Hazards and Intensive Care Unit Economic Burden of Cigarette Smoking on Critically Ill Surgical Patients: Analysis of the THAI-SICU Study

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Objective: *Cigarette smoking is not only has detrimental effects on the respiratory system but also contributes to development of atherosclerosis and inflammatory vascular reactions. We hypothesized whether smoking is associated with increased risk of acute respiratory distress syndrome (ARDS), systemic inflammatory response syndrome (SIRS), sepsis, distant organ dysfunctions, and the increase of total cost of surgical intensive care unit (SICU) in critically ill surgical patients.*
Material and Method: *We performed analysis using the THAI-SICU data, a prospective, observational, multicenter study in patients who admitted to SICU in nine university-based hospitals in Thailand. The patients were categorized into 3 groups based on their smoking histories, which were 1) never smoked, 2) former smoker, and 3) current smoker. The primary outcome was probability of ARDS and the secondary outcomes included incidences of SIRS, sepsis, distant organ dysfunction (included acute kidney injury (AKI) and acute myocardial infarction (AMI)), total SICU cost, and 28-day mortality.*
Results: *A total of 4,652 patients had complete data of smoking and were analyzed. The smoking status was never smoked (2,947 patients), former smokers (1,148 patients), and current smokers (557 patients). Compared to current smokers and former smokers, patients who had never smoked had significantly lower proportion of patients with chronic obstructive pulmonary disease ($p<0.01$) and had significantly higher PaO_2/FiO_2 ratio on SICU admission ($p = 0.02$). Compared to patients who had never smoked and former smokers, current smokers had significantly higher probability of ARDS ($p = 0.003$), higher incidence of SIRS ($p = 0.006$), and AKI ($p<0.001$), after adjustment for age, gender, APACHE II score, and patients' pre-existing diseases. We found that every 1-pack year of cigarette smoking increased risk of ARDS with a hazard ratio of 1.02 (95% CI 1.01-1.03, $p = 0.001$). There was no difference in incidence of sepsis, AMI, and 28-day mortality among three groups of patients. Current smokers had significantly higher SICU cost, followed by former smokers, and patients who had never smoked ($p = 0.02$).*
Conclusion: *In critically ill surgical patients, we found dose-response association between smoking pack year and risk of ARDS. Compared to patients who had never smoked and former smokers, current smokers had significantly higher probability of ARDS, higher incidence of SIRS, AKI, and higher total SICU cost. Our findings demonstrated harm of cigarette smoking in critically ill surgical patients who admitted to SICU.*

Keywords: *Smoking, Acute respiratory distress syndrome, Intensive care unit outcome, Surgical intensive care unit*

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Smoking is a global healthcare problem and remains a leading cause of morbidity and mortality[1,2]. It appears to be linked to several major health problems such as lung cancer[2], kidney cancer[3], chronic obstructive pulmonary disease (COPD)[4], and cardiovascular diseases[5,6]. Since 1980, numbers of smokers are increased worldwide and the prevalence of smoking varies across countries[1]. In Thailand, even in view of smoking cessation programs was promoted for several years[7], smoking prevalence is still high and smoking consumption was found to be between

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10-20 cigarettes per smoker, per day[1,8].

There is growing evidence to support that cigarette smoking not only directly injured the alveoli, but also effects a number of biological mediators of inflammation through its effect on immune-inflammatory cells, leading to an immunosuppressant state, inflammatory vascular reactions, and development of atherosclerosis and organ dysfunctions[9-12]. Critically ill surgical patients, who are smokers and were admitted to the surgical intensive care unit (SICU) how cigarette smoking affect outcomes after critically ill is unknown. This study was designed to determine whether current smokers who were admitted to the SICU have a higher risk of acute respiratory distress syndrome (ARDS), systemic inflammatory response syndrome (SIRS), sepsis, and distant organ dysfunctions, than patients who had never smoked and former smokers, and how the impact of smoking may affect to the total cost of SICU.

Material and Method

Patient cohort THAI-SICU database

The THAI-SICU study is a multicenter, prospective, observational trial in nine Thai university-based hospitals aimed to monitoring the occurrence and report adverse outcomes of Thai patients who were admitted to SICU. Full details of patient characteristics and methodology of the THAI-SICU study were described elsewhere[13]. Briefly, all 17,579 patients admitted to those nine SICUs within 19.7 months of a recruitment period (April 2011 to November 2012) were recruited and analyzed. In this study, we recruited the patients who had available data on cigarette smoking. And those patients were classified into 3 groups based on their smoking status which were: 1) never smoked (patient who denied history of cigarette smoking), 2) former smokers (patient who had smoked and quitted at least a month before admitted to the hospital), and 3) current smokers (patients who had smoking history and continue smoking until within a month before being admitted to the hospital). Baseline characteristics of the patients were measured and included age, gender, pre-existing conditions identified on the basis of patients' medical history, and major sites of surgery in those underwent surgery. Smoking pack year and baseline laboratory variables (PaO_2/FiO_2 ratio and serum creatinine) were also measured.

Outcome measurements

Our primary outcome measurement was probability of ARDS. Secondary outcomes were incidence of SIRS, sepsis, distant organ dysfunctions (included acute kidney injury (AKI) and acute myocardial infarction (AMI)), 28-day mortality, SICU-length of stay (LOS), and total SICU cost. ARDS was defined using the American-European Consensus Criteria[14], which was the presence of bilateral pulmonary infiltration on chest radiography without evidence of left atrial hypertension by clinical signs or pulmonary capillary wedge pressure less than or equal to 18 mmHg, and PaO_2/FiO_2 less than or equal to 200. SIRS was defines as presence of symptoms meeting two or more SIRS criteria[15]. Sepsis was defined by the presence of both SIRS and infection with/without organ failure or unstable hemodynamics[15]. AKI was defined by using increasing serum creatinine criteria levels of more than 0.3 g/dL from baseline. AMI was defined if there were at least two of the following criteria: 1) positive troponin-T, 2) prolonged ischemic symptoms more than 20 min, and 3) alterations of ECGs[13].

Statistical analysis

We tested for the differences in baseline characteristics between three groups of patients (never smoked, former smoker, and current smoker) by using a Kruskal-Wallis test or between two groups of patients (former smoker and current smoker) by using Mann-Whitney U test for continuous data or a Chi-square test for categorical data, from which we can report the median and interquartile range (IQR). We evaluated the primary outcome variables by using a log-rank test to compare probability of ARDS curves for never smoked patients, former smokers, and current smokers. Multivariate analysis for the risk of ARDS was expressed as hazard ratio (HR) with 95% confidence interval (CI). We tested for the influence of covariates, including APACHE (Acute Physiology and Chronic Health Evaluation II) score, gender, COPD, diabetes, coronary artery disease, and smoke pack year by using logistic regression analysis. We tested for differences in secondary outcomes between three groups of patients using a Kruskal-Wallis test for continuous data and Chi-square test for categorical data, from which we report the median and IQR. Differences were considered significant by using a two-tailed *p*-value of less than 0.05. Statistical analyses were performed using SPSS (v.23.0; IBM Corporation, NY, USA) statistical software packages.

Results

Patient characteristics

Of those 4,652 patients who had data on

Table 1. Baseline characteristics among three groups of patients

	Never smoked (n = 2,947)	Former smoker (n = 1,148)	Current smoker (n = 557)	*p*-value
Age (year)	64 (50-76)	68 (57-77)	55 (42-67)	<0.001
Male, n (%)	1,156 (39)	1,069 (93)	499 (90)	<0.001
BMI (kg/m^2)	22.5 (20.0-25.7)	21.8 (19.3-24.4)	22.0 (19.1-24.2)	<0.001
APACHE II score	10 (7-15)	11 (7-16)	10 (6-16)	0.150
Cigarette smoking pack year	0 (0-0)	15 (8-30)	15 (5-30)	0.040#
Pre-existing diseases, n (%)				
COPD	42 (1.4)	133 (11.6)	37 (6.6)	<0.001
Diabetes	718 (24.4)	244 (21.3)	56 (10.1)	<0.001
Hypertension	1,474 (50.0)	632 (55.1)	162 (29.1)	<0.001
Coronary artery disease	299 (10.1)	141 (12.3)	20 (3.6)	<0.001
Chronic kidney disease	304 (10.3)	111 (9.7)	27 (4.8)	<0.001
Operated, n (%)	2,362 (80.2)	893 (77.8)	394 (70.7)	<0.001
Major sites of surgery, n (%)				
Thoracic	88 (3.0)	66 (5.8)	34 (6.1)	<0.001
Upper abdomen	808 (27.4)	327 (28.5)	166 (29.8)	0.470
Lower abdomen	873 (29.6)	298 (26.0)	111 (19.9)	<0.001
Baseline laboratory variables				
PaO_2/FiO_2 ratio	342 (222-460)	310 (212-427)	323 (224-440)	0.020
Serum creatinine (mg/dL)	0.8 (0.7-1.0)	1.0 (0.8-1.1)	0.9 (0.8-1.1)	<0.001

Data are median (interquartile range) for continuous variables. The *p*-values compared among 3 groups of patients using the Chi-square test or Kruskal-Wallis test. # Compared between former smoker vs. current smoker
(APACHE = Acute Physiology And Chronic Health Evaluation; COPD = chronic obstructive pulmonary disease)

cigarette smoking available, there were 2,947 patients who had never smoked, 1,148 former smokers, and 557 current smokers (Table 1). There was no difference in APACHE II severity score among three groups of patients. Men obviously outnumbered women in former smoker and current smoker groups ($p<0.001$). Former smokers had the lowest BMI ($p<0.001$). Compared to former smokers and current smokers, patients who had never smoked had significantly lower proportion of COPD patients ($p<0.001$) and lower proportion of patients underwent thoracic surgery ($p<0.001$). Compared to the patients who had never smoked and former smokers, current smokers were significantly younger and had lower proportion of patients with diabetes ($p<0.001$), hypertension ($p<0.001$), coronary artery disease ($p<0.001$), and chronic kidney disease ($p<0.001$). Compared to former smokers and current smokers, patients who had never smoked had significantly higher baseline PaO_2/FiO_2 (342, IQR 222-460) ($p = 0.02$), and lower serum creatinine (0.8 mg/dL, IQR 0.7-1.0 mg/dL) ($p<0.001$). Former smokers had a statistically significant higher number of smoking pack year (15, IQR 8-30) than current smokers (15, IQR 5-30) ($p = 0.04$).

Probability of ARDS

There were 174 (3.7%) patients who were diagnosed ARDS after being admitted to the SICU. Compared to patients who had never smoked and former smokers, current smokers had a significantly higher probability of ARDS ($p = 0.003$) (Fig. 1). We then further analysed the relationship between cigarette smoking and the risk of ARDS using Cox proportional hazard and we found that, compared to patients who smoked less than 10-pack years, patients who smoked between 10 to 20-pack years and patients who smoked more than 20-pack years had a HR of 2.29 and 2.34, respectively ($p<0.05$). Analysis of dose response relationship between the effect of cigarette smoking and ARDS using median of patients' smoke pack years, patients who smoked more than 15-pack years had higher risk of ARDS 2.5 times to patients who smoked less than 15-pack years (95% CI 1.65-3.66, $p<0.001$). In multivariate analysis, after adjusting for age, gender, operated vs. non-operated, APACHE II score, and patients' pre-existing diseases (COPD, hypertension, coronary artery disease, diabetes, chronic kidney disease), we found that every 1-pack year of cigarette smoking before hospital admission is associated with

increased risk of ARDS with a HR of 1.02 (95% CI 1.01-1.02, $p = 0.001$) (Table 2).

Incidence of SIRS, sepsis, AKI, AMI, and 28-day mortality

There were 1665 (35.8%), 907 (19.5%), 786 (16.9%), and 66 (1.4%) patients who were diagnosed SIRS, sepsis, AKI, and AMI, respectively. While there was no difference in incidence of sepsis ($p = 0.13$) and AMI ($p = 0.19$) among three groups of patients (Fig. 2), we found that the patients who had never smoked had the lowest incidence of SIRS (34%), followed by former smokers (37%), and current smokers (41%) ($p = 0.006$) (Fig. 2A). Patients who had never smoked also had the lowest incidence of AKI (15.3%), followed by former smokers (19.0%), and current smokers (21.0%) ($p<0.001$) (Fig. 2C). However, after adjusted to patients' pre-existing diseases (COPD, coronary artery disease, diabetes, hypertension, chronic kidney disease), the number of smoke pack year was not independent risk factor of SIRS and AKI. There was no difference in 28-day mortality among three groups of patients (never smoked, n = 404 (13.7%), former smoker, n = 157 (13.7%), and current smoker, n = 81 (14.5%)) ($p = 0.86$).

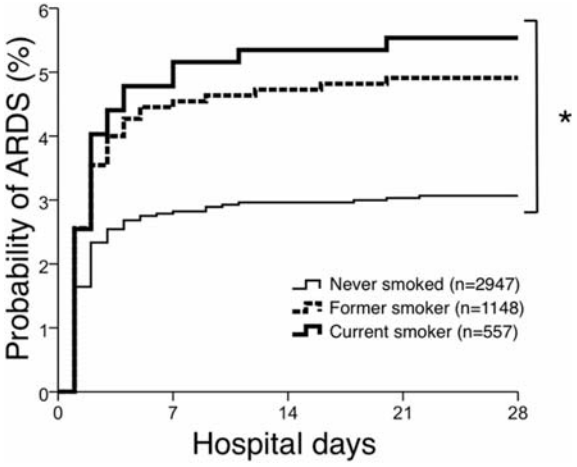

Fig. 1 Probability of acute respiratory distress syndrome (ARDS) among three groups of patients based on cigarette smoking status (Log-rank analysis, *$p = 0.003$).

SICU economic burden

Although statistical difference was significantly reached, no clinical difference was observed for SICU-LOS among the three groups of patients. Patients who had never smoked had SICU-LOS of 2 days (IQR 1-4), former smokers had SICU-LOS of 2 days (IQR 1-4), and current smokers had SICU-LOS of 2 days (IQR 1-5) ($p<0.001$). Interestingly, we found that current smokers had the highest total SICU cost (49,315 Thai Baht (THB), IQR 24,892-105,747 THB), followed by former smokers (44,188 THB, IQR 21,439-96,380 THB), and patients who never smoked (42,371 THB, IQR 20,704-88,056 THB) ($p = 0.02$) (Fig. 3).

Discussion

Cigarette smoking is one of leading cause of death and a risk factor for many diseases worldwide[2,16,17]. In a large prospective cohort study in 169,871 Chinese adults 40 years of age or older, found that there was a significant, dose-response association between pack years smoked and death from any cause[17]. In our study, even though we found no differences in 28-day mortality among patients who had never smoked, former smoker, and current smoker, which may be because our cohort had smaller numbers than the Chinese cohort to detect mortality difference, we found significant differences in morbidity outcomes which were incidence of ARDS, SIRS and AKI.

In Thailand, it was found that a number of

Table 2. Multivariate analysis for likelihood of having ARDS

	Hazard ratio	95% CI	*p*-value
Age (year)	1.01	1.01-1.03	0.020
Male (vs. female)	0.69	0.46-1.03	0.070
Operated (vs. non-operated)	2.45	1.69-3.55	<0.001
APACHE II score	1.12	1.10-1.14	<0.001
COPD	1.47	0.54-4.00	0.450
Cigarette smoking (1 pack: year)	1.02	1.01-1.03	0.001

Adjusted to age, gender, APACHE II score, operated/non-operated, pre-existing diseases (chronic obstructive pulmonary disease (COPD), hypertension, coronary artery disease, diabetes, chronic kidney disease), and cigarette smoking pack year

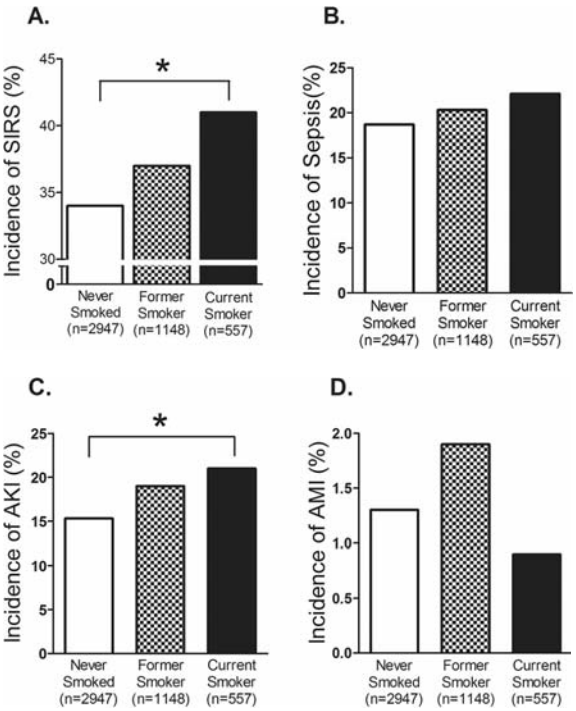

Fig. 2 Incidence of systemic inflammatory response syndrome (SIRS) (A), sepsis (B), acute kidney injury (AKI) (C), and acute myocardial infarction (AMI) (D) among three groups of patients based on cigarette smoking status (Chi-square's test, * $p<0.05$).

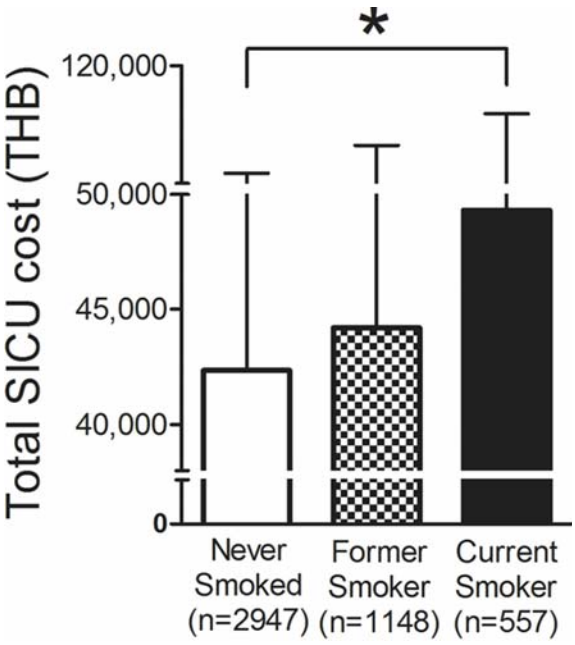

Fig. 3 Total SICU cost among three groups of patients based on cigarette smoking status (Kruskal-Wallis test, * $p = 0.02$).

smokers are significantly higher in men than in women[1,8] and our findings validated this current fact. According to baseline characteristics among three groups of patients in our cohort, we found that current smokers in our cohort were younger than the other groups of patients; this finding might explain why our patients in the current smoker group had a significantly lower proportion of patients with diabetes, hypertension, coronary artery disease, and chronic kidney disease at enrolment. However, we did find that current smokers had a significantly higher proportion of COPD patients compared to the other two patient groups.

It is a controversial issue whether cigarette smoking increases susceptibility to ARDS. One study in traumatic patients found no correlation between smoking and the risk of ARDS[18]. This result was contradicted by at least two studies of which the first study was a retrospective cohort study in multiethnic population, which found an independent dose-response association between current smokers and subsequent hospital presentation of ARDS[19]. Another study by Calfee et al found that smoker patients with non-pulmonary sepsis were significantly associated with increased risks of ARDS[20]. These results were aligned to our study in which we found that current smokers had the highest probability of ARDS, followed by former smokers, and never smoked patients. And we confirmed the effect of cigarette smoking on the likelihood of having ARDS adjusted to patients' baseline characteristics. We still found that every 1-pack year of cigarette smoking increases risk of ARDS with a HR of 1.02 (95% CI 1.01-1.03, $p = 0.001$). These are our major findings and may explain the fact that cigarette smoking could cause alveolar damage and thus directly contribute to respiratory insufficiency and ARDS. This concept was supported by previous experimental studies demonstrated that active smoking causes pathophysiological changes similar to those seen in ARDS[21,22].

In terms of systemic inflammation and distant organ dysfunctions, there is growing evidence supporting that smoking also contributes to development of atherosclerosis, peripheral vascular diseases, and organ dysfunctions[9-12]. In our study, we found that current smokers had a higher incidence of SIRS compared to patients who had never smoked and former smokers. Likewise, we found a surprising result that even current smokers had lower proportion

of patients with chronic kidney disease at enrollment, but they had significantly higher incidence of AKI compared to the patients who had never smoked and former smokers. This finding supports evidence that long-term cigarette smoking may be associated with kidney disease[23]. However, this effect may be result from "extrapulmonary effects" of COPD itself. One study in 189,561 individuals with COPD found that incidence of AKI is relatively high in COPD patients[24]. Also, there is increasing evidence that COPD also has important systemic manifestations and this may contribute to a higher incidence of SIRS and AKI in current smoker group in our cohort. This finding still needs validation in further well-controlled studies.

On the other hand, we found no difference in incidence of sepsis among three groups of patients, even there is evidence of impaired immunocompetence in smokers[12]. Our result was aligned with study by Ferro et al which recruited trauma patients with Injury Severity Score of more than or equal to 20 and excluded COPD patients, the authors found that there was no correlation between smoking and sepsis[18]. These findings may be explained by the small number of the patients in our cohort to detect differences in cases of sepsis, or the cause of sepsis in critically, surgical ill may be from multifactorial reasons and smoking is just one of the contributing factors. However, further large clinical trials are needed to confirm this hypothesis.

It has been reported that long-term smoking not only lead to left ventricular diastolic function alteration[25], but also promotes systemic atherosclerosis, alteration of lipid metabolism via increased lipolysis and lipotoxicity, and insulin resistance[26]. In a perioperative setting, smoking also reduces oxygen-carrying capacity, which is an additional risk factor for decreased oxygen supply to heart places the surgical patients at higher risk of perioperative AMI[27]. However, we found no difference in incidences of AMI among the three groups of patients.

Regarding the health burden, cigarette smoking was found to be one of leading risk factors related to disability-adjusted life years in the US population[28]. A recent study by Prochaska et al studied in employment service setting and clearly demonstrated that, compared to non-smoker, current smokers had a lower likelihood of re-employment at 1 year and were paid less than non-smokers when re-employed[29]. In our study of critically ill surgical patients, in terms of economic burden, we found that current smokers had a significantly higher SICU cost compared to patients who had never smoked and former smokers. This finding raises our concern about economic perspective regarding hospitals, especially in a developing country where hospital resources are limited. Further, well-controlled study is needed to confirm the economic burden of cigarette smoking on SICU's.

However, this study, itself, has some limitations. Firstly, we do not have pro-inflammatory cytokine data in our cohort. Even though we found that cigarette smoking was associated with increased risk of ARDS, SIRS, and AKI, which might be because of cigarette smoking induced systemic inflammation, it was only hypothetically generated. Another limitation of this study was that it was retrospective in nature; our cohort lacked important data such as echocardiographic studies to confirm the detrimental effects of smoking on the left ventricular function. In addition, in our cohort, we have no cigarette smoking exposure biomarkers such as plasma nicotine, cotinine levels or urine 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanol to confirm smoking exposure. So we performed analysis using only history-confirmed cigarette smoking, not biomarker-confirmed cigarette smoking. Thus, at our best, we only confirmed possible accuracy in our cohort by finding that current smokers had a significantly higher proportion of COPD patients compared to the other two groups of patients.

Conclusion

We found an evidence of dose-response effect between cigarette smoking and the risk of ARDS. Compared to the patients who had never smoked and former smokers, current smokers had significantly higher probability of ARDS. These finding suggested that a smoking cessation program possibly one effective strategy to prevent ARDS and reduce economic burden in SICU.

What is already known on this topic?

Smoking is linked to several major health problems such as chronic obstructive pulmonary disease and cardiovascular diseases.

What this study adds?

This study demonstrated that, compared to patients who had never smoked and former smokers, current smokers had significantly higher probability of acute respiratory distress syndrome, higher incidence of systemic inflammatory response syndrome, acute kidney injury, and higher total cost of the treatments in surgical intensive care unit.

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Potential conflicts of interest

The abstract of this study was presented to the 35th International Society of Intensive Care and Emergency Medicine (ISICEM) conference.

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อันตรายและภาระทางเศรษฐกิจในหออภิบาลผู้ป่วยวิกฤตจากการสูบบุหรี่ของผู้ป่วยวิกฤตทางศัลยกรรม: การศึกษาแบบย้อนหลัง

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วัตถุประสงค์: *การสูบบุหรี่ไม่เพียงมีผลกระทบต่อระบบทางเดินหายใจ แต่ยังพบว่ามีผลทำให้เกิดการอักเสบและการแข็งตัวของหลอดเลือดในร่างกาย สมมุติฐานของการศึกษานี้คือ ผู้ป่วยวิกฤตทางศัลยกรรม ที่สูบบุหรี่อาจเพิ่มโอกาสการเกิดภาวะหายใจล้มเหลวฉับพลัน ภาวะกระตุ้นกระบวนการการอักเสบในร่างกาย (systemic inflammatory response syndrome; SIRS) ภาวะ sepsis ภาวะอวัยวะต่างๆ ในร่างกาย ทำงานผิดปกติฉับพลัน และอาจมีค่าใช้จ่ายขณะรักษาตัวในหออภิบาลผู้ป่วยวิกฤตทางศัลยกรรมที่สูงขึ้น*

วัสดุและวิธีการ: *ดำเนินการศึกษาแบบย้อนหลังโดยใช้ตัวอย่างผู้ป่วยจากการศึกษา THAI-SICU ซึ่งศึกษาในผู้ป่วยที่รับการรักษาตัวในหออภิบาลผู้ป่วยวิกฤตทางศัลยกรรมจำนวน 9 แห่งในประเทศไทย โดยแบ่งผู้ป่วยที่มีข้อมูลของการสูบบุหรี่ออกเป็น 3 กลุ่มได้แก่ 1) ผู้ป่วยที่ไม่เคยสูบบุหรี่เลย 2) ผู้ป่วยที่เคยสูบบุหรี่และเลิกสูบแล้ว 3) ผู้ป่วยที่ยังสูบบุหรี่อยู่ โดยเปรียบเทียบโอกาสการเกิดภาวะหายใจล้มเหลวฉับพลัน อัตราการเกิดภาวะ SIRS ภาวะ sepsis ภาวะไตทำงานผิดปกติฉับพลัน ภาวะกล้ามเนื้อหัวใจขาดเลือดฉับพลัน และค่าใช้จ่ายในหออภิบาลผู้ป่วยวิกฤตทางศัลยกรรมในผู้ป่วยทั้ง 3 กลุ่ม*

ผลการศึกษา: *จากจำนวนผู้ป่วยที่มีข้อมูลการสูบบุหรี่ทั้งหมด 4,652 คน แบ่งเป็นผู้ป่วยที่ไม่เคยสูบบุหรี่เลย 2,947 คน ผู้ป่วยที่เคยสูบบุหรี่และเลิกแล้ว 1,148 คน และผู้ป่วยที่ยังสูบบุหรี่อยู่ 557 คน เมื่อเปรียบเทียบกับผู้ป่วยที่เลิกสูบบุหรี่แล้วและผู้ป่วยที่ยังสูบบุหรี่อยู่ พบว่าผู้ป่วยที่ไม่เคยสูบบุหรี่มีอัตราส่วนของผู้ป่วยที่เป็นโรคถุงลมโป่งพองน้อยกว่า ($p<0.01$) และมีค่า PaO_2/FiO_2 ในเลือดสูงกว่า ($p = 0.002$) อย่างมีนัยสำคัญ ผู้ป่วยที่ยังสูบบุหรี่อยู่มีโอกาสเกิดภาวะหายใจล้มเหลวฉับพลัน ($p = 0.003$) ภาวะ SIRS ($p = 0.006$) และภาวะไตทำงานผิดปกติ ($p<0.001$) สูงกว่าผู้ป่วยอีก 2 กลุ่ม อย่างมีนัยสำคัญหลังจากควบคุมตัวแปรต่างๆ ที่อาจมีผลต่อการเกิดภาวะหายใจล้มเหลวฉับพลันและทำการวิเคราะห์ พบว่าบุหรี่ที่สูบเพิ่มขึ้นทุกๆ 1 วัน/ซอง/ปี จะเพิ่มความเสี่ยงในการเกิดภาวะหายใจล้มเหลวฉับพลัน 1.02 เท่าเมื่อเทียบกับผู้ป่วยที่ไม่สูบบุหรี่เลย (95% CI 1.01-1.03, $p = 0.001$) และพบว่าผู้ป่วยที่ยังคงสูบบุหรี่จะมีค่าใช้จ่ายในการรักษาตัวในหออภิบาลผู้ป่วยวิกฤตทางศัลยกรรมสูงกว่าผู้ป่วยกลุ่มที่ไม่เคยสูบบุหรี่เลย และกลุ่มที่เลิกสูบบุหรี่แล้วอย่างมีนัยสำคัญ ($p = 0.02$)*

สรุป: *ผู้ป่วยที่ยังสูบบุหรี่อยู่มีโอกาสเกิดภาวะหายใจล้มเหลวฉับพลัน ภาวะ SIRS ภาวะไตทำงานผิดปกติ ตลอดถึงค่าใช้จ่ายในหออภิบาลผู้ป่วยวิกฤตทางศัลยกรรมสูงกว่าผู้ป่วยที่เลิกสูบบุหรี่แล้วและผู้ป่วยที่ไม่เคยสูบบุหรี่เลยอย่างมีนัยสำคัญ การศึกษานี้ชี้ให้เห็นถึงอันตรายของการสูบบุหรี่ในผู้ป่วยที่มีภาวะวิกฤตทางศัลยกรรม*