

Understanding lungs' degradation mechanisms due to blast loading

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Lung injuries are the primary cause of death due to an explosion-induced shock wave [1]. Hence, it is essential to understand the mechanisms of those injuries for protection purposes. For the moment, shock waves' effects on lungs are not well described. Models of lung facing a blast mainly describe the evolution of intra-pulmonary pressure [2]. In the literature, one can distinguish two distinct communities, which consider that degradation is caused either by the pressure transmitted in the lungs, or by the crushing of the lungs due to the movement of the thoracic cage. This shows a lack of understanding of the mechanical origins of lung degradation. Moreover, actual models and global injury criteria described in the literature are not related to physical mechanisms explaining the degradation of the lung. The main goal of this study is to determine the mechanisms of degradation of the lung faced with an explosion. Therefore, we will rely on macroscopic observations of injury in order to sort out the possible mechanisms of injury at the microscopic scale. Next, we will couple this to a study of macroscopic loads, to determine relevant criteria on local injury indicators.

In a first step, we determined the microscopic degradation of the lung. In order to do so, we compared the injuries caused by a blast wave to those appearing in different situations such as diving accidents or intensive efforts. Such a comparison enables us to determine the mechanisms of degradation that can lead to similar injuries to those caused by an explosion. Hemorrhages are observed on a macroscopic scale, therefore there is a rupture of the capillaries caused by an explosion. Two mechanisms can lead to that, a rupture of alveolar walls caused by a stretching, or a rupture of the blood-gas-barrier due to an important pressure gap between the capillaries and the alveoli.

In a second step, we studied macroscopic loads in order to determine relevant macroscopic injury indicators. As the only information present in the literature is given in a macroscopic point of view, it is important to understand loads on the lung and their effects. Simulations of the macroscopic response of the lung show stretching of the parenchyma. That can be related to stretching of the alveolar walls. However, a link has yet to be established between the position of the stretching area and of the degradation. This would allow a better understanding of lung injuries caused by an explosion and the development of injury criteria, such as local stretching of the parenchyma.

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