ties in Taiwan.[2] In humans, paraquat is quite toxic, and the lung is one of the primary target organs.[3,4] The toxic effects of paraquat on the lung result in pulmonary edema, hypoxemia, respiratory failure, and pulmonary fibrosis, with death attributable to the extensive pulmonary injury.[5] Animal studies have shown that derangement of the pulmonary surfactant system contributes significantly to the pathophysiology of respiratory failure after paraquat intoxication.[6-8] Ingestion of paraquat is associated with a high mortality rate, but this should not detract us from intensive management of such poisoned patients, since patients have occasionally recovered fully even after pulmonary involvement following massive ingestion.[9]

Liquid ventilation has long been studied as a method for the treatment of the many serious consequences of respiratory distress syndrome associated with surfactant deficiency and/or dysfunction.[10-14] In liquid ventilation, a liquid capable of carrying large amounts of oxygen and carbon dioxide and of maintaining the surfactant layer while eliminating gas/liquid interfacial tension is administered into the lungs. The most commonly used liquids are the relatively inert family of compounds known as perfluorocarbons (PFCs). Partial liquid ventilation (PLV) has been studied in acute lung injury induced by saline lavage, endotoxin, acid infusion, and acid aspiration.[15-19] The exact mechanisms by which PLV improves gas exchanges in the setting of acute respiratory distress syndrome are poorly understood. Several mechanisms have been suggested including improved lung compliance by alveolar recruitment and a reduction of surface tension in the states of surfactant deficiency or surfactant dysfunction.[13,14] Interactions between the PFC fluid and exogenous surfactant revealed variable results in previous studies.[20-23] We hypothesized that gas exchange and lung histology can be significantly preserved in rat lungs with paraquat-induced lung injury receiving surfactant treatment before PLV compared to rat lungs receiving PLV alone. FC-77 has been used during liquid ventilation in experimental animal settings.[23-25] The aims of this study were to evaluate the effects of surfactant and PLV with FC-77 on gas exchange and lung histology in a rat model of paraquat-induced lung injury and to investigate the interaction of an exogenous surfactant and FC-77.

MATERIALS AND METHODS

Preparation of Rats

The institutional animal use committee approved this protocol. The study was performed with a total of 33 adult male Sprague-Dawley rats with body weights ranging between 220 and 270 g. The rats were kept on a 12-h light-dark cycle and had free access to food and water. Paraquat (35 mg/kg, Sigma Chemicals, St. Louis, MO, USA) in 0.5 mL saline was administered intraperitoneally to the rats. Three days after paraquat treatment, the rats were anesthetized intraperitoneally with pentobarbital (50 mg/kg, Abbott Laboratories, North Chicago, IL, USA). Electrical heating pads were used to maintain normal body temperature. A polyethylene tubing catheter (PE-50, Becton Dickinson, Sparks, MD, USA) catheter containing heparinized, isotonic saline was placed in a carotid artery to monitor blood gases. Blood gas tensions were measured with a blood gas analyzer (Model 1620; Instrumentation Laboratories, Lexington. MA, USA). A tracheostomy was performed, and a 14-gauge plastic cannula was inserted into the trachea. Each rat was then placed in a supine position and conventional mechanical ventilation was commenced with a time-cycled, pressure-limited ventilator (Sechrist Industries, Anaheim, CA, USA) and ventilated for 120 min. Muscle paralysis was induced with intraperitoneal administration of pancuronium bromide (2 mg/kg, Organon Teknika, Boxtel, Holland) with additional pancuronium bromide injections given intraperitoneally if spontaneous breathing was observed.

Experimental Protocols

At the commencement of the experiment, blood was taken from the arterial catheter to determine the pretreatment blood gas values. Rats were assigned randomly to 1 of 4 treatment groups: surfactant alone (n = 9); PLV alone (n = 8); surfactant + PLV (surfactant at start of mechanical ventilation but switched to PLV at 30 min, n = 9); and no treatment (n = 7). The ventilator strategy was identical for the 4 groups and