The Documentation of Communicable Diseases in Peruvian Mummies

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Communicable disease in Egyptian mummies was documented by Ruffer and Ferguson when early in this century they reported a case of smallpox. A case of schistosomiasis was also reported by Ruffer. Various intestinal parasites have been reported from mummies, and suggestive evidence has been presented for poliomyelitis and tuberculosis. Much of this work was done at a time when good laboratory techniques were not available.

In the case of soft tissue pathology, good embedding and staining techniques now make it possible to perform an autopsy on a mummy and study its tissue much as one would a modern corpse. New concepts of pathology are necessary since the standard hematoxylin and eosin section with its cellular morphological approach is generally useless. The electron microscope has certain applications as do standard bacteriological morphology techniques especially if they can be supported by immunological studies. The material below illustrates some applications of these techniques to diagnostic problems.

The question of interchange of disease between America and Europe during and after the conquest has always been debatable. For example, it was thought that syphilis was a disease of New World origin and tuberculosis a disease of Old World origin. The problem of tuberculosis has been resolved by us and shown to be present in the New World as early as 700 AD.

The mummy of a seven-year-old child found in an unusual sitting position on a molded adobe, cushioned seat was our earliest case of tuberculosis and revealed Pott's disease with a psoas abscess and tuberculosis of the kidneys. The terminal event was a miliary tuberculosis with a tuberculous pericarditis. The diagnosis was based on the presence of acid-fast bacilli inside nodules (Fig 1) that were evidently tubercles, but lacked epithelioid cells, macrophages, and inflammatory cells. These multiple isolated lesions still had the fibrous tissue structures of tubercles and, with bone changes in the vertebrae, the sac-like psoas abscess full of dried pus, the pericarditis, and the miliary tubercles, all combined to enable us to make this diagnosis in the absence of a clinical history and tissue cellular morphology. The diagnosis was originally made tentatively on the basis of x-ray
studies where the lesion of Pott’s disease and the psoas abscess were seen. In this case, it is important to emphasize that the mycobacteria remained acid-fast in this mummy for 1,200 years, although all efforts to culture them were futile.

A second diagnostic case based on pathology was that of a man with bartonellosis in the verruga phase at the time of death. On opening this man’s mummy bundle, we noted lesions on the skin which were accentuated when the hand and forearm were rehydrated to normal consistency. These lesions were obviously in different stages, some large and pendulous while others were healing and forming scars. Sections taken of these lesions showed them to resemble granulomas, but acid-fast and Gram’s stains showed no organisms in them. Giemsa-stained sections readily revealed numbers of small bacilli (Fig 2) that, when viewed in section with the scanning electron microscope, were seen to have flagella. Regular sections were studied in the electron microscope, and the organism was seen with a typical corkscrew flagellum (Fig 3). Measurements and morphology were compatible with Bartonella bacilliformis. The discovery of these organisms in the characteristic lesions led to the diagnosis of this disease entity so typical of Peru.

We have had less success with the etiological agents of pneumonia. A number of cases of pneumonia have been diagnosed initially, based on gross alteration in appearance of the lung. The normal Peruvian mummy’s lung is collapsed, about the thickness of a playing card and somewhat adherent to the posterior surface of the pleural cavity. In pneumonia, the lung is irregularly thickened or voluminously swollen. The inflammatory exudate and edema fluid present at the time of death cause it to fix in this unnatural position. If pleurisy is present, spotty attachments are noted to the anterior or lateral pleural surfaces or
both. In one case, a hemorrhage had occurred in the pleural cavity. Unfortunately, the fluid in the lungs is rich in nutrients and as a result, microorganisms of all types are found in the tissue, making it nearly impossible to identify the etiological agent. In one case, the etiology of a pneumonia was made in a man who had aspirated a tooth.\(^7\) All of the pathology seen in modern autopsy aspiration pneumonia could be visualized in this man (Fig 4, Fig 5) who died around 950 AD. A case of resolving pneumonia with adhesions in a two-year-old child was of interest to us as the child had meningitis visualized as thick dry pus adherent to the dura of the spinal cord. The brain itself had disintegrated. Microscopically, small bacilli compatible in size with *Hemophilus influenzae* were seen, but we were never able to identify them using fluorescent antibody techniques. Among the mummies with pneumonia was one with a generalized infectious disease of the skin and numerous internal organs. The mummy was a woman who died in colonial times, around 1610 AD. Her lungs were voluminous and when rehydrated had whitish nodular lesions (Fig 6) that on section were noted with Gram's stain to contain masses of yeast (Fig 7, Fig 8). The yeast took up the safranin stain, a common occurrence of dead, gram-positive organisms. Studies of similar lesions in other organs showed the same yeast-like organism and in the skin, the organism showed pseudohyphae. This is an interesting case since such infections today are not commonly seen outside individuals with immunological or endocrine problems. It would have been interesting if this woman could have been found to have diabetes, but unfortunately her pancreas could not be recovered.

In the gastrointestinal tract, we have explored several ways of locating agents of disease. The scan-
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Fig 5—Section of a lung posterior to an aspirated tooth. This portion was grossly thickened, the air passages contained dry pus, and this section shows the alveoli and bronchioles to be full of debris considered to be the remains of pus (Rehydrated tissue, X100).

Fig 6—An external, gross view of a rehydrated lung. Note the white raised firm nodules.

The electron microscope is extremely useful at X80 for examining relatively large pieces of intestine for worms (Fig 9). It was in this way that we were able to visualize *Ancylostoma duodenale*. The identification was made by cutting serial sections from a paraffin block until we could see the teeth. An immunological method was developed by us to screen feces for pathogens. The feces were injected, with Freund’s adjuvant, into rabbits and after allowing time for antibody build-up, the animal was sacrificed and the serum collected periodically. Such serum under properly controlled testing can be checked against a battery of bacterial antigens to screen for a rise in titer against, for example, *Escherichia coli*. Through such studies a number of bacterial antigens have been detected in feces. One of importance that has been noted is a Salmonella Group D in a man from the Huari culture. In the case of Salmonella where multiple antigens are found, it is important to do absorption studies to pinpoint the dominant antigen. The use of fluorescent antibody techniques might prove useful in some of these studies, but in this case, a patchy diffuse immunofluorescence was noted not attached to any bacillary body. Perhaps the enzymes released in the inflammatory response resulted in bacterial disintegration after death, leaving the antigen in an amorphous state.

The last case was of interest to us as it involved a case of collagen disease that was probably lupus erythematosus. Recently, a line of dogs has been developed that carries this disease, and the disease has been transmitted to them in cell-free filtrates sugges-
tive of a viral origin. For a number of years, virus-like particles have been reported in kidneys from individuals diagnosed as having this disease. We have reported such virus-like particles from the kidney of a teen-age girl who died around 950 AD. These particles are tubelike and compatible in size with one of the myxoviruses (Fig 10). In humans, the role of these viruses in collagen disease has not been established, but their presence even after 1,000 years is of great interest.

The few cases presented above show the possibility of finding different microorganisms over 1,000 years after the individual has died and suggest a number of approaches to the identification of infectious diseases in which these agents might be involved.
Fig 10—Electron micrograph of virus-like particles from the kidney of a mummy. This teen-age girl died of a generalized collagen disease (Original magnification, ×32,000, but greatly enlarged photographically).

REFERENCES


