prone to developing PSLs. Females were more prone to PSLs. Conclusion: PSLs in prone position spine surgery occur frequently, and their incidence is proportional to the duration of positioning and weight of the patients. Face is the most commonly affected area.

Keywords: Pressure skin lesions, prone position, spine surgery

INTRODUCTION

Intraoperative pressure-related skin ulcers are types of iatrogenic injuries that result from the breakdown of the skin and/or underlying tissues when that area of the skin is placed under constant pressure for a long period of time, leading to ischemia, cessation of nutrition and oxygen supply to the tissues, and tissue necrosis. This complication is frequently observed in patients who have undergone a surgical procedure in a prone position. Various factors that predispose to these complications are as follows: advanced age, obesity, shear friction, effects of anesthesia and paralysis, therapy with steroids, surgical length, anesthesia time, blood loss and transfusion, and physical maneuvering.[1,2] Of all these factors, duration of the surgical procedure is the single largest risk factor.[1] Spine surgery, whether noncomplex or complex, performed in prone position, creates favorable environment to the occurrence of such iatrogenic pressure-related skin damage, neurovascular injuries, and injury to eyes and ears.[4,5] When a surgical patient develops a pressure ulcer within 72 h after surgery, it most likely indicates that the ulcer occurred during surgery.[6] These injuries, though seem trivial in nature most of the time, can act as a nidus for infection requiring protracted hospital stay or even surgical intervention occasionally, ultimately leading to increased morbidity and health-care cost.[7] The nonmonetary costs related to these skin breakdowns include...
pain, infection, consumption of additional hospital resources, and emotional and physical effects on patients and their caregivers.\cite{8, 9} Reported rates of pressure-related skin ulcers from prone position surgery vary from 5% to 66%.\cite{10}

In the English language literature, there are many retrospective case series as well as a systematic review on this aspect of prone position.\cite{11} However, from the Arab countries, no published study investigating this complication could except a previous case report of lip necrosis.\cite{12} This prompted us to conduct an audit of intraoperative pressure-related skin injuries resulting from spine surgeries performed in prone position in our hospital, which conducts approximately 300 surgical procedures on spine every year.

**Methods**

This being a retrospective review of electronic data record of patients, requirement of informed consent was waived off; for the same reason, no registration with the Central Trial Registry was deemed necessary. After obtaining ethical committee approval, we retrospectively reviewed the 1-year data (from December 1, 2017, to November 30, 2018) of patients aged 16 years or more who underwent spine surgery performed in prone position for various pathologies. They were all provided standard anesthesia care: induction with propofol, tracheal intubation following administration of rocuronium, maintenance with inhalational agent, and infusions of remifentanil and rocuronium. The patients were placed in prone on a Jackson table, with face resting on a disposable polyurethane foam, nonface-contoured prone positioner support (Orthopedic System Inc. [OSI], Union City, CA, USA), with a T-shaped gap in the middle to prevent pressure on the eye balls and nose, and a side channel to accommodate the tracheal tube. The chest and pelvis were supported on soft cushions. Fluids were infused depending on the extent of surgical exposure, and blood transfusion was performed whenever blood loss exceeded 20% of the patient’s estimated blood volume. At the end of the surgical procedure, the patients were turned supine on bed, and after reversing the residual effect of rocuronium, the patients were extubated. A thorough survey of patients’ body surface was conducted by a nursing staff before transferring the patient to the postanesthesia care unit (PACU) or neurointensive care unit. Skin lesion, if present, along with its anatomic location, was noted and subsequently recorded in a hospital incident reporting system (Datex). Another survey of skin integrity was performed in the PACU or neurointensive care unit immediately prior to transferring the patient to the ward, and any positive skin finding was recorded in the Datex. We retrieved these data to review the type, number, and location of pressure-related skin injuries. A Modified European pressure ulcer advisory panel was used to grade the pressure-related skin ulcers, as follows:\cite{13}

- Grade I: Nonblanching skin erythema
- Grade II: Blister
- Grade III: Peeling of epidermis
- Grade IV: Peeling of full skin thickness
- Grade V: Exposure of the underlying muscle.

We studied a possible correlation of the skin pressure lesions with the duration of prone positioning, weight, and gender of the patients.

**Results**

A total of 307 patients underwent spine surgery performed in prone position during the study period. The mean age of the patients was 41.5 years, with an almost equal gender distribution [Table 1]. The duration of prone positioning varied from 46 to 1060 min (mean: 470 min). The minimal duration of prone positioning of 46 min was in a 16-year-old patient, who required wound debridement only. A total of 103 skin lesions were observed in 45 patients (14.7%), with a pressure-related skin injury incidence of 43.7% in the affected patients. Majority of the affected patients (18, 40%) had a prone positioning duration of 421–600 min. More than one skin lesions were observed in 24 (53.3%) of the total affected patients [Table 2]. Twenty-one patients (46.7%) had one skin lesion only, whereas four (8.8%) had six lesions each [Table 2]. In all patients who developed one lesion, the injury was limited to the face only. The anatomical distribution of skin lesions is depicted in Table 3. Women had nearly 4.5-fold higher incidence of injuries compared with their male counterparts. In terms of severity, Grade I and III skin lesions were the most common, whereas Grade II lesions were the least common. None of the patients had Grade IV/V lesions [Table 4]. We also observed that Grade I and III lesions occurred more frequently when the duration of prone positioning was between 421 and 600 min [Table 4]. The overall incidence and the severity of lesions were greatest when the duration of prone positioning was between 180 min and 600 min; however, both incidence and severity were minimal when the duration of prone positioning was either <180 min or >600 min [Table 4]. Body...

| Duration of prone position (min) | 470 |
|---------------------------------|-----|

**Table 1: Demographic profile and duration of prone positioning (number or mean)**

| Total | 307 |
|-------|-----|
| Gender (male:female) | 151:156 |
| Age (years) | 41.5 |
| Weight (kg) | 71 |

**Table 2: Distribution of the number of skin lesions (n=103) in relation to the number of affected patients (n=45)**

| Number of skin lesions | Number of patients, N (%) |
|------------------------|---------------------------|
| 1 | 21 (46.6) |
| 2 | 12 (26.6) |
| 3 | 3 (6.6) |
| 4 | 5 (11.1) |
| 5 | 1 (2.2) |
| 6 | 4 (8.8) |
weight had a direct effect on the incidence of pressure-related skin lesions [Table 5].

**DISCUSSION**

All patients undergoing surgery in prone position should be considered vulnerable to pressure-related skin ulcers, and standard pressure prevention strategies should be practiced. On most occasions, it is impossible to avert these injuries completely in spite of adopting the best practices in positioning surgical patients. Unfortunately, in literature, the majority of prone position-related skin injuries are either mentioned only as case reports or retrospective case series, and no prospective study has been conducted. Therefore, the incidence of this complication varies in different studies, and the exact incidence remains elusive. Indeed, the occasional nature of the reported incidences raises suspicion, that is, its incidence may be underreported for fear of medico-legal implications.

The spectrum of skin pressure lesions ranges from nonblanching erythema to necrosis.[12] The areas that are highly at risk for pressure ulcer development when in prone position are as follows: forehead, cheek, male genitalia, female breast, ankles, and toes.[14]

| Anatomical area | Number of patients (n=45), n (%) | Number of lesions (n=103) |
|-----------------|---------------------------------|--------------------------|
| Face            | 21 (46.7)                       | 36                       |
| Chest           | 19 (42.2)                       | 21                       |
| Iliac crests    | 12 (33.3)                       | 17                       |
| Knees           | 8 (17.7)                        | 15                       |
| Thighs          | 5 (11.1)                        | 7                        |
| Arms            | 3 (6.6)                         | 4                        |
| Abdomen         | 1 (2.2)                         | 3                        |

Twenty-four patients had >1 lesions on the same or different anatomical area

| Duration (min) | n (%) | Number of lesions | Grade of lesions |
|---------------|-------|-------------------|------------------|
| <180          | 1 (2.3)| 6                 | 0 0 0 0 0 0      |
| 180-420       | 17 (37.3)| 35               | 12 11 12 0 0     |
| 421-600       | 18 (40) | 39                | 14 5 20 0 0      |
| >600          | 9 (20)  | 23                | 9 0 14 0 0       |
| Total         | 45 (100)| 103               | 41 16 46 0 0     |

In our series, 14.7% (45 of 307) of the patients developed pressure-related skin injuries. A total of 103 skin lesions were observed in 45 patients (which accounts for 43.7% of the total skin injuries reported in the affected patients) because nearly half of the affected patients had more than one skin lesions either on the same anatomic area or on a different area. Majority of the patients (21, 46.7%) developed pressure-related skin lesions on the face, whereas the remaining patients had injuries in other body areas such as the chest, iliac crests, and knees [Table 3]. All of these injuries were of Grade I, II, or III, and none of the patients had skin injury higher than Grade III.

Facial injury higher than Grade III may cause serious psychological trauma to a patient from cosmetic reasons. Therefore, most of the studies on pressure injuries from prone position have focused their investigation on the prevalence and prevention of facial injuries. The amount of pressure on the face while in a prone position is around 30 mmHg, but can be higher than 50 mmHg on certain areas such as the chin and forehead above the supraorbital ridge.[13] These bony prominences on the face, which are subjected to higher interface pressure and shearing forces, also have reduced muscle tone due to the effects of anesthesia, leading to perturbations of local blood flow.[16] Moreover, the extremely less muscle mass on the forehead and face also contributes to the insufficient blood supply to the surrounding skin and subcutaneous tissues. All of these factors create a favorable environment for pressure ulcer formation on the face within the time frame of most spine surgeries. Therefore, efforts must be directed to avoid excessive pressure on the face.

Grisell and Place compared the amount of facial pressure on each of the three types of face positioners: the OSI foam positioner (the one used in our patients), Protective Helmet system that uses a disposable polyurethane foam head positioner (Dupaco positioner, Oceanside, CA, USA), and a neoprene air-filled bladder “dry floatation” device by ROHO (The ROHO Group, Belleville, IL, USA).[7] They observed that tissue pressures seemed equal within the first 15 min and then remained fairly constant. The pressures measured for the Dupaco positioner were lowest at all time points for both the forehead and the chin in comparison to the other two positioners. Unfortunately, the OSI system used to support the face of our patients does not follow the contour of the face; therefore, it failed to prevent excessive pressure on the patients’ facial bony prominences.

Supportive padded headrests and bed inclination to elevate the head can be used to minimize the pressure on the face.[17] However, the latter is not always possible as lumbar flexion is frequently the requirement for optimal access during spinal surgery, thus increasing the pressure on the face. Koreckij et al. proposed an upward traction on the head to alleviate pressure on the face using the Gardner–Wells tongs applying 15 lbs of traction at a 45° angle.[17] To free the face from any pressure while in a prone position, some authors recommend to place face on face contoured device or the head and face should be suspended over the table using the Mayfield head holder.[1,18] In the absence of such measures, one should try to
maximize the contact surface area of the face using a large soft supporting pad; the larger the contact surface area, the lower the average pressure on the bony prominence. In our study, all the facial injuries were of Grade I or II, which were expected to heal without leaving a scar. Aside from the data on the magnitude of pressure on the face in prone position, no study has evaluated the amount of pressure on the other body areas at risks of developing pressure-related skin ulcers in spine surgeries performed in prone position. However, from the aforementioned study on facial pressure, we can assume that the pressure on the chest, iliac crests, and knees may also be of similar magnitude, thereby making these areas vulnerable to pressure injuries too. As in prone position the chest and iliac crests support the weight of the patient, these two areas along with the knees are subjected to high friction and shear during spine instrumentation. Thus, these areas frequently develop skin breakdown. In literature, no study has highlighted the incidence of pressure skin ulcers on these body parts. In our study, 24 patients (53%) developed pressure-related skin ulcers on body areas other than the face. There were 19, 12, and 8 patients who developed pressure-related skin injuries on the chest, iliac crest, and knees, respectively, in addition to skin lesions on other body parts. All of them were of Grade I, II, or III, with no incidence higher than Grade III.

A Grade IV/V chest pressure-related skin injury may restrict deep breathing and cough because of pain, leading to retention of secretions and possible chest infection. Similarly, a Grade IV/V pressure-related skin injury on the knee may prevent early ambulation of the patient, thereby predisposing to deep-vein thrombus occurrence.

In our analysis, the incidence of pressure-related skin injuries was highest (77.7%) when the duration of prone position was between 180 and 600 min. Surprisingly, beyond 600 min of prone positioning, there was a sharp decline in the incidence of injuries to 20%. This decline in incidence in these patients was probably related to the types of surgical procedures in these patients, which did not require spine instrumentation and thus prevented friction or shear. The duration of surgery (and therefore, prone position) has been recognized as the single greatest determinant of pressure-related skin lesions.[13] However, there is no definitive upper cutoff limit on the duration of positioning, beyond which pressure skin ulcers may develop, and it may range anywhere from 180 to 600 min.[19]

The wide range of the duration of prone positioning in relation to the development of pressure skin injuries may be due to other contributory factors such as body weight, steroid intake for some comorbid condition, the type of material placed under the bony prominences, intensity of shear, friction, effects of anesthetics, and paralysis.[16,20] Even the nature of surgical procedure as well as spinal deformity surgery influences the incidence of these injuries.[9,22]

Besides longer duration of surgery, elevated body mass index (BMI) also appears to play a role in the development of pressure-related skin injuries associated with surgeries performed in prone position.[23] Although BMI is the basic indicator of obesity, we believe that the patient’s weight is more likely a contributory factor in the development of pressure-related skin ulcers; it is the weight of body tissues regardless of BMI that causes a direct pressure over the bony prominences. In our study, the incidence of pressure skin lesions (PSLs) was 60% when the patient’s weight exceeded 70 kg, whereas it was 40% in patients who weighed <70 kg [Table 5].

There was a 4.5-fold higher incidence of pressure-related skin ulcers in women than in men in our study. Gao et al. showed that men have more propensity to develop pressure-related skin ulcers.[5] The factors that may safeguard women from getting pressure-related skin ulcers may be related to the distribution of adipose tissues; perhaps, a larger mass of adipose tissue in women might protect their bony prominences by distributing pressure over a greater surface area during these longer surgeries. Literature is silent on the issue of gender-related incidence of PSLs in prone position surgeries. In our study, we speculate that the principal reason for the higher incidence of skin ulcers in women were possibly because of the duration of surgery; therefore, prone position was longer in more number of women compared with their male counterparts. However, further prospective studies should be conducted to confirm this finding.

Although several risk factors have been associated with pressure-related skin ulcers in prone position surgery, the primary factor is patient’s immobility and inability to perceive pain or discomfort from unrelieved pressure, as well as friction and shearing forces.[24] Another risk factor related to the intraoperative experience is the amount of time a patient spends on the operation room bed: a patient can tolerate excessive pressure for a short period of time or a low amount of pressure for a longer period of time without sustaining tissue damage. Pressure causes skin injury either by its direct effect per se or by occluding the blood supply to the area at risk. The safe limit as well as safe duration of pressure on the body surface is unknown. However, Landis demonstrated that whenever surface pressure on skin increases beyond 32 mmHg, small vessels collapse and thrombose, resulting in the cessation of blood flow with consequent ischemia, cell death, and pressure sore formation.[25] Tissue ischemia may occur after 2 h, and necrosis occurs after 6 h of unrelieved pressure. The study of Gao et al. showed that even physical maneuvering is also a risk factor for the occurrence of pressure ulcers.[2] Manipulations during surgery, such as instrument placement and retractors, is another factor contributing to an increased pressure ulcer occurrence. Even positioning devices, warming devices, anesthetic agents, sedation, vasoactive agents, type of surgery, and intraoperative hemodynamics (reflected in a diastolic pressure below 60 mmHg), may also substantially increase the risk of pressure-related skin ulcers.[3] Delayed transfusion also contributes to skin lesions, tissues become hypoxic with increasing blood loss during surgery, and physicians often transfuse blood only after excessive blood loss has occurred. Subsequent transfusion relieves tissue hypoxia, and they
become oxygenated, which might produce superoxide free radicals, causing capillary and skin damage and thus promoting the occurrence of skin ulcers.

**Limitations**

Owing to the inherent drawbacks associated with a retrospective study, we might have missed some data. Furthermore, our observations were limited to the operation room only, and we did not follow the patients in the ward. It is known that changes in skin can appear within 72 h after surgery. Moreover, this being a single-center study, the data may not be representative of the entire Middle-East countries.

**Conclusion**

Pressure-related skin ulcers is a frequent complication of prolonged prone positioning under anesthesia during spine surgeries, with face bearing most of the brunt. Pressure-related skin injuries are directly proportional to the duration of prone positioning and weight of the patients. This being a single-center retrospective study, we recommend that a multicentric prospective study be conducted to determine the more precise incidence of this complication.

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**Conflicts of interest**

There are no conflicts of interest.

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