oxygenation, compliance, and lung pathology during PLV in an animal model of saline-lavaged lung injury.[20] Pretreatment with an exogenous surfactant before PLV improved compliance and decreased inflation pressure in excised preterm lamb lungs.[21] A synthetic surfactant given before PLV did not further improve lung mechanics and gas exchange compared with PLV alone during conventional ventilation in preterm lambs with respiratory distress syndrome.[22] Merz et al. demonstrated impaired gas exchange when PLV with FC-77 was combined with surfactant treatment.[23] In this study, we found that instillation of FC-77 alone or after an exogenous surfactant led to a deterioration of oxygenation in this animal model of paraquat-induced lung injury. There are several explanations for the unfavorable gas exchange and lung histology after PLV alone or the combined treatment of surfactant and PLV.

First, these studies used a different surfactant and PFC fluid in a different lung injury model. It is difficult to compare the results from different studies when the agents and management techniques are dissimilar. Miller et al. reported that different PFC properties and lung conditions might influence PFC elimination, gas exchange, and compliance.[27] The surfactant and PFC liquid used in those studies with favorable responses were a natural surfactant and perflubron, respectively.[20,21] The harmful effects of surfactant + PLV treatment noted in the present study and that of Merz et al. may have resulted from the use of FC-77 as the PFC agent. Burns et al. also found that PLV with FC-77 was detrimental and increased mortality in a rat model of kerosene aspiration.[28] Hartog et al. found that PLV increased the conversion of active form of a surfactant to its inactive form in acute lung injury induced by saline lavage.[29]

Second, the addition of perfluorocarbon to the surfactant may have produced a negative interaction on the integrity and distribution of the surfactant. Mrozek et al. suggested that the addition of PFC liquid after surfactant administration might deliver both compounds more effectively into gas-exchange areas and move debris, edema fluid, and exudates proximally, and thus improving the surfactant function.[20] However, this effect was not found in the present study, and it is possible that the addition of FC-77 might have displaced the surfactant from the alveolar surface. Bachofen et al. reported an increase in interfacial tensions and several fragmentations of the surfactant film in excised rabbit lung filled with or rinsed with FC-77.[30]

Neutrophil accumulation within the pulmonary microvasculature has been implicated in the pathogenesis of acute lung injury.[31] We found that neutrophil counts in lung specimens significantly increased in the no-treatment animals when compared with those of the surfactant, PLV, and surfactant + PLV groups. The finding of decreased neutrophil infiltration in the PLV group compared with the no-treatment group is similar to that reported by Rotta et al.[18] However, the responses of gas exchange and the pressure-volume curve did not parallel neutrophil counts in these groups. These results suggest that neutrophil infiltration is not the only factor implicated in the complex process of ARDS, and that PLV with FC-77 after administration of an exogenous surfactant may be detrimental to the lessening of lung inflammation. The static pressure-volume curves showed that the mean lung volume correlated with PaO_2 at 120 min in this animal model. This result is consistent with the observation that a higher lung volume would translate into a higher functional residual capacity and better oxygenation.[32]

In conclusion, we found that surfactant therapy improved gas exchange and lung histology, and that PLV with FC-77 transiently improved oxygenation in a rat model of paraquat-induced lung injury ventilated for 2 h. PLV with FC-77 did not further improve the effects of the exogenous surfactant on gas exchange and lung histology.

REFERENCES

1. Salmona M, Donnini M, Perin L, et al. A novel pharmacological approach for paraquat poisoning in rat and A549 cell line using ambroxol, a lung surfactant synthesis inducer. *Food Chem. Toxicol.* 1992;30:789-94.
2. Department of Health, Executive Yuan, ROC. The analysis of poisonous cases between 1985 to 1993 in Tai-