Cigarette smoking and risk of pressure ulcer in adult intensive care unit patients

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The objective of this study was to assess relationship between smoking, some other risk factors and ulcers development in intensive care unit. This prospective cohort study was performed in two university-affiliated hospitals. The sample consisted of adult male patients who were admitted to medical–surgical intensive care units. All eligible patients were grouped according to their cigarette smoking status as smoker and non-smoker. The final sample included 160 smokers and 192 non-smokers. Pressure ulcer occurred in 62 smoker patients and 28 of non-smoker who showed significant difference. Also number of pack-year of cigarettes smoking showed significant association with ulcer development. Ulcer stage was significantly different between the two groups. Besides of smoking, age, length of stay, faecal incontinency, diabetes mellitus, anaemia and trauma were significantly associated with pressure ulcers. Our study showed significant association between smoking and development of pressure ulcers.

Key words: adult, intensive care unit, pressure ulcers, risk factors, smoking.

INTRODUCTION

Pressure ulcer (PU) is a common and serious complication of multiple morbidity and lack of mobility in hospital. It is defined as an area of localized damage to the skin and underlying tissue usually over a bony prominence, caused by pressure, shear or friction, or a combination of these. These ulcers are associated with an increased risk of infection, disability, high level of dependence, longer hospital stay and higher hospitalization costs. Development of PU is complex and multifactorial. The most important pathologic event is the changes in the blood supply to dermal tissues that leads to decreased capillary blood flow and tissue ischaemia. These changes are ultimately responsible for necrosis of skin and subcutaneous tissue and formation of PU. Several risk factors are associated with increased prevalence of PU including immobility, vascular diseases, neuropathies, nutritional status, urine and faecal incontinency, age, and chronic diseases such as diabetes mellitus.
Patients in intensive care units (ICUs) are at high risk for development of PUs because of severity of illness, haemodynamic instability, movement restriction for extended periods and use of sedative and analgesic drugs that decrease sensory perception. The reported incidence of PU in critical care patients varies widely from 1% to 56%.

The first step in preventing PUs is determining the preventable risk factors. Consensus on some risk factors is lacking, and the significance of these factors is yet to be elucidated. Smoking is one of risk factors that has been suggested for the development of PU.

Smoking has been associated with significant effects on all systems of the body including skin. The currently available literature suggests that smoking exerts deleterious effects on both morphological and functional aspects of the microcirculation. The mechanisms of this action include compromised endothelial-dependent vasorelaxation, thickening of the walls of arterioles, platelet aggregation and endothelial cell dysfunction. In addition, collagen synthesis and the deposition of mature collagen in the extracellular matrix are reduced by smoking. This phenomenon leads to an imbalance between biosynthesis and degradation of dermal proteins. On the other hand, smoking can also cause delayed wound healing secondary to decreased blood flow.

Few studies have been published about the relationship between smoking and the incidence of PU in ICU patients and most studies conducted on non-ICU patients. Several of these studies have found a relationship between smoking and PU, whereas additional studies have not found a similar relationship. The objective of this study was to determine the effect of smoking and some other risk factors on the incidence of PU in adult male patients hospitalized at ICU.

MATERIALS AND METHODS
This prospective cohort study was conducted in ICUs (20 medical–surgical beds) in the two university-affiliated hospitals in Semnan province (Iran) from July 2011 to March 2012. All adult male patients admitted to the ICU who met the inclusion criteria were included in this study. Patients were included if they were male, 18 years or older, stayed for > 24 h in ICU and were free of PUs on admission. Because smoking rate between women is very low in our community, we did not include women in the study. Patients were excluded if they had a PU at the time of admission to the ICU, died during the study before development of PU, not evaluated within 24 h after admission and if admitted to ICU from other services of the hospital.

The study was approved by the Research and Ethical Committee of the Semnan University of Medical Science. Informed written consent was obtained from all patients (where possible) or from their family in the cases of the unconscious patients. All eligible patients were grouped according to their cigarette smoking status as smoker (cases) and non-smoker (control). Smoking data were obtained from the patient and/or family. Subjects were defined as cigarette smokers if they had smoked five or more cigarettes per day for at least 6 months. Pack-year smoking (average number of packs of cigarettes smoked per day multiplied by the total number of years of smoking) was calculated. Undetermined, intermittent and ex-smoker were excluded.

The following data were prospectively gathered in the first day of admission for each subject: age, body mass index (BMI), reason of hospitalization, haemoglobin level, level of consciousness, faecal incontinence, history of diabetes mellitus and hypertension. BMI was derived from the height and weight recorded for all patients admitted to the hospital. Patients’ level of consciousness was assessed by Glasgow Coma Scale (GCS) that routinely used in these wards. Patients had been classified according to the GCS into mild (13–15), moderate (9–12) and severe (≤8).

Diabetes mellitus was defined as self-reported (or family reported) history of diabetes mellitus, use of oral hypoglycaemic agents or insulin. Hypertension was defined as self-reported history of hypertension and/or use of antihypertensive medications. Incontinence status was defined based on the observation of skin moisture and soiling with stool during the skin assessment. Urinary incontinence is not usually a problem in ICU because most patients have a bladder catheter and not included in our study.

PU screening was performed to all patients within the first day of admission. The skin of each patient was assessed daily by one physician-researcher to identify the presence and stage of PU. PUs were classified into four stages according to the European Pressure Ulcer Advisory Panel staging bedsore. A patient was considered to acquired PU if the ulcer was documented after admission in the ICU as a stage I or greater. PU stage I was defined if the skin was intact but showed a persistent
erythematous area that did not blanch when it is pressed with a finger. The number of days from the ICU admission to the formation of PU was also registered. Patients were evaluated until PU onset or until ICU discharge or death in the group without PUs.

During the study period, routine protocols for prevention of PUs were in place in both ICUs. Preventive measures included turning patients every 2 h, alternating pressure mattress and the use of support surfaces. Data were analysed by one sample Kolmogorov–Smirnov test, $\chi^2$ test, Mann–Whitney U-test, Student’s $t$-test and logistic regression using SPSS software (version 16.0, SPSS Inc., Chicago, IL, USA).

RESULTS

Of the 2046 patients admitted to both ICU during the study period, 352 patients met the inclusion criteria. This final sample was included 160 smokers and 192 non-smokers and evaluated for development of PU.

Mean ($\pm$ standard deviation (SD) ) age of patients was 55.7 ($\pm$ 20.3) years and control 48.8 ($\pm$ 24.7) years ($P < 0.001$). Mean ($\pm$ SD) BMI of smoker was 24.1 ($\pm$ 2.7) and for non-smokers was 24.0 ($\pm$ 2.30) with no significant difference ($P = 0.357$). Clinical characteristics of the subjects are summarized in Table 1.

Overall, 90 (25.6%) of patients admitted to ICUs developed PU. PUs occurred in 62 smoker patients (38.8%) and 28 (14.6%) of non-smoker that showed significant difference ($P < 0.001$). Also, PU development was significantly associated with pack-year of smoking ($P < 0.003$).

Ulcer stages in two groups are shown in Table 2. Most ulcers were stage I. No patient developed a stage IV ulcer. Ulcer stage was significantly different between two groups ($P = 0.003$).

Patients with PU were more likely to be older ($P = 0.001$), have higher BMI ($P = 0.029$), diabetes mellitus ($P < 0.001$), hypertension ($P = 0.006$), anaemia ($P = 0.007$), faecal incontinency ($P < 0.001$), lower GCS ($P < 0.001$) trauma ($P < 0.001$) and longer duration of hospitalization ($P < 0.001$).

Logistic regression analysis showed that development of a PU was significantly associated with smoking pack-year, age, length of ICU stay, faecal incontinency, diabetes mellitus, trauma and anaemia (Table 3).

DISCUSSION

PU represents one of the main complications among critical patients. It is generally burdensome to treat, results in complication and prolonged hospital stay and increases financial burden. Accurate identification of risk factors and patient who might be at risk is a prerequisite for determining and implementation of appropriate strategies to prevent PUs after admission to the hospital.

The results of this study revealed that the overall PU incidence in intensive care settings was 25.6%. Other studies have shown varying incidences. These widely varied reported incidences of PUs in critically ill patients are due to differences in population characteristics,

Table 1: Clinical characteristics of study patients

<table>
<thead>
<tr>
<th></th>
<th>Smoker</th>
<th>Non-smoker</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of ICU stay,</td>
<td>11.0 ± 12.3</td>
<td>10.4 ± 14.4</td>
<td>0.009</td>
</tr>
<tr>
<td>days (Mean ± SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reason of admission</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trauma</td>
<td>86 (53.8)</td>
<td>104 (54.2)</td>
<td>0.791</td>
</tr>
<tr>
<td>Postsurgical</td>
<td>30 (18.8)</td>
<td>35 (18.2)</td>
<td></td>
</tr>
<tr>
<td>CVA†</td>
<td>13 (8.1)</td>
<td>16 (8.3)</td>
<td></td>
</tr>
<tr>
<td>Unconsciousness</td>
<td>13 (8.1)</td>
<td>10 (5.2)</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>31 (19.4)</td>
<td>37 (19.3)</td>
<td></td>
</tr>
<tr>
<td>Anaemia n (%)</td>
<td>93 (58.1)</td>
<td>107 (55.7)</td>
<td>0.651</td>
</tr>
<tr>
<td>Diabetes mellitus n%</td>
<td>24 (12.5)</td>
<td>10 (5.2)</td>
<td>0.015</td>
</tr>
<tr>
<td>Hypertension n%</td>
<td>21 (13.1)</td>
<td>24 (12.5)</td>
<td>0.861</td>
</tr>
<tr>
<td>Faecal incontinency n%</td>
<td>64 (40)</td>
<td>38 (19.8)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Level of consciousness n %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td>103 (64.4)</td>
<td>143 (74.5)</td>
<td>0.075</td>
</tr>
<tr>
<td>Moderate</td>
<td>31 (19.4)</td>
<td>24 (12.5)</td>
<td></td>
</tr>
<tr>
<td>Sever</td>
<td>26 (16.2)</td>
<td>25 (13)</td>
<td></td>
</tr>
</tbody>
</table>

† Cerebrovascular accident.

Overall, 90 (25.6%) of patients admitted to ICUs developed PU. PUs occurred in 62 smoker patients (38.8%) and 28 (14.6%) of non-smoker that showed significant difference ($P < 0.001$). Also, PU development was significantly associated with pack-year of smoking ($P < 0.003$).

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DISCUSSION

PU represents one of the main complications among critical patients. It is generally burdensome to treat, results in complication and prolonged hospital stay and increases financial burden. Accurate identification of risk factors and patient who might be at risk is a prerequisite for determining and implementation of appropriate strategies to prevent PUs after admission to the hospital.

The results of this study revealed that the overall PU incidence in intensive care settings was 25.6%. Other studies have shown varying incidences. These widely varied reported incidences of PUs in critically ill patients are due to differences in population characteristics,
inclusion criteria, different preventive methods implemented and data collection methods. Some studies reported similar or higher incidence when compared with our finding. \(^{14,17,23–25}\) A lower incidence than our study was reported by other investigators. \(^{10,26–28}\) Some of the aforementioned studies that reported lower incidence did not include stage I ulcers. A low incidence might also reflect a good application of preventive measures and or a high proportion of low-risk patients.

This study supports other studies, which revealed that the highest PU prevalence rates were found for PUs stage I.\(^{6,26,29}\) Having the majority of the PUs to be stage I is assumed to be due to the effect of the PU preventive measures implemented in the ICUs. In addition, the patients included have had younger age when compared with most previous studies.

We found significant differences in PU incidence among the smoker and non-smoker in our study (\(P < 0.001\)). Our analysis also revealed that the higher number of cigarette smoking significantly was associated with the risk of PU (\(P < 0.001\)). Smoking has a vasoconstrictive effect on the capillaries at the dermal level, which diminishes the amount of oxygenated blood reaching the tissues. This effect mostly is mediated by nicotine. Nicotine inhibits the release of prostacyclin and thus causes vasoconstriction in skin. On the other hand, components of cigarette smoke, especially carbon monoxide, and hydrogen cyanide interfere with the processes involved in wound healing.\(^{30}\)

This significant association between smoking and development of PUs is consistent with some previous studies that have found a relationship between smoking and PUs. In one study on 105 ICU patients, smoking was significantly associated with PU.\(^{14}\) In another study in an ICU on immobilized patients, smoking was significantly associated with PU.\(^{31}\) In a prospective cohort study that was conducted in two ICUs on 235 patients, results showed that cigarette smoking has a significant association with PUs.\(^{17}\) Krause et al. in a study on 650 individuals with spinal cord injury found evidence that cigarette smoking is significantly associated with the risk of PU.\(^{15}\) In a retrospective study of 176 spinal cord injured patients, PU incidence rates were more than fourfold higher in the smoker than in the non-smoker.\(^{32}\) In a large study, persons with spinal cord injury who smoked a pack of cigarettes or more per day were 2.82 times more common to develop PU than non-smokers.\(^{16}\)

However, some previous research reported that smoking had no correlation with PU development.\(^{18–21}\) In Rodriguez et al.’s study although there was an association between smoking and PU development, this factor did not reach statistical significance.\(^{11}\) Most of these studies that not confirmed this association were conducted on non-ICU patients.

Another finding in our study was that the ulcer stage was significantly difference between two groups (\(P = 0.003\)). Smoker patients have had higher stage of PU when compared with non-smoker. The result shows that more pack-years of smoking had significant association with higher incidence and more extensive pressure sores.

Six other variables that were independently associated with risk of PU were age, duration of hospitalization, faecal incontinency, diabetes mellitus, anaemia and trauma.

### Table 3 Logistic regression analysis results for the associations between variables and pressure ulcer

<table>
<thead>
<tr>
<th>Variables</th>
<th>(\beta) Coefficient</th>
<th>SE ((\beta))</th>
<th>(P)-value</th>
<th>Odds ratio (OR)</th>
<th>95% CI for OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.05</td>
<td>0.01</td>
<td>&lt;0.001</td>
<td>1.05</td>
<td>1.03–1.07</td>
</tr>
<tr>
<td>Length of ICU stay</td>
<td>0.17</td>
<td>0.03</td>
<td>&lt;0.001</td>
<td>1.19</td>
<td>1.13–1.25</td>
</tr>
<tr>
<td>Faecal incontinency</td>
<td>1.23</td>
<td>0.44</td>
<td>0.005</td>
<td>3.42</td>
<td>1.45–8.06</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1.77</td>
<td>0.59</td>
<td>0.003</td>
<td>5.58</td>
<td>1.83–18.70</td>
</tr>
<tr>
<td>Anaemia</td>
<td>0.99</td>
<td>0.40</td>
<td>0.014</td>
<td>2.68</td>
<td>1.22–5.91</td>
</tr>
<tr>
<td>Smoking</td>
<td>0.03</td>
<td>0.01</td>
<td>0.003</td>
<td>1.03</td>
<td>1.01–1.06</td>
</tr>
<tr>
<td>Trauma</td>
<td>2.77</td>
<td>0.74</td>
<td>&lt;0.001</td>
<td>15.95</td>
<td>3.72–68.65</td>
</tr>
<tr>
<td>Constant</td>
<td>-9.47</td>
<td>1.3</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

CI, confidence interval.
CONCLUSION

Our study showed significant association between smoking and development of PU as well as its severity. Advising to quit smoking can be undertaken as an important part for reduction of PUs. Future researches especially with larger sample size and with targeting the smoking as an important risk factor in relation to PU development are recommended.

ACKNOWLEDGEMENT

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