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ORIGINAL RESEARCH

Diagnostic accuracy and reliability of fiberoptic bronchoscopy in lung injury due to inhalation burns

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Abstract

Background: Lung injury resulting from inhalation of smoke or chemical combustion products is a significant cause of morbidity and mortality. It is important to make an early diagnosis, accurately determine the severity of the injury, and intervene early. The aim of this study is to evaluate the accuracy and reliability of bronchoscopy in the diagnosis and mortality of patients admitted to the burn intensive care unit (ICU) with a preliminary diagnosis of inhalation burn. **Methods**: This retrospective study was conducted on 48 patients admitted to our burn ICU between 2017 and 2022 with a preliminary diagnosis of inhalation injury. Demographic data, comorbidities, initial physical examination findings TBSA (total body surface area), inhalation injury grades, Baux score, ABSI (A Body Shape Index), type of admission to the ICU (extubated/intubated), additional trauma, difficult airway, facial burn, accompanying carbon monoxide or cyanide poisoning its existence was recorded. Initial blood gas, lactate, carboxy hemoglobin values, the ratio of partial pressure of oxygen in arterial blood to the fraction of inspiratory oxygen concentration (P/F) ratio, chest radiography and fiberoptic bronchoscopy (FOB) findings (based on abbreviated injury score (ASI) criteria, ASI G0: no injury; G1: mild; G2: moderate; G3: severe; and G4: massive injury), duration of mechanical ventilation (MV), hospital and ICU stay, complications of inhalation injury, supportive treatments (Extracorporeal membrane oxygenation (ECMO), and Renal Replacement Therapy (RRT)) and correlations with mortality were also evaluated. **Results**: It was observed that the most deaths were in G2, the highest ABSI scores and the longest MV, ICU and hospital stays were in G3. In addition, it was determined that the cases that non-survivors were older ($p = 0.005$), had more burn surfaces ($p = 0.026$), and bicarbonate and P/F ratios were higher. **Conclusions**: It was concluded that FOB is an accurate and safe tool in the diagnosis and early treatment of inhalation burns, and that its routine use, even repeated at intervals, can reduce mortality.

Keywords

Bronchoscopy; Airway burns; Diagnostic

1. Introduction

The most important factors affecting the prognosis of burn patients are; total burn surface area, age and the presence of inhalation injury [1, 2]. Inhalation burn can be defined as acute mucosal damage to the respiratory system as a result of inhalation of particulate matter contained in flame, steam, smoke or toxic gas. Even today, it is an important cause of morbidity and mortality in burn patients, as it can trigger hypoxia, pneumonia, septicemia, acute respiratory distress syndrome (ARDS) and respiratory failure [3].

It is known that prevention or early diagnosis and treatment of life-threatening complications will reduce morbidity and mortality in inhalation burns. Anamnesis, physical examination, chest radiography, arterial blood gas analysis, and imaging techniques can identify airway damage. However, the diagnosis of inhalation injury begins with anamnesis and learning the physical conditions of the environment where the burn occurred. The risk of smoke inhalation is high in fires of closed environments.

Nonspecific symptoms such as agitation, confusion, burned nasal or facial hair, smoke blackness on the nose and face, hoarseness, dyspnea, stridor, and wheezing may be observed [4]. However, although both injuries occur together, clinical symptoms may not be evident before fatal pulmonary complications to occur, as inhalation injuries can sometimes be presented without cutaneous injuries.

Inhalation burns may be suspected in case of increased carboxyhemoglobin (COHb) level [3]. However, if oxygen has been administered or a significant period of time has passed

since the first exposure to carbon monoxide (CO), the COHb level may appear normal. All patients inhaling smoke should also be evaluated for toxic compounds such as CO, cyanide and aldehydes. Arterial blood gas analyzes are normal until 1–2 days after the onset of damage. Due to delayed pathological changes that occur with smoke inhalation, chest radiography is normal in many cases in the early period, or nonspecific findings such as edema and pulmonary infiltration may be observed. Bronchiectasis and a frosted glass image can be seen in the lungs on Computerized Tomography scans performed immediately after inhalation injury [5]. Since these are not obvious specific findings, it has been reported in recent years that fiberoptic bronchoscopy (FOB) is the most valuable diagnostic method, even the gold standard, in determining the diagnosis and severity of inhalation injuries [6]. However, there is still no clear information about the reliability of bronchoscopy as a consistent diagnostic criterion in lung injury due to burns.

The main purpose of our retrospective study was to determine the effect of fiberoptic bronchoscopy on mortality in patients with inhalation burns who were admitted to the burn intensive care unit with a preliminary diagnosis of inhalation injury but whose actual diagnosis was made by fiberoptic bronchoscopy. Our secondary aim was to evaluate the other factors affecting the mortality of patients with inhalation burns.

2. Materials and methods

This retrospective study was conducted by evaluating patients who were followed up with a preliminary diagnosis of inhalation burn in our burn intensive care unit (ICU) between January 2017 and December 2022, following the approval of University of Health Science Kartal Dr Lütfi Kırdar City Hospital Ethics Committee (No: 2022151412271, Date: 08 June 2022). Informed consent was obtained from all subjects and data were collected in accordance with the Declaration of Helsinki bioethics. Confidentiality policies also were provided. Inclusion criteria were age between 6 and 75 years, patients with 20% to 60% total body surface area burns (TBSA), and patients who underwent bronchoscopy within 24 hours. Outpatients, recurrent patients, cases with incomplete medical records and concurrent complications or a history of psychological disorders and suicidal burns were excluded.

Demographic data, comorbidities, initial physical examination findings (TBSA, inhalation injury grades, Baux score (Age + Burn% + 17), A Body Shape Index (ABSI), type of admission to the ICU (extubated/intubated), additional trauma, difficult airway, facial burn, accompanying CO or cyanide poisoning its existence was recorded. Initial blood gas analysis, lactate, carboxy hemoglobin values, PaO_2/FiO_2 (P/F) ratio, chest radiography (no pathology/infiltration/edema and bronchoscopy findings using an Olympus BF260 video bronchoscope (Olympus Medical Systems Corporation; Tokyo, Japan) based on abbreviated injury score (ASI) criteria as ASI 0: no injury; 1: mild; 2: moderate; 3: severe; and 4: massive injury [7] (Table 1), duration of mechanical ventilation (MV) (Pressure-controlled mode was applied to patients receiving mechanical ventilation, with a plateau pressure below 35 cmH_2O, inspired oxygen concentration (FiO_2) at Oxygen saturation (SpO_2) 90–92%, low tidal volume (5–7 mL/kg), and positive end-expiratory pressure (PEEP) of 8–10 cmH_2O, however, in patients with high ASI scores where inadequate oxygenation could not be achieved, we applied High tidal volume (HTV), High-frequency percussive ventilation (HFPV), or High Frequency Oscillatory Ventilation (HFOV) modes), hospital and ICU stay, complications of inhalation injury such as ARDS, sepsis, pneumonia, *etc.*, supportive treatments like Extracorporeal membrane oxygenation (ECMO), and Renal Replacement Therapy (RRT). Besides the correlations with mortality were recorded.

3. Statistical analysis

SPSS (SPSS Inc., Chicago, IL, USA) version 25 statistical package program was used for statistical analysis. While evaluating the study data, descriptive statistical methods (mean, frequency, percentage, minimum, maximum) were used to summarize the data. Shapiro-Wilk Test was used for normality tests of continuous variables. To investigate the differences between the two groups, *t*-test was applied for continuous variables showing normal distribution, and Mann Whitney U Test was applied to compare data that did not. According to the scores of the patients, their mortality risks were investigated using the Cox Regression method, which is a survival analysis. The significance level was taken as 0.05 for all tests performed.

Using the G*Power 3.1 (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, NW, Germany) package program for the research, the number of samples required for 85% test power was found to be 45. The calculation was made by taking into account whether continuous variables comply with normal distribution or not and the tests that should be used in both cases. The number of patients included in the study was 48, and according to this number, the power of the test was calculated

TABLE 1. Abbreviated injury score criteria for bronchoscopic findings of inhalation injury [7].

Grade	Fiberoptic Bronchoscopy Findings
Grade 0: (no injury)	Existence of carbonaceous deposits, erythema, edema or obstruction
Grade 1: (mild injury)	Minor or patchy areas of erythema, carbonaceous deposits in proximal or distal bronchi
Grade 2: (moderate injury)	Moderate degree of erythema, carbonaceous deposits, bronchorrhea, with or without compromise of the bronchi
Grade 3: (severe injury)	Severe inflammation with friability, copious carbonaceous deposits, bronchorrhea, bronchial obstruction
Grade 4: (massive injury)	Evidence of mucosal sloughing, necrosis, endoluminal obliteration

as 87.50%.

4. Results

Of the 48 inhalation burn patients admitted to our University Hospital Burn Intensive Care Unit, 13 (27.1%) were non-survivors and 35 (72.9%) were survivors. Forty-two of the patients in our study were male and 6 were female.

No edema was observed in 4 (8.33%) patients. However, mild laryngeal edema and erythema were observed in 10 (20.83%) patients, moderate mucosal edema and erythema in 29 (60.41%) patients, and severe tracheal mucosal edema and erythema in 5 (10.41%) patients. In our study to evaluate the role of FOB in inhalation injuries, frequency and percentage distributions of FOB findings with gender, comorbidity status, inhalation injury grade, 3rd grade burn, extubated-intubated status, presence of tracheostomy, first chest radiography categorical variables are given in Table 2.

It was observed that there was no accompanying cyanide poisoning and no need for noninvasive mechanical ventilation or ECMO in any patient. We also observed that the highest mortality rate was in the G3 group: 60% and followed by the G1 group with a rate of 40%. The distribution of FOB results and other categorical variables are shown in Table 3.

Changes of FOB results with continuous variables such as age, burn surface area, Baux and ABSI scores, intubation time, duration of MV, ICU and hospitalization, and p values of Mann Whitney Tests performed due to lack of normality according to FOB groups are given in Table 4.

The duration of ICU is longer in patients with G3, and the average ABSI scores of this group of patients are higher than other groups. If the significance level is taken as 10%, it is analysed that there is a difference in the first partial oxygen pressure (pO_2) value (p value < 0.10) and that this value is higher in patients without laryngeal edema than in other groups. There are no differences between FOB groups regarding the arterial blood gas analysis.

While the Baux score was 89.17 (62–121) in survivors and 110.38 (91–124) in non-survivors ($p < 0.001$), the ABSI score was 8.49 (6–11) and 10.23 (8–11) respectively ($p < 0.001$). It

TABLE 2. Fiberoptic bronchoscopy findings and distribution of categorical variables.

Variables	Fiberoptic Bronchoscopy Findings			
	G0 n = 4	G1 n = 10	G2 n = 29	G3 n = 5
Sex, n (%)				
Male	4 (100%)	9 (90%)	26 (89.7%)	3 (60%)
Female	0 (0%)	1 (10%)	3 (10.3%)	2 (40%)
Comorbidity, n (%)				
No	4 (100%)	10 (100%)	23 (79.3%)	5 (100%)
Yes	0 (0%)	0 (0%)	6 (20.7%)	0 (0%)
Inhalation injury grade, n (%)				
0	1 (25%)	0 (0%)	1 (3.4%)	0 (0%)
2	0 (0%)	3 (30%)	3 (10.35%)	0 (0%)
3	1 (25%)	6 (60%)	22 (75.9%)	4 (80%)
4	1 (25%)	0 (0%)	1 (3.45%)	1 (20%)
5	1 (25%)	1 (10%)	2 (6.9%)	0 (0%)
3rd grade burn, n (%)				
No	1 (25%)	3 (30%)	4 (13.8%)	0 (0%)
Yes	3 (75%)	7 (70%)	25 (86.2%)	5 (100%)
Extubated-Intubated, n (%)				
Extubated	0 (0%)	0 (0%)	1 (3.4%)	0 (0%)
Intubated	4 (100%)	10 (100%)	28 (96.6%)	5 (100%)
Tracheostomy, n (%)				
No	4 (100%)	10 (100%)	26 (89.7%)	2 (40%)
Yes	0 (0%)	0 (0%)	3 (10.3%)	3 (60%)
First chest X-ray, n (%)				
No pathology	3 (75%)	9 (90%)	24 (82.8%)	1 (20%)
Infiltration	1 (25%)	1 (10%)	4 (13.8%)	3 (60%)
Edema	0 (0%)	0 (0%)	1 (3.4%)	1 (20%)

TABLE 3. Fiberoptic bronchoscopy findings and distribution of categorical variables.

Variables	Fiberoptic Bronchoscopy Findings			
	G0 n = 4	G1 n = 10	G2 n = 29	G3 n = 5
Complication 1, n (%)				
None	4 (100.0%)	10 (100.0%)	26 (89.7%)	4 (80.0%)
Tracheal stenosis	0 (0.0%)	0 (0.0%)	2 (6.9%)	1 (20.0%)
Stridor	0 (0.0%)	0 (0.0%)	1 (3.4%)	0 (0.0%)
Complication 2, n (%)				
No	4 (100.0%)	7 (70.0%)	27 (93.2%)	5 (100.0%)
Pneumonia	0 (0.0%)	0 (0.0%)	1 (3.4%)	0 (0.0%)
Acute respiratory distress syndrome	0 (0.0%)	2 (20.0%)	1 (3.4%)	0 (0.0%)
Sepsis	0 (0.0%)	1 (10.0%)	0 (0.0%)	0 (0.0%)
Live, n (%)				
Non-survivors	0 (0.0%)	4 (40.0%)	6 (20.7%)	3 (60.0%)
Survivors	4 (100.0%)	6 (60.0%)	23 (79.3%)	2 (40.0%)
Hyperbaric O_2 therapy, n (%)				
No	4 (100.0%)	10 (100.0%)	29 (100.0%)	4 (80.0%)
Yes	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (20.0%)
CO poisoning, n (%)				
No	4 (100.0%)	9 (90.0%)	26 (89.7%)	5 (100.0%)
Yes	0 (0.0%)	1 (10.0%)	3 (10.3%)	0 (0.0%)
Facial burn, n (%)				
No	0 (0.0%)	1 (10.0%)	3 (10.3%)	0 (0.0%)
Yes	4 (100.0%)	9 (90.0%)	26 (89.7%)	5 (100.0%)
Difficult airway, n (%)				
No	4 (100.0%)	10 (100.0%)	27 (93.1%)	4 (80.0%)
Yes	0 (0.0%)	0 (0.0%)	2 (6.9%)	1 (20.0%)
Presence of additional trauma, n (%)				
No	4 (100.0%)	10 (100.0%)	28 (96.6%)	5 (100.0%)
Yes	0 (0.0%)	0 (0.0%)	1 (3.4%)	0 (0.0%)
Renal replacement therapy, n (%)				
No	4 (100.0%)	7 (70.0%)	23 (79.3%)	2 (40.0%)
Yes	0 (0.0%)	3 (30.0%)	6 (20.7%)	3 (60.0%)

CO: carbon monoxide, O_2: oxygen.

TABLE 4. Fiberoptic Bronchoscopy Findings and distribution of continuous variables and difference test results (median, range, the significance level was taken as 0.05).

Variables	Fiberoptic Bronchoscopy Findings				*p* value
	G0 n = 4	G1 n = 10	G2 n = 29	G3 n = 5	
Age, yr	32.50 (22–44)	39.10 (18–61)	37.31 (16–74))	41.20 (34–52)	0.788
TBSA, %	37.13 (23–50)	37.55 (25–56.5)	40.10 (21–64)	50.60 (35–63)	0.185
Baux score	86.63 (62–111)	93.60 (65–119)	94.12 (64–124)	108.8 (92–115)	0.221
ABSI	8.50 (7–10)	8.70 (6–11)	8.83 (6–11)	10.60 (10–11)	0.050
Intubation time, day	6.67 (0.38–0.96)	5.36 (0.11–20.30)	2.67 (0.40–12.13)	0.56 (0–2.45)	0.205
Duration of MV, hour	182 (90–288)	260.5 (72–528)	411.61 (0–3360)	1042.20 (252–2065)	0.137
Duration of ICU stay, day	26 (22–33)	21.90 (12–40)	31.24 (6–155)	74.40 (25–133)	0.048
Duration of hospital stay, day	44.50 (33–72)	40 (12–84)	51.66 (6–169)	82.20 (43–139)	0.310
Level of COHb, %	1.75 (0.9–3.6)	2.07 (0.7–8.8)	1.90 (0.6–8.4)	0.82 (0.2–1.4)	0.429
Initial P/F ratio, %	206.5 (178–280)	236.1 (90–320)	197.52 (79–360)	215.6 (100–336)	0.636

TBSA: Total body surface area, ABSI: A Body Shape Index, MV: Mechanical ventilation, ICU: Intensive Care Unit, COHb: Carboxyhemoglobin, P/F: PaO_2/FiO_2.

was observed that both scores are high in mortal cases.

Due to Cox Regression Analysis the Baux score was more effective in determining mortality, and as seen in Fig. 1, the mortality rate increases as the Baux score increases, according to hazard distribution.

Fig. 2 shows the change in duration of hospital and the life-threatening rates for patients. We observed that as the length of hospital stay of patients increases, the mortality rate also increases.

The distribution of mortality and gender, American Society of Anesthesiologists (ASA), additional disease, 3rd degree burn, facial burn, additional traumatic injury, difficult airway, CO and cyanide poisoning, inhalation burn complications, presence of tracheostomy, degree of inhalation injury, extubated-intubated status, first chest radiography findings, Non Invasive Mechanical Ventilation (NIMV) requirement, hyperbaric O_2, ECMO and RRT treatments is given in Table 5.

Mortality rates were observed to be higher in patients with male, comorbidities, 3rd degree burns, tracheostomy and infiltration on the first chest radiograph. There were no complications in the complication 2 category for surviving patients. We also observed more frequently RRT application in non-survivor patients (Table 5).

Mortality and continuous variables including age, burn surface area, intubation time, duration of MV, ICU and hospital stay are given in Table 6. The non-survivors were older and had more TBSA. The duration of hospital stay for non-survivor patients was longer. The mean initial HCO_3 level and initial

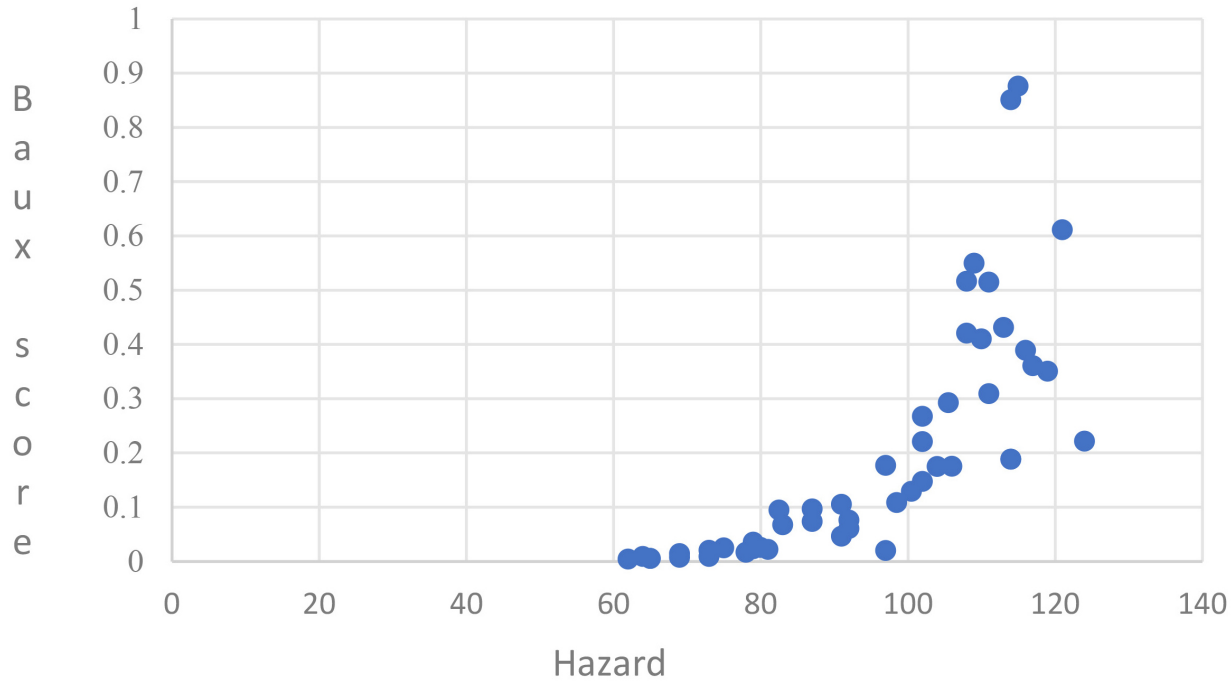

FIGURE 1. Baux score and mortality rate.

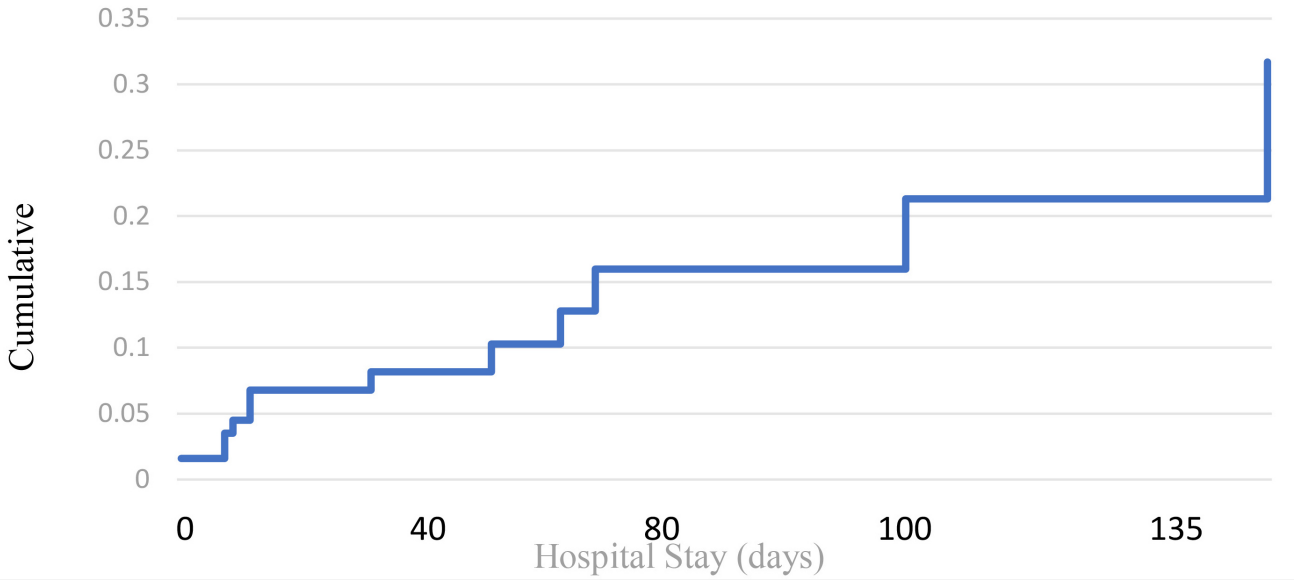

FIGURE 2. Duration of hospital stay and mortality rate.

TABLE 5. Distribution of categorical variables by hospital discharge status.

Variables	Hospital discharge status	
	Survivors n = 35	Non-survivors n = 13
Sex, n (%)		
Male	30 (85.7%)	12 (92.5%)
Female	5 (14.3%)	1 (12.5%)
Comorbidity, n (%)		
No	33 (94.3%)	9 (69.2%)
Yes	2 (5.7%)	4 (30.8%)
Inhalation injury grade, n (%)		
0	2 (5.7%)	0 (0.0%)
2	5 (14.3%)	1 (7.7%)
3	23 (65.7%)	10 (76.9%)
4	1 (2.9%)	2 (15.4%)
5	4 (11.4%)	0 (0.0%)
3rd grade burn, n (%)		
No	7 (20.0%)	1 (7.7%)
Yes	18 (80.0%)	12 (92.3%)
Extubated-Intubated, n (%)		
Extubated	1 (3.9%)	0 (0.0%)
Intubated	34 (97.1%)	13 (100.0%)
Tracheostomy, n (%)		
No	33 (94.3%)	9 (69.2%)
Yes	2 (5.7%)	4 (30.8%)
First chest X-ray, n (%)		
No pathology	28 (80.0%)	9 (69.2%)
Infiltration	5 (14.3%)	4 (30.8%)
Edema	2 (5.7%)	0 (0.0%)
Complication 1, n (%)		
No	32 (91.4%)	12 (92.3%)
Tracheal stenosis	2 (5.7%)	1 (7.7%)
Stridor	1 (2.9%)	0 (0.0%)
Complication 2, n (%)		
No	35 (100%)	8 (61.5%)
Pneumonia	0 (0.0%)	1 (7.7%)
ARDS	0 (0.0%)	3 (23.0%)
Sepsis	0 (0.0%)	1 (7.7%)
Hyperbaric O_2 therapy, n (%)		
No	35 (100.0%)	12 (97.9%)
Yes	0 (0%)	1 (2.1%)
CO poisoning, n (%)		
No	32 (91.4%)	12 (92.3%)
Yes	3 (8.6%)	1 (7.7%)

TABLE 5. Continued.

Variables	Hospital discharge status	
	Survivors n = 35	Non-survivors n = 13
Facial burn, n (%)		
No	3 (8.6%)	1 (7.7%)
Yes	32 (91.4%)	12 (92.3%)
Difficult airway, n (%)		
No	34 (97.1%)	11 (84.6%)
Yes	1 (2.9%)	2 (15.4%)
Presence of additional trauma, n (%)		
No	34 (97.1%)	13 (100.0%)
Yes	1 (2.9%)	0 (0.0%)
ECMO, n (%)		
No	35 (100.0%)	13 (100.0%)
Yes	0 (0.0%)	0 (0.0%)
RRT, n (%)		
No	31 (88.6%)	5 (38.5%)
Yes	4 (11.4%)	8 (61.5%)

ECMO: Extracorporeal membrane oxygenation, RRT: Renal Replacement Therapy, ARDS: Acute Respiratory Distress Syndrome, CO: carbon monoxide, O_2: oxygen.

TABLE 6. Distribution of continuous variables by hospital discharge status and difference test results.

Variables	Hospital discharge status		*p* values
	Survivors n = 35	Non-survivors n = 13	
Age, yr	34.11 (16–62)	47.31 (21–74)	0.005[1]
TBSA, %	38.10 (21–64)	46.65 (30–63)	0.026[1]
Intubation time, day	1.53 (0.09–12.13)	1.38 (0.0–20.30)	0.728[2]
Duration of MV, hour	377 (0–3360)	560 (72–1800)	0.379[2]
Duration of ICU, day	32.4 (12–155)	35.92 (6–133)	0.731[2]
Duration of hospital stay, day	57.69 (18–169)	36.0 (16–133)	0.05[2]
Level of COHb, %	1.79 (0.6–8.8)	1.85 (0.2–7.2)	0.921[2]
Initial pH	7.31 (7.08–7.55)	7.31 (7.17–7.45)	0.807[1]
Initial pO_2, mmHg	142.34 (43–401)	137.08 (59.8–288)	0.668[1]
Initial pCO_2, mmHg	41.15 (19.8–63.1)	43.17 (25.6–63.9)	0.702[1]
Initial HCO_3, mmol/L	19.71 (14.8–28.9)	22.07 (15.4–31)	0.05[1]
Initial base excess	−5.96 (−13.7–3.4)	−4.05 (−12.4–5)	0.237[1]
Initial SaO_2, %	95.34 (69.6–100)	97.2 (89.1–99.1)	0.508[2]
Initial lactate, mmol/L	2.79 (1.1–6)	3.2 (1.1–7.6)	0.719[1]
Initial P/F %	180.4 (79–280)	283 (184–360)	<0.001[1]

[1]*Mann-Whitney Test.* [2]*t test. Bold numbers represent the value* $p < 0.05$.
MV: Mechanical ventilation, ICU: Intensive Care Unit, COHb: Carboxyhemoglobin, P/F: PaO_2/FiO_2; TBSA: Total body surface area, pO_2: partial oxygen pressure, pCO_2: partial carbon dioxide pressure, HCO_3: bicarbonate, SaO_2: arterial oxygen saturation.

P/F ratio of non-survivor patients were also found to be higher than survivors (Table 6).

5. Discussion

There is no consensus on the diagnosis, severity grading, and prognosis of inhalation burns, and many have low sensitivity and reliability. Although it has not been fully established that there is a direct correlation between bronchoscopic degree and mortality, it was reported that fiberoptic bronchoscopy is the most used and reliable method to diagnose the severity of inhalation injuries [8]. However, most burn centers determine diagnostic methods according to their own facilities and practical applications [9]. It is difficult to determine its effect in predicting complications and mortality.

In previous studies, the mortality rate of inhalation injuries in burn patients was approximately 30% [10, 11]. Consistent with the results of the researchers, we determined the mortality rate in our study to be 27%. While in several studies [12, 13] higher grade injuries were associated with poor prognosis, one study [14] reported no correlation between them. Mosier *et al*. [13], in their study on patients with inhalation injury, reported that there was no consistent correlation between bronchoscopy grading and fluid resuscitation requirement and mortality. Consistent with the study by previous researchers, we observed worse oxygenation and longer ICU stay in patients with inhalation injury with high-grade bronchoscopic grading in our study [3, 11, 15, 16].

Controversy still exists to predict the outcome using the FOB skills. In our study, unlike many researchers, we did not detect a significant difference in the frequency of complications between patients with high-grade inhalation injuries and patients with low-grade inhalation injuries [13, 16]. On the other hand, in a retrospective trial of 160 subjects, both low and high grade inhalation injury had no significant effect on the incidence of mortality or ARDS [15].

In terms of mortality, the incidence rate in G0, G1, G2 and G3 were determined as 0%, 40%, 20%, 60%, respectively. Consistent with the studies of Gad *et al*. [16] and Endorf *et al*. [7], we concluded that the bronchoscope had a role in evaluating the severity and outcome of inhalation injury. Chou *et al*. [17] included 167 inhalation burn patients in the study and investigated the effect of FOB in predicting acute lung injury. The authors reported that they applied FOB to all patients within the first 24 hours and that the mortality rates were low because they repeated this occasionally for treatment purposes. Ji *et al*. [18], in their study on patients with inhalation burns, reported that, SOFA score is good predictor of outcomes after inhalation burns. In accordance with the researchers, we applied FOB to the patients admitted to our burn intensive care unit with the preliminary diagnosis of inhalation burn, when they were hospitalized and at regular intervals thereafter. In our repeated applications, we performed bronchoalveolar lavage for therapeutic purposes and also evaluated the response to our treatments. However, since there was no patient group with non-repeated bronchoscopy in our study, we do not have data comparing the mortality rates of these two groups. For this reason, researchers may not have a clear idea about whether it reduces mortality or not.

In a single-centre cohort study of critical inhalational injury patients, prior implication of FOB grading determined the risk factor for mortality [19]. The authors recommended further studies to display the diagnostic accuracy and reliability of FOB. In our study, we found a positive correlation between total burn surface area, age, P/F ratio with mortality. You *et al*. [20] determined a significant difference between survivors and non-survivors in terms of age, TBSA burn percentage, ABSI score, mechanical ventilation requirement and P/F ratio, and bronchoscopic grades in patients undergoing bronchoscopy with suspicion of inhalation injury. They stated that severe inhalation injury in mechanical ventilation and bronchoscopy are independent determinants of mortality and that all factors should be taken into account in the diagnosis of inhalation injury.

6. Limitations

The main limitation of this study was its retrospective nature. Another limitation was being a single-center study. Furthermore, the number of samples was small. Further research through registries will contribute more.

7. Conclusions

Based on our findings that mortality was most common in the group with severe airway damage on bronchoscopy, we conclude that FOB is an accurate and safe tool for the diagnosis, mortality, and indirect early treatment of inhalation burns. We think that its routine use in treatment may be effective in reducing mortality. We believe that further studies should be conducted to evaluate the therapeutic effect of FOB by performing it at repeated intervals.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

KTS and AS—designed the research study. GA—performed the research. SY, ŞA and ÖS—analyzed the data. GA and PR—wrote the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was following the approval of University of Health Science Kartal Dr. Lütfi Kırdar City Hospital Ethics Committee (No: 2022151412271, Date: 08 June 2022). Informed consent was obtained from all subjects and data were collected in accordance with the Declaration of Helsinki bioethics.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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