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Macroscopic and histological findings in the healing process of inhalation injury

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ARTICLE INFO

Article history:

Accepted 26 October 2006

Keywords:

Inhalation injury
Burns
Bronchoscopy
Histological findings
Healing process
Recovery stage

ABSTRACT

Although many investigators reported the diagnostic and therapeutic value of bronchoscopy in the early stage of inhalation injury, few findings in the late stage of inhalation injury have been reported. We investigated histopathological changes of in trachea and bronchi after inhalation injury. Five survivors with inhalation injury underwent bronchoscopic examinations combined with biopsies from the early stage to the late stage. Although the bronchotracheal membranes improved to near normal under the bronchoscopic findings in the late or recovery stage, invasion of inflammatory cells and the capillary dilatation in the subepithelial region were still remarkable histologically. Goblet cells also increased on the surface of mucous membranes. In cases of the inhalation injury with severe burn, pulmonary edema, bronchial edema and secretions tended to be prolonged.

Results suggested that continuous secretions in the respiratory tracts sometimes cause airway obstruction. Bronchoscopic and histologic findings in the healing process of inhalation injury predict long-term pulmonary functional outcome. Moreover, the aggressive pulmonary toilet seemed to be effective in removing foreign particles and accumulated secretions which also cause the inflammatory response and the obstruction in inhalation injury.

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1. Introduction

The efficacy of flexible fiber bronchoscopy as a diagnostic and therapeutic adjunct for the management of inhalation injury is well established [1–5]. Furthermore, bronchoscopy combined with biopsies has been used for the early diagnosis of inhalation injury in patients suspected of having inhaled smoke, toxic fumes or chemical vapors [2,3]. Although many investigators reported the value of bronchoscopy only in the early stage of inhalation injury, few studies focused on long-term reactions or late stages of inhalation injury. In our

experience, there are a group of patients who are apparently normal on clinical and bronchoscopic examination, but have a poor respiratory outcome in the late stage of inhalation injury. Furthermore, obstructive airway disease commonly occurs several years after inhalation injury [6]. It is essential for better prognosis of inhalation injury to estimate tracheobronchial changes in the late stage. We therefore observed the mucous membrane by fiberoptic bronchoscopy with biopsy from the early stage to the late stage to assess the factors related to predicting respiratory outcome.

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0305-4179/\$32.00 © 2006 Published by Elsevier Ltd and ISBI.

doi:10.1016/j.burns.2006.10.405

2. Patients and methods

Five patients described were taken from a series of patients with inhalation injury who presented to the Burn Unit of Hamamatsu Medical Center from May 2002 to April 2004 and survived. All of the patients were admitted to our hospital immediately after the injury and underwent diagnostic bronchoscopy on admission. Three of them had more than 20% of burn surface area in addition to inhalation injury. After the treatment by our standard protocol including follow-up bronchoscopy, they survived the condition and were discharged from the hospital. They were two men and three women aged 56–83 years old (Table 1).

2.1. Bronchoscopy

Bronchoscopy procedures for diagnostic and therapeutic purposes were taken in account to the patients' families. All patients admitted to the Burn Unit with possible inhalation injury underwent fiberoptic bronchoscopy using an Olympus Fibroptic Bronchoscope (BF Type 1). The first procedure was carried out within 12 h after injury by three experienced bronchoscopists, and the same procedure with bronchial toileting was followed for the next 3 days and on the seventh day. About 1 month after the injury the patients underwent the procedure to diagnose the extent of stenosis of the respiratory tracts. Systematic serial biopsies of the spurs of the bronchi were obtained as deeply as possible. Biopsy specimens of the proximal and distal branches were stored separately. The trachea was never intentionally biopsied, since lesions can deepen or bud and complicate tracheal aspiration in intubated patients.

2.2. Histological study

The biopsy specimens were fixed in 10% formalin and embedded in paraffin; 3 µm sections were stained with hematoxylin–eosin (HE). The slides were read by the same pathologist on the basis of findings of epithelial alterations including stratified regenerated epithelium, cilia and goblet

cells and lamina propria including inflammatory cell infiltration and edema.

3. Result

3.1. Bronchoscopic observations

The procedure was well tolerated by all patients and there were no complications arising from the procedure. Summary of clinical data on five patients with inhalation injury and cutaneous burn is shown in Table 1. Soot deposits and bronchorrhoea in both the supra- and infraglottic airway were seen in the diagnostic bronchoscopy on admission of all the patients suggesting possible inhalation injury, although inflammatory changes including thin or bright red varied from minor to severe. The chest X-ray was abnormal in only one of the five patients. The bronchoscopic findings on day 3 or 4 showed edemat of the mucosa from vocal cord to lobular bronchi and various degrees of erosion or ulceration in all the patients. The findings on day 7 showed increasingly characteristic edema, erosion and ulceration. Abundant and tenacious mucus partly obstructed the airway, and bronchial toilet was mandatory. After repeated toileting, the bronchial mucous membranes was near-normal between days 14 and 31. Some cases showed bronchial edema and serous secretions even in this time, and other cases revealed remarkable stenosis of the bronchi. Although the bronchoscopic findings in the recovery stage varied with cases, bronchial edema and secretions in the patients with severe burn of the skin tended to be prolonged. The chest X-ray and bronchoscopic findings of case 1 are shown in Fig. 1, representative of all the cases.

3.2. Histological findings

There was no histological difference between the proximal and distal biopsies. The lesions on admission through day 3 revealed ulceration including lack of the mucociliated epithelium and coagulation necrosis, which was focal or extensive and superficial or deep depending on the damages. Especially,

Table 1 – Summary of clinical data on patients with inhalation injury and cutaneous burn injury

Patient	1	2	3	4	5
Age	72	83	80	26	56
Cause	House fire	Cigarette ignited bedding	House fire	House fire	Trapped attempting to rescue a daughter
Burn index	30	20	23	5	2
Soot deposits	Skin, nose, mouth	Skin, nose, mouth	Skin, nose, mouth	Skin, nose, mouth	Nose, mouth
Co-Hb (%)	ND	ND	ND	39.1	37.9
Chest X-ray	Normal	Hilar infiltration	Normal	Normal	Normal
Bronchoscopy on admission	Minor inflammatory changes Soot deposits Sooty bronchorrhoea	Severe inflammatory changes Soot deposits Sooty bronchorrhoea	Severe inflammatory changes Soot deposits Sooty bronchorrhoea	Minor inflammatory changes Soot deposits Sooty bronchorrhoea	Minor inflammatory changes Soot deposits Sooty bronchorrhoea
Progress and outcome	Intubation on days 9–33, skin graft on day 26	Immediate intubation, tracheostomy on day 11, skin graft on day 17, septicaemia by candida on day 85	Immediate intubation, tracheostomy on day 15, skin graft on day 15,	Uncomplicated progress	Intubation days 1–16

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