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DNA AND INFLAMMATORY MEDIATORS IN BRONCHOALVEOLAR LAVAGE FLUID FROM CHILDREN WITH ACUTE INHALATIONAL INJURIES

Benny L. Joyner, MD, MPH¹, Samuel W. Jones, MD², Bruce A. Cairns, MD², Bradford D. Harris, MD¹, Andrea M. Coverstone, MD³, Kathleen A. Abode, RN, MPH³, Shiara M. Ortiz-Pujols, MD², Keith C. Kocis, MD, MS, FCCM¹, and Terry L. Noah, MD³

¹Dept. of Anesthesiology, University of North Carolina at Chapel Hill

²Dept. of Surgery, University of North Carolina at Chapel Hill

³Dept. of Pediatrics, University of North Carolina at Chapel Hill

Abstract

Objective—Assess the feasibility of using serial bronchoalveolar lavage fluids (BALF) to characterize the course of cell damage and inflammation in airways of pediatric patients with acute burn or inhalation injury.

Design—Prospective, longitudinal descriptive pilot study.

Setting—Burn and Pediatric Intensive Care Units in a tertiary-care medical center.

Subjects—Six consecutive intubated, mechanically ventilated pediatric patients with acute inhalational injuries were studied.

Interventions—Serial BALF specimens from clinically-indicated bronchoscopies were used to measure DNA and cytokine levels.

Measurements and Main Results—BALF DNA levels for the 6 pediatric burn subjects were highest within the first 72 hours after burn injury and declined thereafter. At the early stages after injury, BALF DNA levels (median [min, max] 3789 [1170,11917] ng/ml) were similar to those in adult burn patients and pediatric cystic fibrosis or bronchiectasis patients, and higher than those in pediatric recurrent pneumonia patients. BALF DNA levels in children and adults with inhalation injury correlated significantly with BALF IL-6, IL-8, and TGF- β 1 levels. The patient with the most severe early visible airway mucosal damage and soot pattern at bronchoscopy, as well as the most extensive burns, also had the highest average early BALF DNA level (11917ng/ml) and the longest ventilator course and hospital stay. Procedures were well tolerated.

Conclusions—In children with acute burn and inhalational injury, airway cellular damage and inflammation (reflected in high BALF DNA levels) appear to peak during the first 72 hours after burns or inhalation injury followed by a slow decline. Serial analysis of factors in airway secretions is feasible and has the potential to reveal important pathophysiologic pathways and therapeutic targets for treatment of acute inhalational injuries.

Keywords

DNA; BALF; cytokines; inhalation injury; pediatric; burn

INTRODUCTION

In burn victims, inhalation injury remains a significant risk factor for mortality and respiratory morbidity, including airway obstruction and acute lung injury or acute respiratory distress syndrome (ALI/ARDS). The mechanisms by which inhalation injury contributes to this risk are unclear. One hypothesis is that a massive influx of inflammatory mediators and cells (primarily DNA-rich neutrophils) results in direct injury to the airway, leading to production of secretions and airway obstruction with mucus and products of inflammatory cell breakdown including DNA [1]. Some existing therapies such as anti-inflammatory agents or DNase might be rational in this setting [2]. These agents are often used in clinical practice but there are few data specifically supporting a pathophysiologic rationale for their use [2–4].

Serial bronchoscopy is employed at some burn care centers for assessment of the extent of inhalational injury, and for therapeutic purposes to clear soot and cellular debris from airways [5, 6]. The latter may be especially important in children with inhalation injuries, since their small airway caliber may make them more susceptible to airway obstruction [7]. Studies have demonstrated the importance of inflammatory cells and their breakdown products in the pathophysiology of cystic fibrosis (CF), in which DNA from necrotic neutrophils contributes to the viscosity of airway secretions that obstruct airways [8, 9]. There is evidence that the use of anti-inflammatory drugs or inhaled DNase improves morbidity in CF [2, 3, 10, 11]. Inhaled DNase has also been studied in mechanically ventilated pediatric patients with atelectasis and has been shown to decrease inflammation and improve atelectasis compared to mechanical ventilation maneuvers alone [4, 12]. However, the composition of airway secretions in children with inhalation injury has not been described.

We carried out a pilot study investigating inflammatory and injury markers in airway secretions after burn injury, using serial bronchoalveolar lavage fluids (BALF) from pediatric patients undergoing endotracheal intubation and bronchoscopies as part of their care after burn injuries. Our general goal was to assess the feasibility of quantifying serial markers of injury or inflammation in the setting of acute inhalational injuries in children. Our specific goals were (1) to measure the quantity of DNA in airway secretions as a marker of airway injury and inflammatory cell breakdown; (2) to compare DNA levels from pediatric burn patients with those from relevant comparison populations; and (3) to assess the relationship of BALF DNA levels to inflammatory factors and clinical parameters.

METHODS

Study Design and Patients

This was a single-center, prospective, descriptive study in which we measured levels of DNA and inflammatory markers in BALF obtained during clinical care of pediatric patients who were intubated after acute burn and inhalational injuries over a one-year period. Patients underwent one or more diagnostic/therapeutic flexible bronchoscopic examinations according to a standard protocol (see below) based on their clinical needs, as determined by the attending physician at the University of North Carolina Hospitals/North Carolina Jaycee Burn Center. A sample of consecutive pediatric patients admitted over a 1-year period was planned. Excess BALF beyond that needed for clinical purposes was collected for the study and processed as described below. Additionally, clinical data regarding outcomes and severity (length of hospital and ICU stay, ventilator course duration, presence of infection, % body surface area of burns (%BSA), and PaO₂ to FiO₂ ratios, if available) were collected, and digital images of the large airways were recorded for grading according to a previously published semi-quantitative scale [13].

We compared study samples to samples obtained from children with CF or bronchiectasis undergoing diagnostic bronchoscopy for lower airway cultures; and children with chronic cough or wheeze not due to bronchiectasis or CF who were undergoing diagnostic bronchoscopy. Samples from these pediatric comparison groups were available from a separate research study [14]. Finally, we obtained bronchial washing samples from a series of intubated adult patients with similar burn/inhalational injuries as the children in the study.

The study was approved by the UNC Biomedical Institutional Review Board and informed consent was obtained from all adult subjects or their legal representative and from the parents of all pediatric subjects.

Bronchoscopy protocol

Flexible bronchoscopy and bronchoalveolar lavage were performed according to a protocol developed jointly by the Burn Center and the UNC Children's Airway Center. All patients with suspected inhalation injury based on history and physical findings (*e.g.*, prolonged exposure to fire in an enclosed space or presence of carbonaceous debris around the nose and/or mouth) underwent bronchoscopic evaluation within 24 hours after admission to assess for the presence of inhalation injury. To perform the bronchoscopy, the bronchoscope was inserted via the endotracheal tube, and the distal trachea and airways were inspected to the level of the lobar bronchi. Bronchoalveolar lavage was carried out using standardized lavage volumes as previously described [15]. The location of the initial lavage was in the lobe which appeared to be most heavily involved with soot or mucosal damage, but lavages were done in multiple locations. However, if no distinct "worst" location was apparent, then the initial lavage was done in the right middle lobe or lingula. At subsequent procedures, the same approach was taken, but BALF for research purposes was processed only for the lobe identified as "worst" at the initial procedure for each individual patient. The frequency and timing of subsequent procedures was at the discretion of the attending Burn Center physician, and depended on several factors including the initial soot burden the severity of initial mucosal damage and the degree of difficulty with mucus clearance.

In adult burn patients, a similar bronchoscopy protocol was used, but lavages were done in both the left and right mainstem bronchi in all patients. At each procedure, an initial 20 ml aliquot was instilled then suctioned back and collected for research purposes, with subsequent aliquots at the discretion of the care team for therapeutic indications. Bronchoalveolar lavages for clinical indications in pediatric comparison groups were done as described above for pediatric burn patients, but on only a single occasion and typically in only one lobe.

Video images of the airways recorded at bronchoscopy were scored according to the scale described by Chou et al. in which central airways appearance is graded as G0 (negative), G1 (mild edema and hyperemia $\pm$ soot), G2 (severe edema and hyperemia $\pm$ soot), or G3 (ulcerations, necrosis, absence of bronchial secretions, dry) [13].

BALF processing

BALF specimens were processed within 24 hours of specimen collection. Previous studies have suggested that BALF can be stored on ice for up to 24 hours without significant impact on specimen viability[16] [15]. Briefly, total cell count was carried out and cytocentrifuged BALF was stained with modified Wright stain for differential cell counts. The remaining BALF was then centrifuged at 300 g and the resulting cell-free supernatant was stored at -80° C for subsequent mediator measurements. BALF double-stranded DNA was quantified using QuantItTM PicoGreen[®] dsDNA Assay Kit (InvitrogenTM Ltd, Eugene, OR), a fluorescent nucleic acid stain, according to the manufacturer's instructions. BALF

Interleukin-6 (IL-6), interleukin-8 (IL-8) and transforming growth factor β 1 (TGF- β 1) assays were performed using commercial ELISA kits (R & D Systems, Minneapolis, MN) according to the manufacturer's instructions. These mediators were selected as representative markers for inflammation and injury repair. [9, 17, 18]

Statistical methods

For descriptive purposes, data comparisons among multiple groups were done using nonparametric 1-way ANOVA with Dunn's post-test. Correlations between DNA and cytokine levels in BALF were analyzed using linear regression and log transformed data. All statistical comparisons were done using GraphPad Prism (GraphPad Prism Software, Inc., La Jolla, CA). $P < 0.05$ was considered statistically significant throughout.

RESULTS

Patient characteristics

Over the study period, we collected serial BALF from 6 children who required endotracheal intubation after acute burn and inhalational injuries. All children were healthy prior to their acute injury. Some of their clinical characteristics are shown in Table 1. Ages at the time of injury ranged from 2–16 years. Three of the children were injured in house fires, two in motor vehicle crashes, and one from a paint can explosion. All six children underwent an initial bronchoscopy within the first 24 hours after injury. Subsequent bronchoscopies were dictated by the initial severity of injury and subsequent clinical course, as per routine clinical protocol. Percent body surface area (% BSA) burn in the 6 children ranged from 13%–50%. The degree of initial visual evidence for inhalational injury varied from mild to severe. One patient was transferred to another burn center at 6 days post injury and was lost to our follow-up. For the remaining 5 children, the length of stay in ICU ranged from 14–167 days, while overall hospital stay ranged from 28–254 days. Subject 6, who had both the highest initial bronchoscopic injury grade and the most extensive burns in this series, also had the lowest minimum $\text{PaO}_2/\text{FiO}_2$ ratio and longest ventilator course and hospital stay (Table 1). No complications were noted for any of the bronchoscopy procedures.

DNA and inflammatory markers in BALF

DNA quantity in BALF for these six patients generally showed the highest levels within the first several days after burn injury, and declined thereafter (Fig. 1) except for Subject 6 who had the most severe injury (Table 1). As shown in Figure 1, the number and timing of bronchoscopies varied among patients according to clinical indication. Cairns et al. have shown in animal models that cytokine responses at <3 days post burn injury differ from those obtained at later time points [19]. For descriptive analysis we averaged "early" (<3 days) data for each subject, when more than one procedure was done during that time frame. Figure 2 shows that "early" BALF DNA levels from pediatric burn patients (median [min, max] = 3789 [1170,11917] ng/ml) were significantly elevated compared to specimens obtained from pediatric patients undergoing clinically indicated bronchoscopies for chronic or recurrent wheeze or pneumonia (208 [191,586] ng/ml), and similar to levels obtained from pediatric CF/bronchiectasis patients (7196 [537,22840] ng/ml) and adult burn patients 2483 [304,16820] ng/ml). DNA levels generally followed the pattern seen for other markers of inflammation.

"Early" BALF showed a predominance of neutrophils (71 ± 10 % neutrophils, and $1.29 \pm 0.68 \times 10^6$ neutrophils/ml). In a subset of 3 of the children with burns, and in serial specimens from 11 adult burn patients, there were sufficient BALF samples remaining to measure levels of several inflammatory cytokines. Figure 3 shows that IL-8, IL-6 and TGF- β 1 levels for the both adult and pediatric patients all correlated significantly with DNA in

these samples, (IL-6: $r^2=0.416$, $p=0.007$; IL-8: $r^2=0.742$, $p<0.001$; TGF- β_1 : $r^2=0.65$, $p<0.001$ for pediatric patients). The adult and pediatric data are shown together for descriptive comparison.

DNA and clinical indicators

Clinical grading of inhalational injury is typically done at initial presentation. For the purposes of our study, we assessed the relationship between BALF DNA levels and bronchoscopic evidence for inhalational injury at all available time points, using a semi-quantitative injury scale of bronchoscopic images as described in the Methods section. There were a total of 16 days for which both video images and BALF DNA data were available among the 6 pediatric patients. No grade G0 images were observed. Median BALF DNA levels from procedures with grade G1 appearance (median [min, max] 2729 [266,8168] ng/ml; N = 7) tended to be lower than those with grade G2 or G3 (4157 [757,29275] ng/ml; N = 9), but there was marked variability and the observed differences were not statistically significant. Similar results were found when comparing DNA levels between bronchoscopies where visible soot was present (4609 [390,29275] ng/ml; N = 9) vs. not (2729 [266,4859] ng/ml; N = 7). Patient #6 was the only initial severe (G3) classification in this series, and also had the highest individual BALF DNA level (29,275 ng/ml on Day 1 post injury), greatest percent body surface area burn (50%), and the longest ICU and hospital length of stay in the series (see Figure 4). Interestingly, a second increase in dsDNA appeared to occur following a diagnosis of pneumonia in this patient.

DISCUSSION

In a small series of pediatric burn patients, we have described time courses for levels of total DNA and inflammatory factors in lower respiratory secretions, and their relationships with clinical factors. Our study suggests that studies of airway secretions in the setting of acute inhalational injuries in children are feasible, since bronchoscopy and bronchoalveolar lavage were well tolerated and several biomarkers of interest were easily measurable. Our finding of markedly elevated “early” DNA levels in the child with the most severe inhalation injury and clinical course, coupled with the overall correlation between DNA and inflammatory cytokines, suggests that early bronchoscopy-derived markers of inflammation or injury might predict clinical outcomes. This conclusion requires replication of our findings in larger studies.

Our patients had variation in the extent of cutaneous burns. As has been well described in other studies, cutaneous burns may have distant organ effects (*e.g.*, acute lung injury) that are independent of inhalation injury [20, 21]. These effects may be responsible for a portion of the inflammatory response seen in these subjects. A larger study could further elucidate this relationship.

Our primary specific finding was that BALF DNA levels were elevated early after burn or inhalation injury, and generally correlated with the cytokine markers of inflammation and injury, IL-6, IL-8, and TGF- β_1 . While elevated early BALF levels of inflammatory mediators IL-6 and IL-8 have been reported in a recent study of adult burn/inhalation victims [22], we believe these are the first pediatric data describing airway responses to this type of acute respiratory injury. Potential sources of DNA in airway secretions include directly damaged epithelial cells and inflammatory cells responding to injury or infection [1, 9, 11]. For example, the second elevation of DNA in patient 6 following the diagnosis of pneumonia—as might have been due to neutrophil responses to infection. Our data cannot differentiate among these cellular sources, since all of the factors measured could be derived from multiple cell types.

The DNA levels observed in this series were similar to those from a comparison group of children with bronchiectasis (Fig. 2), and also similar to those reported in the literature for children with CF [8, 9]. In CF, DNA from lysed neutrophils is the major source of viscosity in airway secretions [8–10], and treatment with DNase has shown some clinical benefit in terms of improvement in airways obstruction [3, 11]. While the pathophysiology of CF and inhalation injury are obviously different, our finding of BALF DNA levels in the “CF range” suggests a rationale to use DNase to reduce risk of airway obstruction early in the setting of acute inhalational injury. Controlled trials are required to provide evidence that this is clinically effective. Additionally, future studies may better allow for grading of the secretion pattern and determination of clinical indications for mucolytics.

Our study relied on airway secretions obtained during bronchoscopies done as part of a clinical protocol at our center. Bronchoscopy has been described as having diagnostic and potentially therapeutic usefulness in the setting of acute burns and inhalational injury [5, 6, 23, 24], and two recent studies describe similar data to ours, from bronchoscopic lavage specimens in an inhalational injury population [25, 26]. Our clinical experience suggests that bronchoscopy and bronchoalveolar lavage are well-tolerated in mechanically ventilated children after burn and inhalational injury. Though limited, our data suggest the possibility that the bronchoscopic appearance of the airways (soot, edema, hyperemia, necrosis etc.) may reflect the severity of mucosal injury or inflammation, and may further be reflected in specific BALF mediator concentrations.

Clinical research in the setting of critical illness is inherently difficult, and additional limitations are present when investigating critically ill children. While the management strategy during the study period was fairly uniform, our series of patients was heterogeneous regarding type and amount of specific toxins inhaled, patient size, and sample availability based on clinical management decisions. Additionally, variable dilution of native airway secretions could well affect our data, and estimating this dilution is problematic especially in the setting of the rapidly changing mucosal permeability [27–29]. We attempted to minimize some of these sources of variability by comparing same-lobe BALF in individual children over time and adjusting BAL aliquots by patient size, but conclusions are limited by the small sample size given these sources of data heterogeneity. Finally, while all samples were processed within 24 hours there was some variability in the timing of the processing of samples due to the unpredictable timing of patient presentation, which may have introduced some variability in the results.

Children may have an elevated risk for respiratory complications from thermal and inhalational injuries. The pathophysiology of responses to these injuries is not well understood in this age group. Despite limitations, our data suggest that clinically derived specimens such as those we describe may serve as a useful resource for research aiming to translate concepts from experimental models to the clinical arena.

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References

1. Sterner JB, et al. Inflammatory mediators in smoke inhalation injury. *Inflamm Allergy Drug Targets*. 2009; 8(1):63–9. [PubMed: 19275694]

2. McLaughlin AM, et al. Treatment of lobar atelectasis with bronchoscopically administered recombinant human deoxyribonuclease in cystic fibrosis? *Clin Respir J*. 2008; 2(2):123–6. [PubMed: 20298317]
3. Paul K, et al. Effect of treatment with dornase alpha on airway inflammation in patients with cystic fibrosis. *Am J Respir Crit Care Med*. 2004; 169(6):719–25. [PubMed: 14684561]
4. Prodhan P, et al. Recombinant human deoxyribonuclease improves atelectasis in mechanically ventilated children with cardiac disease. *Congenit Heart Dis*. 2009; 4(3):166–73. [PubMed: 19489944]
5. Carr JA, Phillips BD, Bowling WM. The utility of bronchoscopy after inhalation injury complicated by pneumonia in burn patients: results from the National Burn Repository. *J Burn Care Res*. 2009; 30(6):967–74. [PubMed: 19826269]
6. Marek K, et al. Fiberoptic bronchoscopy in routine clinical practice in confirming the diagnosis and treatment of inhalation burns. *Burns*. 2007; 33(5):554–60. [PubMed: 17376597]
7. Tiddens HA, et al. Cystic fibrosis lung disease starts in the small airways: can we treat it more effectively? *Pediatr Pulmonol*. 2010; 45(2):107–17. [PubMed: 20082341]
8. Koehler DR, et al. Lung inflammation as a therapeutic target in cystic fibrosis. *Am J Respir Cell Mol Biol*. 2004; 31(4):377–81. [PubMed: 15381503]
9. Kirchner KK, et al. Increased DNA levels in bronchoalveolar lavage fluid obtained from infants with cystic fibrosis. *Am J Respir Crit Care Med*. 1996; 154(5):1426–9. [PubMed: 8912759]
10. Konstan MW. Therapies aimed at airway inflammation in cystic fibrosis. *Clin Chest Med*. 1998; 19(3):505–13. vi. [PubMed: 9759552]
11. Ratjen F, et al. DNA concentrations in BAL fluid of cystic fibrosis patients with early lung disease: influence of treatment with dornase alpha. *Pediatr Pulmonol*. 2005; 39(1):1–4. [PubMed: 15532079]
12. Riethmueller J, et al. Clinical and in vitro effect of dornase alfa in mechanically ventilated pediatric non-cystic fibrosis patients with atelectases. *Cell Physiol Biochem*. 2009; 23(1–3):205–10. [PubMed: 19255515]
13. Chou SH, et al. Fiber-optic bronchoscopic classification of inhalation injury: prediction of acute lung injury. *Surg Endosc*. 2004; 18(9):1377–9. [PubMed: 15164282]
14. Harris WT, et al. Plasma TGF-beta(1) in pediatric cystic fibrosis: Potential biomarker of lung disease and response to therapy. *Pediatr Pulmonol*. 2011; 46(7):688–95. [PubMed: 21337732]
15. Kazachkov MY, et al. Lipid-laden macrophage index and inflammation in bronchoalveolar lavage fluids in children. *Eur Respir J*. 2001; 18(5):790–5. [PubMed: 11757629]
16. Ng DP, et al. Effect of storage conditions on the extraction of PCR-quality genomic DNA from saliva. *Clin Chim Acta*. 2004; 343(1–2):191–4. [PubMed: 15115694]
17. Schmalstieg FC, et al. Interleukin-8, aquaporin-1, and inducible nitric oxide synthase in smoke and burn injured sheep treated with percutaneous carbon dioxide removal. *ASAIO J*. 2001; 47(4):365–71. [PubMed: 11482488]
18. Traber DL, et al. Inhalational and acute lung injury. *Shock*. 2005; 24(Suppl 1):82–7. [PubMed: 16374378]
19. Cairns BA, et al. Toll-like receptor 2 and 4 ligation results in complex altered cytokine profiles early and late after burn injury. *J Trauma*. 2008; 64(4):1069–77. discussion 1077–8. [PubMed: 18404077]
20. Ward PA, Till GO. Pathophysiologic events related to thermal injury of skin. *J Trauma*. 1990; 30(12 Suppl):S75–9. [PubMed: 2254996]
21. Till GO, et al. Oxygen radical dependent lung damage following thermal injury of rat skin. *J Trauma*. 1983; 23(4):269–77. [PubMed: 6842628]
22. Wright MJ, Murphy JT. Smoke inhalation enhances early alveolar leukocyte responsiveness to endotoxin. *J Trauma*. 2005; 59(1):64–70. [PubMed: 16096540]
23. Herndon, DN., editor. *Total burn care*. London; New York: W.B. Saunders; 2002.
24. Schneider W, et al. Diagnostic and therapeutic possibilities for fiberoptic bronchoscopy in inhalation injury. *Burns Incl Therm Inj*. 1988; 14(1):53–7. [PubMed: 3370519]

25. Albright JM, et al. The acute pulmonary inflammatory response to the graded severity of smoke inhalation injury. *Crit Care Med*. 2011
26. Davis CS, et al. Early pulmonary immune hyporesponsiveness is associated with mortality after burn and smoke inhalation injury. *J Burn Care Res*. 2012; 33(1):26–35. [PubMed: 21979852]
27. Efimova O, et al. Ligation of the bronchial artery in sheep attenuates early pulmonary changes following exposure to smoke. *J Appl Physiol*. 2000; 88(3):888–93. [PubMed: 10710383]
28. Dargaville PA, et al. Validity of markers of dilution in small volume lung lavage. *Am J Respir Crit Care Med*. 1999; 160(3):778–84. [PubMed: 10471596]
29. Roberts CM, et al. Changes in epithelial lining fluid albumin associated with smoking and interstitial lung disease. *Eur Respir J*. 1993; 6(1):110–5. [PubMed: 8425580]

Figure 1.

BALF DNA over time post injury for 6 pediatric burn patients. “Day 0” is the day of injury. Each line represents a separate patient (one G1 patient had a single sample obtained on Day 1). For reference, horizontal broken line at 500 ng/ml is near both the upper limit for the pediatric recurrent pneumonia comparison group, and the lower limit for the pediatric CF comparison groups in the study.

Figure 2.

BALF DNA levels in pediatric burn patients compared to several other patient groups. (A) Averaged DNA levels in first 72 hours after injury in 6 children with burns (Ped Burn Acute), vs. 5 children with chronic bronchiectasis (Ped Bronchiectasis), 11 adult burn victims (Adult Burn Acute), and 5 pediatric patients with recurrent pneumonia but without bronchiectasis (Ped Rec Pneumonia). * = $P < .05$ vs. pediatric recurrent pneumonia group.

Figure 3.

Relationship of BALF dsDNA to (A) IL-8, (B) IL-6, and (C) TGF- β . Data are shown for BALF samples from pediatric patients (in red) and adult patients (in black). Correlation coefficients (r^2) and P values calculated by linear regression for the samples from pediatric patients are described in the text.

Figure 4.

Serial bronchoscopic images of the distal trachea in patient #6 (grade G3 inhalational injury initially), demonstrating early soot and mucosal damage followed by clearing.

Demographic and clinical characteristics of six pediatric burn patients studied.

TABLE 1

Pt	Age (yrs)	% BSA burn	Mechanism of Injury	Initial bronchoscopic injury grade	Minimum PaO2/FiO2 ratio(day #)	Bronchoscopies performed(number)	Infection present? (Y/N)	Mechanical Ventilation (days)	ICU length of stay (days)	Hospital length of stay (days)	Hours post-injury at time of first bronchoscopy
1	8	23	House Fire	2	303 (1)	3	N	9	14	28	8 hours
2	10	15	Explosion [‡]	2	108 (1)	2	N	9	31	38	18 hours
3	2	43	MVC [‡]	1	56 (1)	1	N	6 [*]	6 [*]	6 [*]	23 hours
4	4	30	MVC [‡]	1	253 (1)	2	Y±	56	61	71	18hours
5	16	13	House Fire	1	185(1)	4	N	19	24	24	2 hours
6	2	50	House Fire	3	55 (1)	8	Y±±	94	167	254	10 hours

* Patient transferred to another burn center after 6 days

[‡] Paint can explosion

[‡]Motor Vehicle Crash

±(>10×10⁶ CFU + CXR findings)

±±(PNA based on ISDA definition of HAP)[1]