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Scanning Electron Microscope Study of the Lung in Drowning

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ABSTRACT: The authors describe the results obtained using the scanning electron microscope (SEM) to study drowned lungs and control lungs. Results are compared with a previous study carried out using laboratory animals. The results from both studies are analogous, in the absence of chronic pulmonary emphysema. The diagnosis of chronic pulmonary emphysema is simple with the SEM even when dealing with autoptic material obtained 24 to 48 h after death, but the diagnosis of drowning becomes difficult in lungs with chronic emphysema.

KEYWORDS: pathology and biology, drowning, microscopy, chronic pulmonary emphysema

Ultrastructural alterations that occur in pulmonary alveoli following drowning have been described [*1–6*]. In a previous scanning electron microscope (SEM) study [*7*] we described dilation of the alveoli with stretching and even rupture of the septa; we also found small lacerations of the epithelial lining of the alveoli, which at times reached the basal lamina and the capillary walls, and there were alterations of the surface of Type II alveolar cells.

In the present paper we examine the appearance of the human lung in drowning and compare it with lungs of individuals, with or without chronic emphysema, in which asphyxia was not the cause of death.

Materials and Methods

Lung samples were obtained from corpses (24 to 48 h after death) in eight definite cases of drowning.

Samples were washed by numerous immersions in 0.1*M* phosphate buffer (pH 7.4), followed by fixation for 4 h in 2.5% glutaraldehyde in 0.1*M* phosphate buffer (pH 7.4). None of the preceeding operations were carried out at positive pressure.

After further washes in 0.1*M* phosphate buffer, the samples were dehydrated by immersion in a series of alcohols and finally in amyl acetate; they were then critical point-dried, mounted on suitable stubs, and gold-coated.

Observation was carried out using a Cambridge Stereoscan 250 scanning electron microscope.

Samples of lung from individuals, with or without chronic emphysema, whose death was a result of causes other than mechanical asphyxia, were subjected to identical treatment.

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Results

The structure of the lung in subjects who died of causes other than asphyxia, without chronic pulmonary emphysema, is basically that which is found in experimental animals used as controls, especially if the material was obtained within a few hours after death (Fig. 1). Postmortem alterations of the alveolar walls are present: adjacent cell boundaries are difficult to identify and there is disorganization of the microvilli.

In samples obtained from drowning cases and who did not have chronic pulmonary emphysema, alterations similar in part to those found in drowned laboratory animals were observed. These included lacerations of the alveolar walls and stretching of the capillary network. Finer alterations cannot be appreciated because of superimposition of postmortem changes (Fig. 2).

In subjects with chronic pulmonary emphysema and whose deaths were a result of causes other than drowning, there is skeletonization of the alveolar walls which appear to be made up

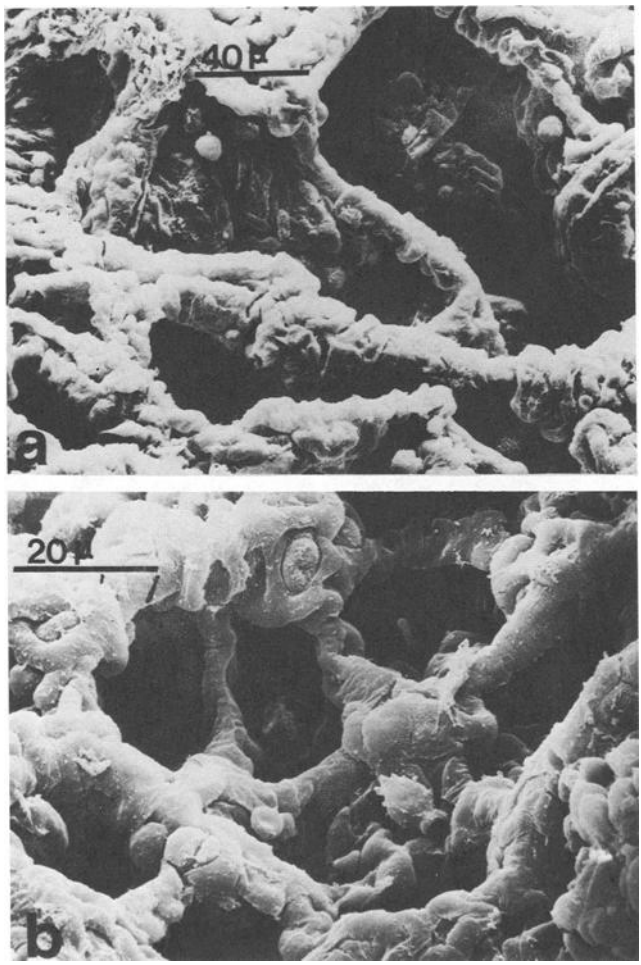

FIG. 1—(a) *Lung from youth who died from head injuries. The general appearance of the air spaces is analogous to that found in experimental animals* (b). *Septa are relatively thick and the capillary network is swollen with blood cells. Numerous alveolar macrophages can be observed but the fine ultrastructural characteristics (cellular boundaries, microvilli, and so forth) are undiscernable because of postmortem changes.* (b) *Photograph from the experimental study referred to in Ref* 1.

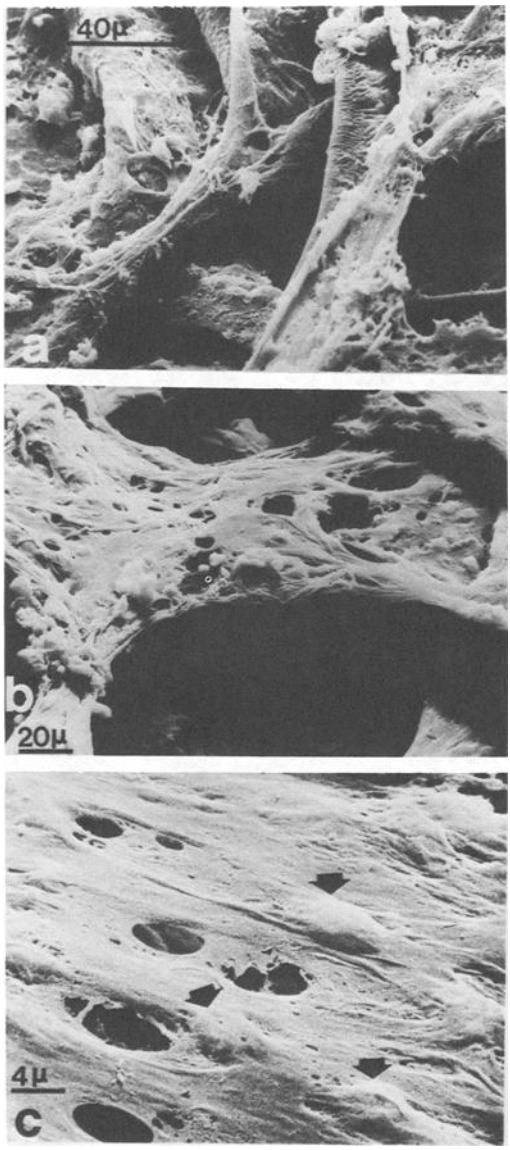

FIG. 2—*Lung from drowned youths (without chronic pulmonary emphysema).* (a) *Stretched alveolar walls with generally unrecognizable vasculature except in a few places* (arrow), *where it is stretched, thinned, and devoid of contents. Because of postmortem changes, the details of the epithelial elements are lost and the wall presents fine stretch marks.* (b) *The interalveolar septum is stretched and lacerated. The interruptions have irregularly lacerated margins. Again, the vasculature is difficult to appreciate.* (c) *At higher resolution, there is flattening of the vasculature with round prominences* (arrows) *as a result of isolated erythrocytes or nuclei.*

of only the free-floating capillary network and structures derived from the alveolar mouth or from anastomotic vascular rami. The alveoli are very ample but not deformed (Fig. 3).

In drowned subjects with chronic pulmonary emphysema the alveolar structure is identical to that found in the previous group. In numerous fields of observation, particularly at low magnification, there is deformation of the alveoli with stretching of the parietal structures which is observed, on a smaller scale, in drowned, nonemphysematous subjects and in experimentally drowned laboratory animals (Fig. 4).

Discussion

Postmortem alterations considerably hamper attempts at high-resolution observation of the fine ultrastructural modifications occurring in drowned human lung. These modifications have already been described in laboratory animals [7].

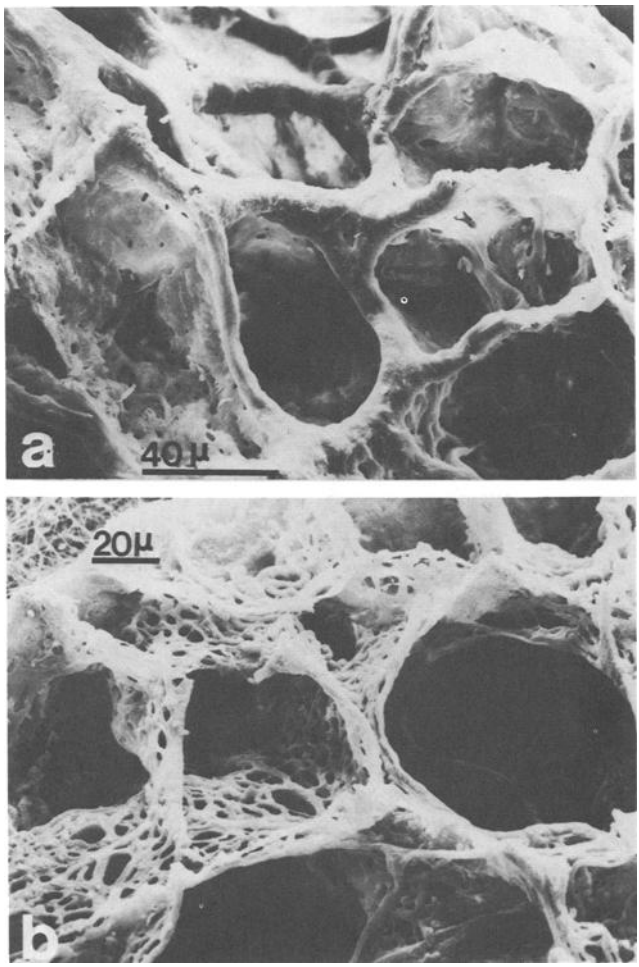

FIG. 3—*Lung from subjects with chronic emphysema: death as a result of nonasphyctic causes.* (a) *The alveolar walls are anchored to a robust three-dimensional system consisting of the smooth muscle of the alveolar mouth or an anastomotic vascular net.* (b) *The alveolar capillary network seems free-floating and with a lacy appearance because of atrophy of the epithelial lining.*

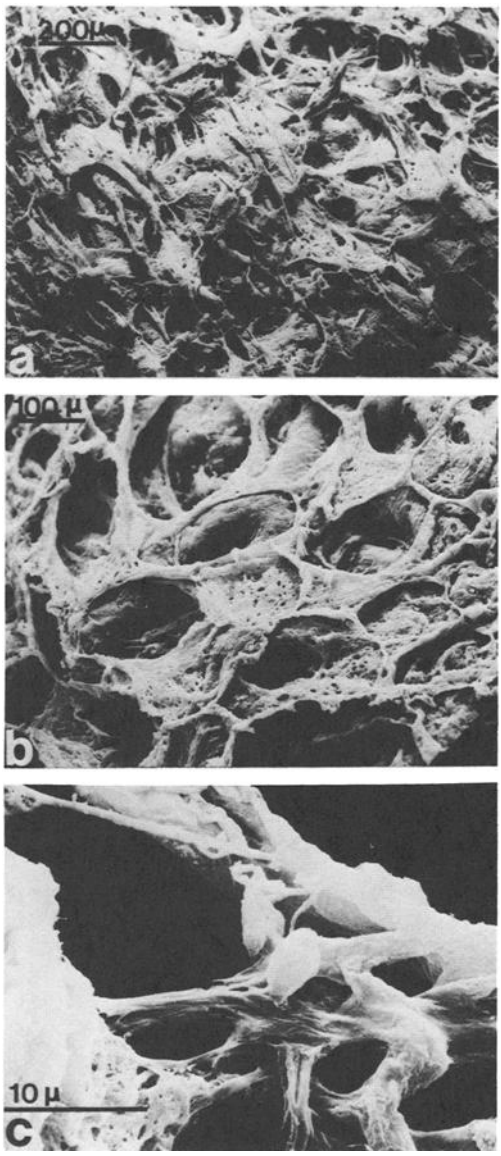

FIG. 4—*Lung from subjects with chronic emphysema: death by drowning.* (a, b) *Low magnification: stretching of the alveolar walls with deformation of the air spaces. The diffuse fenestrations of the wall can be attributed to the preexistant chronic pneumopathy. Higher magnification* (c): *images suggest stretching of alveolar structures.*

The general appearance of the alveolar wall (stretchings, flattening of the capillaries and lacerations) is similar to that found in laboratory animals. When comparing drowned lung with control lung, the former presents a striking global thinning of the alveolar walls (Figs. 1 and 2). Controls present thick, irregular walls as a result of vascular (that is, erythrocyte-filled capillaries) and cellular prominences. Drowned lung has thin, smooth walls interrupted occasionally by lacerations and fissures. The capillary prominences are almost completely cancelled

with few residual reliefs caused by pinched intravascular erythrocytes or endothelial cell nuclei.

These morphologic aspects of drowning, characterized by anemia of the capillary bed, are consistent with the macroscopic finding of dry lung, which is routine in forensic medicine.

The appearance of lungs with chronic pulmonary emphysema is analogous to the description by Kuhn et al [8] and Parra et al [9] of human emphysema and papain-induced emphysema. Therefore, we can exclude that the dilation of the alveoli and the ample parietal fenestrations are caused by postmortem alterations.

The width of the air spaces could account for the objective scarcity of alterations in coexisting chronic emphysema and acute emphysema of drowning. Such ample cavities are probably unaffected by mechanical stretching; furthermore, the effects of the acute injury could be masked by the preexisting alterations caused by the chronic pneumopathy. Mechanical traction is likely to produce greater lacerations in an integral, continuous wall than in an abundantly fenestrated one. This also explains why blood vessels are little affected by the stretching. Therefore, thinning and flattening of the capillaries has never been observed.

In conclusion, we feel that the scanning electron microscope is capable of making certain diagnoses of chronic pulmonary emphysema in the corpse, even in the presence of postmortem alterations. In fact, the appearance of the vasculature and the fenestrations are unmistakable and the technique can distinguish chronic emphysema from the acute emphysema of drowning. In the latter, the alveolar wall may be lacerated in a few places but under no circumstances do we find fenestrations with regular margins.

When acute emphysema of drowning and chronic emphysema coexist, the diagnosis becomes difficult and uncertain. The deformation of the air spaces suggests drowning but not clearly enough for certain diagnosis.

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