Introduction
The inhalation of toxic environmental particles is a world-wide public health issue (Hiraiwa and van Eeden 2013). These particles may be made up metals, metalloids, nonmetals, internal transitional elements (Kleeman et al. 1999; Minguillón et al. 2012), sulfate, nitrate, and ammonium ion (Kleeman et al. 1999), organic and elemental carbon (Simoneit et al. 2004), lipids, endotoxins, fungal spores, pollen (Monn and Koren 1999) and viruses (Phalen and Phalen 2012). To avoid the pulmonary damage, the lung presents various cells, the most important is the alveolar macrophage, since is the primary defense of the innate immune system, keep the alveolar-blood barrier interface, clearing the air spaces of infectious,

Abstract. The inhalation of toxic environmental particles is a worldwide public health issue. To avoid the pulmonary damage, the lungs contain the alveolar macrophages, which are the primary defense of the innate immune system, since it engulfs the toxic or allergic particles. Morphologically, particulate matter inside of macrophage is observed as numerous round dark granules of various size. In guinea pig, the inhalation of fine particles in real time showed single round dark granules inside of the macrophages. After particles exposure, the alveolar macrophage can activate some cytokines such as TNF-α, IL-1β, IL-6, IL-8, and GM-CSF, which increases the inflammatory response or to activate the Th2 response. The alveolar macrophage interacts with bronchial and bronchiolar epithelium, heart, and blood vessels producing a variety of problems, such as nonfatal heart attacks, irregular heartbeat, decreased lung function, and increases respiratory symptoms such as irritation of the airways, coughing or difficulty breathing, aggravated asthma, and produce premature death in people with heart or lung disease.

Keywords: Bronchoalveolar lavage; Phagocytosis; Particulate matter; Air pollution.

Resumen. La inhalación de partículas tóxicas ambientales es un problema de salud pública en todo el mundo. Para prevenir el daño, los pulmones contienen a los macrófagos alveolares, los cuales son la defensa primaria del sistema inmune, ya que fagocitan los tóxicos o partículas alérgicas. Morfológicamente, el material particulado dentro de los macrófagos alveolares se observa como numerosos gránulos redondos de varios tamaños. En cobayos, la inhalación de partículas finas en tiempo real mostró gránulos redondos oscuros dentro de los macrófagos. Después de la exposición a las partículas, el macrófago alveolar puede activar algunas citocinas como TNF-α, IL-1β, IL-6, IL-8, and GM-CSF, las cuales incrementan la respuesta inflamatoria o activan la respuesta Th2. El macrófago alveolar interactúa con el epitelio bronquial y bronquiolar, corazón y vasos sanguíneos, produciendo una variedad de problemas, tales como afecciones cardíacas, arritmias, disminución de la función pulmonar, e incrementa los síntomas respiratorios como irritación de las vías respiratorias, tos, dificultad para respirar, agrava el asma y produce muertes prematuras en personas con enfermedades cardíacas y pulmonares.

Palabras clave: Lavado broncoalveolar; Fagocitosis; Material particulado, Contaminación atmosférica.

IMÁGENES EN TOXICOLOGÍA

Particulate matter inside of the alveolar macrophage
Material particulado dentro del macrófago alveolar

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and engulfs toxic or allergic particles (Rubins 2003). In the alveolar region, particles whose diameter is >8 µm are phagocytized, this size range is efficient for uptake a bacteria (Phalen and Phalen 2012). Furthermore, fine particles (>100 nm or >0.1 µm) are also readily phagocytized by alveolar macrophage (Takenaka et al. 2001). However, previous studies showed that instilled colloidal carbon particles (30 nm or 0.03 µm) can be present in the macrophages (Takenaka et al. 2001). Interestingly, it was evidenced that ultrafine particles smaller than 0.1 µm in diameter are not efficiently phagocytized. This effect is due to their smaller chemical or physical signals. What is certain is that, the macrophage must recognize a certain particles size to initiate engulfment (Phalen and Phalen 2012). Morphologically, particulate matter inside of the macrophage is observed as numerous round dark granules of various size (aggregated) (Gottipolu et al. 2009). This event occurs when agglomerated ultrafine particles are administrated intratracheally or high concentrations are inhaled; then PM is phagocytized by alveolar macrophages. In a guinea pig model, the inhalation during 36 h (4 h/9 days) of fine particles from México City in real time showed single round dark granules inside of the macrophage in the bronchoalveolar lavage (Figure 1). Also, the number of the alveolar macrophages increased in the pulmonary alveolus in these animals.

**Figure 1.** The macrophages in the bronchoalveolar lavage. A) Guinea pigs who inhaled filtered air. B) Guinea pig exposed to fine particles from México City. Green arrows show the fine particles inside of macrophages. 850X. Original images obtained of our research.

After PM exposure, the macrophage is capable of producing pulmonary inflammatory mediators such as TNF-α, IL-1β, IL-6, IL-8, and GM-CSF (Hiraiwa and van Eeden 2013). Human acute exposure of PM showed increased levels of IL-1 and IL-6. These cytokines are similar to those produced by the alveolar macrophage exposed to PM both ex vivo and in vivo (Hiraiwa and van Eeden 2013). Mediators such as GM-CSF, IL-1, and IL-6 increases the inflammatory response characterized by an increase in circulating leukocytes, platelets, and proinflammatory and prothrombotic proteins (Hiraiwa and van Eeden 2013). In sometimes, the alveolar macrophage is activated to “M2 polarization,” which induce Th2 cytokines (IL-4 and IL-13) (Hiraiwa and van Eeden 2013), this response is associated with the allergic disease as asthma. The alveolar macrophage interacts with bronchial, bronchiolar, and alveolar epithelium, producing a variety of problems, such as aggravated asthma, decreased lung function, as well as, increased respiratory symptoms, as irritation of the airways, coughing or difficulty breathing or to increase other pulmonary diseases. Particles also produces heart, and blood vessels damage, producing premature death in people with heart disease or nonfatal heart attacks, (EPA 2016).

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