A FAIR SOUTH WIND

Deans of medical schools come and go as the wind and we have had our share of breezes lately. Fairfield Goodale, the MCV/Q editor since 1971, has now joined the “Dean’s Brigade” and has departed for points South and, we hope, grasses greener. To use a well-laundered cliché, MCV’s loss is Georgia’s gain.

Fair came to MCV thirteen years ago as Chairman of the Department of Pathology and evinced an interest in literary matters from the start; it was natural, therefore, to appoint him to the editorial chair after Sami Said, the MCV/Q’s founding editor, moved to Texas. Since then, Fair has been the solicitous, efficient—almost kindly—power behind the press and, under his direction, the Quarterly has prospered both scientifically and financially. Fortunately, Fair has agreed to stay with us as an Editorial Consultant, so we shall be in touch from time to time. All that remains is to wish him well at the Medical College of Georgia and thank him for his five years of benevolent guidance and loyal service.
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COVER: Photograph of a pre-Columbian terra-cotta figure entitled, "Man with Pustules on Body." Courtesy William F. Kaiser M.D.
INTRODUCTION

In 1970, a multidisciplinary study was initiated by the Peruvian government under my direction to evaluate health conditions in a population group which had lived in a relatively stable environment for some 5,000 years. So far, American and Peruvian archeologists, anthropologists, radiologists, anatomic, oral, neuro- and clinical pathologists, chemists, immunologists, an otologist, and students from many different disciplines have been involved in the study which has been supported largely by the National Geographic Society with many individual contributions.

We are often asked the value of such studies and a simplistic answer would be, "what is the value of any study of history?"

Many unanswered questions about the relationship of man and his diseases as well as some problems on the origins of man and his migrations might be partially solved through examination of anthropological material and studies of genetic markers. What are the origins of man's diseases, many of which have been described only within the last 200 years? Does this mean they didn't exist before or have they appeared in a new form? What is the role of the environment in the appearance of a particular disease in a population group? The Americas are unique in that they are a vast land mass inhabited by a single racial group, isolated for millennia, and with a well-documented history of discovery and colonization. This area offers an opportunity for careful anthropological study of man before miscegenation and after; nowhere in the world is such a wealth of anthropological data on a single racial group available in conjunction with its food and artifacts. With colonization we can witness the exchange of disease from one part of the world to another; for example, the exchange of syphilis for tuberculosis was suggested or the possible formation of a new disease, venereal syphilis, from a nonvenereal relative. Such a study might also serve as a baseline to measure the impact of modern medicine in changing man's disease patterns.

Steps have been taken to answer some questions; for example, we now know that tuberculosis was a disease present in native Americans as early as 700 A.D. and in the pre-Columbian Indian, it was probably much like the disease in the white American prior to antibiotics. It was also a major cause of death along with other respiratory diseases, and modern medical practice has not changed this, since respiratory disease, including tuberculosis, is still the major cause of death in Latin America. Childhood illness 5,000 years ago was less than it is today and mortality in infants and children was probably also less. Problems of dental origin have become progressively worse since man first became a farmer and although we have dentists today, it is questionable whether they have improved the oral health of the average man in rural Latin America.

Verification of the written word was made possible when we examined 22 miners from the 17th century in this project. The extensive pneumoconiosis due to silver ore and silica confirmed the statements in the Spanish chronicles that the life expectancy of a miner after he entered the pits was six months to a year. In the same period, mistreatment of the Indians under the colonial government was confirmed by a nearly five hundred fold increase in fractures.

Serological study of ABO and HL-A antigens have enabled us to trace the movements of prehistoric peoples from one valley to another, and these, combined with archeological and nonmetrical genetic markers, have enabled us to establish blood relationships among individuals in the same cemetery. The absence of a native written language has thus in part been overcome. As yet, it has been impossible for us to establish the presence or absence of soft tissue syphilis nor have we been able to discover any new diseases. We do feel there were fewer virulent agents of wound infection in prehistoric Peru, but documentation as to why this is so is poor, although theories are not lacking. We hope in time to establish good, epidemiological data to answer some of these questions as well as many more that will surely arise as our investigations proceed.

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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. 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-
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, ×100).

Fig 6—An external, gross view of a rehydrated lung. Note the white raised firm nodules.
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, $\times 32,000$, but greatly enlarged photographically).

REFERENCES


Primary Generalized Hyperostosis in Ancient Peru

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Primary generalized hyperostosis is a rare disease usually diagnosed by radiographic examination. Uehlinger considers this syndrome to be different from the secondary osteoarthropathy of the Marie-Bamberger variety and Paget's disease. The primary type is probably of familial origin and may involve all the bones of the body, appearing independently of severe pulmonary disease. It is predominantly a disease of males (29:2) and in some cases is associated with pachydermia.4,5

The literature on this disease is primarily European; the case described below is the first in South America and first among pre-Columbian people.

Materials and Methods. Four bones consisting of a left femur, a right hip bone, and two ribs from a single skeleton were recovered from the surface of a Huari culture cemetery (about 1000 A.D.) near El Ingenio in the Ingenio Valley, Ica, Peru. Grave robbers had desecrated the cemetery and opened the mummy bundles looking for valuables. These bones were collected by one of us (Sotil) and taken to the Regional Museum of Ica for study.

X-rays were taken of all bones, and one rib was used for histological study. Several sections were cut on a band saw and ground to a thickness of 80µ to 100µ.

Results. The hip bone (os coxis) was that of a female estimated to be 32 years old by utilizing the pubic symphysis technique of Gilbert.9 This bone weighed 480 gm compared with 180 gm for a normal bone of this size female of a similar age. The left femur was 405 mm long, 50 mm in diameter (mid-shaft) and weighed 750 gm (Fig 1). The marrow cavity measured 8 mm to 15 mm by x-ray (Fig 2). A normal femur from a woman this size and age had a
weight of 350 gm with a diameter of 30 mm; the marrow cavity measured 9 mm to 28 mm. The two ribs each weighed 110 gm compared to 30 gm for a normal rib. All control bones were also from the Huari culture.

Histologically the major finding was an increase in the circumferential lamellae as a series of periosteal proliferations occurring at different times and giving the multilayer effect seen in Figure 3. An increase in Volkmann's canals was also noted. The endosteum had also been active as the marrow cavity virtually disappeared with randomly arranged new haversian systems and interstitial lamellae as seen in Figure 4. In certain areas, as seen in this figure, occasional erythrocytes and hemoglobin pigment may be noted as well as calcified remains of blood vessel walls.

**Conclusion.** The bones described above lack the soft tissue for study, but it is probable that this individual belonged to the group with pachydermia. This observation is based on the extensive disease seen in the femur which is more compatible with hyperostosis associated with pachydermia. Hyperostosis without the skin lesions is usually located on the distal end of the diaphysis.

Although a rare disease, this case is of interest, for the diagnosis is generally a radiological one. Since it is thought to be of familial origin, it is important to document its geographic distribution in the world. This case is the first reported from pre-Columbian South America and in an American Indian.

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Fig 1—The femur from the present case of primary generalized hyperostosis is compared to a normal femur from a woman of the same size. The first weighed 750 gm while the latter weighed 350 gm.

Fig 2—Radiograph of the diseased femur shows some reduction in size of marrow cavity with tremendous thickening of the shaft. Articular surfaces are essentially normal. Rib radiographs showed complete obliteration of marrow cavity.
Acknowledgment: The authors wish to thank Dr. T. D. Stewart of the Smithsonian Institution and Dr. E. Uehlinger of the University of Zurich for looking at some of the material of this case.

REFERENCES


Thyroid Disease in a Peruvian Mummy

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Although the pathogenesis of endocrine disorders has only recently been recognized, disorders of the thyroid gland have been recorded since ancient times, primarily because of the gland's strategic location in the neck. Goiter, enlargement of the gland, was described early in history and endocrine goiter was also mentioned. The earliest written references go back as far as the Chinese of the second millennium BC, Greek and Roman authors of classical times, and medieval manuscripts.\textsuperscript{1,2,3} In his history of goiter, Greenwald\textsuperscript{4} contended that there was no evidence of goiter in the Americas before the coming of the white man, although the protruding eyes of possible exophthalmic goiter are seen in Peruvian ceramic sculpture from 2000 years ago.

The present report deals with a case of goiter diagnosed in a Peruvian mummy on the basis of autopsy findings. The mummy bundle was excavated from the Hacienda Ocucaje, valley of Ica, in southern Peru. The mummy was a female, estimated to have been 30 years old at the time of death, belonging to the Nazca culture. Carbon-14 dating placed the time of her death around 94 BC.

X-ray examination prior to the autopsy showed areas of pathological calcification measuring up to 1 cm in the thyroid area (Fig 1); there was also calcification of the abdominal aorta. The skull film revealed the calvarium to be twice the normal thickness and moderate degrees of osteoarthritis in the lumbar area (second, third, and fourth lumbar) were also observed. The x-ray findings of the long bones showed two Harris lines on the distal femur and tibia occurring approximately at four and eleven years of age and an area of healed osteomyelitis in the left femur. Examination of the body showed a severe degree of oral disease with many missing teeth and advanced osteoclasia of the alveolar ridge. The abdominal aorta had several fibrous and calcified plaques. Blood group typing showed the mummy to belong to group AB.

In the areas of the neck where calcification had been noted, careful dissection revealed the thyroid...
Fig 1—X-ray of neck area reveals calcified nodules in the thyroid area (arrow).

gland containing two large calcified areas (1 cm x 0.5 cm) and several smaller foci. All these calcifications were surrounded by thick tissues. Selected sections were taken for microscopic examination. The histologic sections were stained with NAFT stain, a commercial stain used for biopsies, and showed occasional scattered follicles, most of which were filled with a thick colloid material (Fig 2). The calcium material was stained pale red with the Alizarin red stain.

Hypothyroidism may be produced by a primary failure of the thyroid parenchyma or secondary to absence of thyrotropic hormone secretion by the pituitary. In both instances, the disease manifestations are due to a lack of thyroid hormone. Female patients account for 80% of all cases of spontaneous hypothyroidism which occurs mainly between the ages of 30 and 60 years. The mummy described here falls into this high-risk group. The severe degree of aortic atherosclerosis and some of the bony changes are also consistent with the diagnosis of hypothyroidism. The area where the mummy was found is a short distance from the sea and there is no lack of iodine, but occasional cases are seen in modern coastal inhabitants. Those that were seen in pre-Colombian times are substantiated by ceramics representing goiter or myxedema.

In this case, the woman had an enlarged thyroid (goiter); in autopsies of other mummies the thyroid gland cannot be identified. The areas of calcification were definitely inside the capsule of the gland. The sex and age group, the presence of severe atherosclerosis, and thickened calvarium are all common findings in hypothyroidism. An inflammatory process or auto-immune disease of the gland cannot be ruled out, but the probability of these diagnoses is least likely.

REFERENCES


Morphological Characteristics of the Pre-Columbian Dentition
I. Shovel-Shaped Incisors, Carabelli’s Cusp, and Protostylid

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This Peruvian-American cooperative study of paleopathology of the pre-Columbian Peruvian cultures of Southern Peru began in 1971. The purpose of this study is to evaluate the medical and dental health status of these cultures which date from 600 BC to the Spanish conquest. While several authors such as Leigh, Moodie, Stewart, and Goaz and Miller have studied the dental morphology of Northern Peruvians, the paleodontology and oral paleopathology of the Southern Peruvians has not been recorded. This paper reports dental findings on the morphologic characteristics of the shovel-shaped incisor (Fig 1), Carabelli’s cusp (Fig 2), and protostylid (Figs 3A, 3B, and 3C).

A major aspect of any study of the human dentition is the recognition and assessment of morphological variations. The shovel-shape is one such characteristic and is manifested by the prominence of the mesial and distal ridges which enclose a central fossa on the lingual surface of incisor teeth. Shovel-shaped incisors are seen with greater frequency among the maxillary incisors and only occasionally among the mandibular incisors. For this reason, only the maxillary incisors were examined in this study.

The presence of the shovel-shaped morphological variation has been common knowledge for many years. Hrdlička described the shovel-shaped incisor in 1920 and reported a high frequency...
of this character in the lingual surface of the maxillary incisors of American Indians. As a result of Hrdlička's study, further investigations were made in other populations. Anthropologists have now come to employ this feature as one criterion for the assessment of population affinities and as an aid in tracing population migrations.

In 1842, Carabelli described an accessory cusp on the lingual surface of maxillary molars. This cusp has been used in phylogenetic studies and for racial classification. The cusp of Carabelli is an inherited character and Kraus showed that the mode of inheritance was an exceedingly complex one.

Dahlberg defined and described the protostylid as a primary character found on the buccal surface of the protoconid of mandibular molars both deciduous and permanent. The protostylid is a character which is variable, involving a pit, furrow, and varying degrees of expression of a cusp located in the occlusal third of the buccal surface of mandibular molars. Like the Carabelli's cusp, the protostylid is genetically determined and has an ancestral reputation dating back to the earliest fossil forms. The protostylid is manifested with greatest size and character in the deciduous second mandibular molars and decreasingly from this tooth through the sequence of the first, second, and third permanent mandibular molars.

The aim of our study is: 1) to determine the frequency of these three morphological characteristics in the cultures studied and in the pre-Columbian population as a whole and, with the shovel-shaped incisors, to determine the degree of shovelling as well as its frequency; 2) to compare the frequency...
of these morphological characteristics in the pre-Columbian population with that in other cultures in order to assess racial characteristics of these cultures; 3) to add to the list of genetic markers which will be used to compare and contrast these different cultures, their migrations, and the influences of outside cultural groups on them.

Materials and Methods. A total of 195 mummies and skulls were studied, the material being from the Museo Regional de Ica, Ica, Peru. All the cultures studied were found in the Department of Ica and existed during the following periods: Paracas, 600 BC–100 AD; Nazca, 100 BC–800 AD; Huari, 800 AD–1200 AD; Ica, 1200 AD–1450 AD; Inca, 1450 AD–1532 AD; Colonial, 1534 AD–1700 AD. The dating of these cultures, mummies, and skeletal material has been carried out by both archeological dating and 14C dating. Two large cemeteries, one at Murga and one at Huayuri, are included in this study. The cultural composition of the group from Murga used in this study was 74.2% Colonial (the Murga group encompasses all the Colonials studied) and 25.8% Ica. The cultural composition of the group from Huayuri used in this work consisted of: 66.7% Ica, 20.0% Huari, and 13.3% Nazca. Sex determinations and age estimations have been made for most of the material used in this study and were carried out as outlined by Allison and Gerszten.

The degree and frequency of shovelling was studied in all maxillary incisors of both the deciduous and permanent dentitions. With the use of a modified Boley gauge, the depth of the lingual fossa was measured from a point midway between the incisal and gingival margins, and midway from the mesial and distal enamel margins. The shovel-shaped character was then classified into one of four categories. Each category was identified by numbers from 0 to 3. Zero = no shovel-shape; 1 = <1 mm shovel; 2 = 1 mm shovel, and 3 = >1 mm shovel.

Dahlberg pointed out that the classification of the Carabelli's cusp had always been a problem and at that time, he introduced a new classification, grading the Carabelli cusp into seven categories. The classification system used in this study was that described by Bang and Hasund who reduced the number of categories to three by combining some of Dahlberg's groups. Their three groups consisted of: 0 = smooth surface (no cusp or pit); 1 = single furrow and pit; and 2 = cusps of all sizes. The frequency of this character was studied in the deciduous maxillary second molars and in the first, second, and third permanent maxillary molars.

In this study, only the presence or absence of a protostyloid was noted. Thus this study differentiated the smooth surface with no structure from that con-

<table>
<thead>
<tr>
<th>TABLE 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><em><em>Distribution of Shovel-Shaped Permanent Incisors in the Pre-Columbian Peruvian Cultures</em> (percent)</em>*</td>
</tr>
<tr>
<td><strong>Culture</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td><strong>Shovel Classification</strong></td>
</tr>
<tr>
<td>Paracas</td>
</tr>
<tr>
<td>Nazca</td>
</tr>
<tr>
<td>Huari</td>
</tr>
<tr>
<td>Ica</td>
</tr>
<tr>
<td>Inca</td>
</tr>
<tr>
<td>Colonial</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
</tr>
</tbody>
</table>

* Both sexes included
** No permanent Inca incisors available for study

N = the number of incisors available
TABLE 2
Distribution of Shovel-Shaped Deciduous Incisors in the Pre-Columbian Peruvian Cultures* (percent)

<table>
<thead>
<tr>
<th>Culture</th>
<th>N</th>
<th>Central Incisors</th>
<th>Lateral Incisors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Shovel Classification</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Paracas</td>
<td>10</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Nazca</td>
<td>1</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Huari</td>
<td>3</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Ica</td>
<td>16</td>
<td>12.5</td>
<td>75.0</td>
</tr>
<tr>
<td>Inca</td>
<td>3</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Colonial</td>
<td>24</td>
<td>25.0</td>
<td>70.8</td>
</tr>
<tr>
<td>Totals</td>
<td>57</td>
<td>14.0</td>
<td>75.5</td>
</tr>
</tbody>
</table>

* Both sexes included

N = the number of incisors available for study

Results. The incidence and distribution of the shovel-shaped character is given for this pre-Columbian Peruvian population and its cultures in Tables 1 and 2 (Table 1 for the permanent dentition and Table 2 for the deciduous dentition); both sexes were combined as the difference between them was statistically insignificant. As seen in Table 1, 90.1% of the central incisors and 90.7% of the lateral incisors in the permanent dentitions of this population showed some evidence of shovelling. In the deciduous dentition (Table 2), 86.0% of the central incisors and 85.2% of the lateral incisors showed some degree of shovelling. In studying the cultural differences it should be noted that all the cultures with the exception of the Paracas culture (the earliest studied) approach 100.0% frequency for the shovel character in the permanent dentition. In the Paracas culture, only 71.5% of the central incisors and 60.0% of the lateral incisors demonstrate this character. It is apparent from Tables 1 and 2 that the shovel character was manifested to its maximum degree in the permanent dentition of the Huari culture and in the deciduous dentition of the Ica and Inca cultures. Table 2 shows a significant decrease in the shovel character in the deciduous dentition in the Colonial and Ica cultures with all other cultures approaching the 100.0% frequency level.

The frequency of Carabelli's cusp is given for this pre-Columbian Peruvian population and its cultures in Table 3. Nineteen and seven tenths percent of the permanent dentitions having maxillary molars and 60.0% of the deciduous dentitions having maxillary molars possessed the character known as Carabelli's cusp. In the permanent dentitions, the expression of the cusp more frequently took the form of a single furrow and pit while in the deciduous dentitions, actual cusp formation prevailed over the single furrow and pit expression. The range of expression of this character varied from 0 in the Nazca dentitions...
TABLE 4
Frequency of Protostylid in the Pre-Columbian Peruvian Population and Its Cultures* (percent)

<table>
<thead>
<tr>
<th>Culture</th>
<th>Frequency in Permanent Dentition N</th>
<th>Frequency in Deciduous Dentition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paracas</td>
<td>30</td>
<td>73.3</td>
</tr>
<tr>
<td>Nazca</td>
<td>18</td>
<td>77.8</td>
</tr>
<tr>
<td>Huari</td>
<td>13</td>
<td>69.2</td>
</tr>
<tr>
<td>Ica</td>
<td>26</td>
<td>53.8</td>
</tr>
<tr>
<td>Inca</td>
<td>1</td>
<td>100.0</td>
</tr>
<tr>
<td>Colonial</td>
<td>23</td>
<td>34.8</td>
</tr>
<tr>
<td>Totals</td>
<td>111</td>
<td>61.3</td>
</tr>
</tbody>
</table>

* Both sexes included
** No deciduous mandibular Nazca teeth were available for study

N = the number of individuals in a culture who had mandibular molars for study

(bold permanent and deciduous) and in the permanent Inca dentitions to a 100.0% expression in the deciduous dentitions of the Inca culture. It should be pointed out however that this extremely high (100.0%) expression in the Inca deciduous dentitions was based on the study of only three individuals.

The frequency of the protostylid character is shown in Table 4. The protostylid was expressed in 61.3% of the permanent dentitions and in 67.6% of the deciduous dentitions. The frequency ranged from a low of 34.8% in the permanent dentitions of the Colonial culture to a high of 100.0% in the dentitions of the Inca culture.

Tables 5 through 8 give the frequency and distribution separately of the three characters of shovel-shape, Carabelli's cusp, and protostylid as seen in the mummies excavated from two large cemeteries (Murga and Huayuri). As can be seen from Table 5, all the central and lateral permanent incisors from these two cemeteries, Murga and Huayuri, express the shovel character. The group from Huayuri, however, show a greater degree of shovelling. In Table 6, 75.9% of the central and 78.6% of the lateral deciduous incisors from the Murga group have the shovelling character. In the Huayuri group, 100.0% of the central and 83.3% of the lateral deciduous incisors express the shovel-shape character. Only 3.5% of the group from the Murga cemetery had Carabelli's cusps in the permanent dentition while 50.0% of the deciduous dentitions had expressions of this character as seen in Table 7. The group from Huayuri showed Carabelli's cusps in 14.3% of the permanent dentitions and 100.0% of the deciduous dentitions. Table 8 shows that in the Murga group the protostylids were expressed in 52.6% of the permanent dentitions and in 58.8% of the deciduous dentitions. In the Huayuri group, only 25.0% of the permanent dentitions and none of the deciduous dentitions showed expression of this character.

Discussion and Conclusions. After studying Table 9, it is quite evident that the frequency of shovel-shaped incisors varies considerably in the different population groups. In modern man, marked shovelling usually suggests Mongoloid affinities. The absence of shovel types occurs infrequently in Mongoloid peoples. Hrdlička has shown that in

TABLE 5
Distribution of Shovel-Shaped Permanent Incisors in the Two Large Cemeteries Excavated* (percent)

<table>
<thead>
<tr>
<th>Cemetery</th>
<th>N</th>
<th>Central Incisors</th>
<th>Lateral Incisors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Shovel Classification</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 1 2 3</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Murga</td>
<td>27</td>
<td>0.0 55.6 33.3 11.1</td>
<td>20 0.0 50.0 35.0 15.0</td>
</tr>
<tr>
<td>Huayuri</td>
<td>12</td>
<td>0.0 25.0 33.3 41.7</td>
<td>13 0.0 23.1 30.8 46.1</td>
</tr>
</tbody>
</table>

* Both sexes included

N = the number of incisors available for study

TABLE 6
Distribution of Shovel-Shaped Deciduous Incisors in the Two Large Cemeteries Excavated* (percent)

<table>
<thead>
<tr>
<th>Cemetery</th>
<th>N</th>
<th>Central Incisors</th>
<th>Lateral Incisors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Shovel Classification</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 1 2 3</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Murga</td>
<td>29</td>
<td>24.1 65.5 10.4 0.0</td>
<td>28 21.4 67.9 10.7 0.0</td>
</tr>
<tr>
<td>Huayuri</td>
<td>11</td>
<td>0.0 100.0 0.0 0.0</td>
<td>12 16.7 83.3 0.0 0.0</td>
</tr>
</tbody>
</table>

* Both sexes included

N = the number of incisors available for study
### TABLE 7
Distribution Frequency of Carabelli’s Cusp in the Two Large Cemeteries Excavated* (percent)

<table>
<thead>
<tr>
<th>Cemetery</th>
<th>Permanent Dentition Carabelli’s Classification</th>
<th>Deciduous Dentition Carabelli’s Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>0</td>
</tr>
<tr>
<td>Murga</td>
<td>29</td>
<td>96.5</td>
</tr>
<tr>
<td>Huayuri</td>
<td>14</td>
<td>85.7</td>
</tr>
</tbody>
</table>

*Both sexes included
N = the number of individuals in a cemetery available for study

Caucasoid races the frequency of shovel-shaped incisors is quite low. Lasker\textsuperscript{20} in his later study of American whites also found a low percentage of individuals with the shovel character. All of these authors agree that the degree of shovelling is greater in Mongoloids than in Caucasoids. The degree of shovelling in the permanent incisors has been shown by Hanaihara\textsuperscript{21} to be greater than the degree of shovelling in the deciduous dentition, probably due to the weakness of the lingual marginal ridges of the deciduous incisors. Table 9 shows that the high incidence of shovelling in this pre-Columbian Peruvian population fits with Mongoloid groups, suggesting, of course, affinity to this race. Our study also shows, as

### TABLE 8
Frequency of Protostylid in the Two Large Cemeteries Excavated* (percent)

<table>
<thead>
<tr>
<th>Cemetery</th>
<th>Frequency in Permanent Dentition</th>
<th>Frequency in Deciduous Dentition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>**</td>
</tr>
<tr>
<td>Murga</td>
<td>29</td>
<td>52.6</td>
</tr>
<tr>
<td>Huayuri</td>
<td>16</td>
<td>25.0</td>
</tr>
</tbody>
</table>

* Both sexes included
N = the number of individuals in a cemetery available for study

### TABLE 9
Percentage Frequency of Shovel-Shaped Incisors in Several Populations*

<table>
<thead>
<tr>
<th>N</th>
<th>Population</th>
<th>Frequency</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>Aleuts (centrals)</td>
<td>100.0</td>
<td>Moorrees\textsuperscript{22}</td>
</tr>
<tr>
<td>70</td>
<td>Aleuts (laterals)</td>
<td>100.0</td>
<td>Moorrees\textsuperscript{22}</td>
</tr>
<tr>
<td>96</td>
<td>Polynesians</td>
<td>76.0</td>
<td>Suzuki and Sakai\textsuperscript{23} and</td>
</tr>
<tr>
<td>376</td>
<td>Mapuche Indians (centrals)</td>
<td>56.9</td>
<td>Muñoz\textsuperscript{24}</td>
</tr>
<tr>
<td>376</td>
<td>Mapuche Indians (laterals)</td>
<td>93.6</td>
<td>Muñoz\textsuperscript{24}</td>
</tr>
<tr>
<td>689</td>
<td>Chileans</td>
<td>45.7</td>
<td>Pinto-Cisternas and Figueroa\textsuperscript{24}</td>
</tr>
<tr>
<td>73</td>
<td>Pewenche Indians</td>
<td>95.3</td>
<td>Rothhammer et al.\textsuperscript{26}</td>
</tr>
<tr>
<td>17</td>
<td>Early Am. Indians</td>
<td>63.0</td>
<td>Devoto and Arias\textsuperscript{27}</td>
</tr>
<tr>
<td>24</td>
<td>Mongolian</td>
<td>100.0</td>
<td>Hrdlička\textsuperscript{28}</td>
</tr>
<tr>
<td>40</td>
<td>Eskimo</td>
<td>100.0</td>
<td>Hrdlička\textsuperscript{28}</td>
</tr>
<tr>
<td>2000</td>
<td>American Whites</td>
<td>68.5</td>
<td>Hrdlička\textsuperscript{28}</td>
</tr>
<tr>
<td>642</td>
<td>American Whites</td>
<td>55.0</td>
<td>Lasker\textsuperscript{28}</td>
</tr>
<tr>
<td>226</td>
<td>Pima Indians</td>
<td>100.0</td>
<td>Dahlberg\textsuperscript{17}</td>
</tr>
<tr>
<td>60</td>
<td>Diaguitas Indians</td>
<td>80.3</td>
<td>Campusano et al.\textsuperscript{29}</td>
</tr>
<tr>
<td>53</td>
<td>Contemporary Peruvian Indians from Amazon area</td>
<td>100.0</td>
<td>Goaz and Miller\textsuperscript{4}</td>
</tr>
<tr>
<td>71</td>
<td>Pre-Columbian Peruvian (Perm. centrals)</td>
<td>90.1</td>
<td>Present study</td>
</tr>
<tr>
<td>64</td>
<td>Pre-Columbian Peruvian (Perm. laterals)</td>
<td>90.7</td>
<td>Present study</td>
</tr>
<tr>
<td>57</td>
<td>Pre-Columbian Peruvian (Decid. centrals)</td>
<td>86.0\textsuperscript{2}</td>
<td>Present study</td>
</tr>
<tr>
<td>54</td>
<td>Pre-Columbian Peruvian (Decid. laterals)</td>
<td>85.2\textsuperscript{2}</td>
<td>Present study</td>
</tr>
</tbody>
</table>

* Both sexes included
**All other percentages are for permanent teeth
N = the number of incisors in study
Hanihara\textsuperscript{21} did, that the degree of shovelling is greater in the permanent dentition than in the deciduous.

Carbonell\textsuperscript{19} points out that in 1920, Hrdlička had shown that shovelling generally occurs bilaterally and only very rarely unilaterally. In this study, shovelling was only seen bilaterally, although in one mummy the degree of shovelling was greater on one side than on the other. Carbonell\textsuperscript{19} showed that the frequency of shovelling was greater in the lateral incisor, but also pointed out that the difference was not very significant. In this study, the frequency of shovelling of the lateral incisor was greater in the permanent dentition. However, the 0.6\% difference again is considered insignificant. In view of this noticeable correlation of this morphological character of the central and lateral incisors, it seems quite possible that a common genetic factor is involved.

Morse\textsuperscript{30} and Hrdlička\textsuperscript{10} observed that pronounced shovel-shaped incisors were more frequent in females than in males. In this study, the difference between the sexes as to both the frequency and degree of shovelling was insignificant.

Differences in the frequency and degree of shovelling within racial groups are evident from the study of the differences in frequency of shovel-shaping among the various American-Indian tribes,\textsuperscript{10} in the study of the Chinese from different geographical areas,\textsuperscript{31} and the differences in the observations made by Shaw\textsuperscript{32} and by Carbonell,\textsuperscript{19} studying similar Bantu groups. In our study, differences are seen among the cultural groups as to the frequency and degree of shovelling. Only the Paracas and Colonial cultures vary greatly from the others. This, of course, might be explained by this variation within racial groups, but the possibility of outside racial influences must be entertained especially in the Colonial culture, as this group was influenced by the Spanish conquerors.

In studying the frequency and degree of the shovel character as seen in Tables 5 and 6, it would appear that the group buried at Huayuri expresses this Mongoloid trait to a greater degree than the group buried at Murga. This would be expected since the Murga group includes all of our Colonial culture, the decreased shovel character having already been alluded to in this culture. The Huayuri group is composed of Ica, Huari, and Nazca cultural groups as previously mentioned. In comparing the frequency and degree of expression of the shovel character of these three cultural groups to the Huayuri group as a whole, it is apparent that the Huari, Nazca, and perhaps outside cultural groups have contributed to a greater extent to the high frequency and degree of shovelling in this group.

Kraus\textsuperscript{33} has indicated that a low frequency of expression of Carabelli's cusp coupled with a high frequency of the intermediate expression of this character (pits and furrows) is characteristic of predominate Mongoloid groups. After surveying Tables 3 and 10, it can be seen that this pre-Columbian population does show a low frequency of cusp expression and a higher frequency of expression of the

<table>
<thead>
<tr>
<th>TABLE 10</th>
<th>Incidence of Carabelli's Cusp in Different Populations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed European</td>
<td>Diamond\textsuperscript{14}</td>
</tr>
<tr>
<td>Am. Whites</td>
<td>Dahlberg\textsuperscript{17}</td>
</tr>
<tr>
<td>Am. Army Men</td>
<td>Dietz\textsuperscript{28}</td>
</tr>
<tr>
<td>Japanese</td>
<td>Hirakawa\textsuperscript{26}</td>
</tr>
<tr>
<td>E. Greenland</td>
<td>Pedersen\textsuperscript{13}</td>
</tr>
<tr>
<td>Eskimo</td>
<td></td>
</tr>
<tr>
<td>Diaguitas Indians</td>
<td>Campusano et al.\textsuperscript{29}</td>
</tr>
<tr>
<td>Pima Indians</td>
<td>Dahlberg\textsuperscript{17}</td>
</tr>
<tr>
<td>Contemporary Peruvian Indians</td>
<td>Goaz and Miller\textsuperscript{4}</td>
</tr>
<tr>
<td>Pre-Columbian Peruvian</td>
<td>Present study</td>
</tr>
<tr>
<td>Japanese</td>
<td>Hanihara\textsuperscript{21}</td>
</tr>
<tr>
<td>Am. Whites</td>
<td>Hanihara\textsuperscript{21}</td>
</tr>
</tbody>
</table>

* Based on the number of molars available for study
pits and furrows in the permanent dentition. There is a high frequency of cusp expression in the deciduous dentitions, thus giving rise to the conclusion that outside racial influences were acting on these cultures. The incidence of cusp and pit expression as seen through sequence comparison of the second deciduous maxillary molar, first, second, and third permanent maxillary molars in this pre-Columbian Peruvian population correlates quite well with other Mongoloid populations such as the Pima Indians and the contemporary Peruvian Indians. In this study as in the study of the Alaskan Eskimos by Bang and Hasund, there were no sex differences in the occurrence of Carabelli’s cusp. In examining the data from Murga and Huayuri cemeteries (Table 7), there is a low frequency of expression of Carabelli’s cusp in both groups of permanent dentitions with the Huayuri group having a high frequency of pits. However, both groups show a high frequency of cusp expression in the deciduous dentitions. This again would suggest the influence of Caucasian traits.

Although it has been reported by R. G. Snyder in The Dental Morphology of the Point of Pines Indians, 1959 (unpublished) that the occurrence of the protostylid and Carabelli’s cusp is significantly correlated, Goaz and Miller indicated that in their population of contemporary Peruvian Indians these traits occur independently. In this study of pre-Columbian Peruvians, these characters are independently expressed. Dahlberg stated that the highest incidence of the protostylid occurs in Mongoloid populations. In their 1966 paper, Goaz and Miller showed that the contemporary Peruvian Indians from the Amazon watershed area showed an unusually large number of teeth expressing the protostylid. It can be seen from Table 4 that all the cultures of this pre-Columbian Peruvian population show a high frequency of expression of the protostylid in the permanent dentition with the exception of the Colonial culture. Again outside racial influences appear to effect the incidence of a morphological trait in this culture. Hanihara stated that the deciduous mandibular molars usually have a higher frequency of protostylid than the permanent molars. In this study, 60.0% of the cultures showed a higher frequency of protostylid among the deciduous molars.

Table 11 again gives a clue to the racial origins of the pre-Columbian Peruvians in that the distribution and frequency of protostylid correlates very well with the distributions and frequencies seen in Mongoloid populations such as the Pima Indians and the contemporary Peruvian Indian from the Amazon watershed area. In fact, the frequency of protostylid in this population is among the highest seen. In viewing the frequency of protostylid in the groups from the two cemeteries Table 8 shows that again, as with the Carabelli character, the Huayuri group has characteristics which seem to be influenced by a Caucasian population. In this instance, the protostylid is expressed less than one-half as frequently in the permanent dentition and not at all in the deciduous dentition.

Summary. It is apparent that with a high frequency of shovelling, a low frequency of expression of Carabelli’s cusp, and a high frequency of expression of protostylid that this pre-Columbian Peruvian population is a population of Mongoloid origin.

In viewing the frequency of these three characters in the six cultures, it appears that two of the cultures, the Nazca and Inca, were rather stable as to makeup. Only the high expression of Carabelli’s cusp

### Table 11

<table>
<thead>
<tr>
<th>Population</th>
<th>Author</th>
<th>Sec. Decid.</th>
<th>First Perm.</th>
<th>Incidence (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Molar</td>
<td>Molar</td>
<td>Molar</td>
</tr>
<tr>
<td>Am. White</td>
<td>Dahlberg</td>
<td>15.0*</td>
<td>6.0*</td>
<td>25.5*</td>
</tr>
<tr>
<td>Pima Indian</td>
<td>Dahlberg</td>
<td>60.0*</td>
<td>31.5*</td>
<td>20.0*</td>
</tr>
<tr>
<td>Contemporary Peruvian Indian</td>
<td>Goaz and Miller</td>
<td>44.5</td>
<td>68.2</td>
<td>44.8</td>
</tr>
<tr>
<td>Pre-Columbian Peruvian</td>
<td>Present study</td>
<td>69.2**</td>
<td>66.5**</td>
<td>51.7**</td>
</tr>
<tr>
<td>Am. White</td>
<td>Hanihara</td>
<td>13.0</td>
<td>13.0</td>
<td>13.0</td>
</tr>
<tr>
<td>Japanese</td>
<td>Hanihara</td>
<td>44.7</td>
<td>44.7</td>
<td>44.7</td>
</tr>
<tr>
<td>Negro</td>
<td>Hanihara</td>
<td>17.0</td>
<td>17.0</td>
<td>17.0</td>
</tr>
</tbody>
</table>

* Percentage for male population only; percentage includes those teeth having a distal deviation of the buccal groove and all the various gradations of cusp size

** Based on the number of molars available for study
in the deciduous dentitions of these two cultures distorted the picture of a true Mongoloid as seen in these characters. In both these cultures, this high frequency of expression of Carabelli’s cusp came about as the result of a small sample; only one in the Nazca group and three in the Inca group. It would also appear that the Ica culture and the Colonial culture more especially came under the influence of outside Caucasian groups, which assuredly the Colonial culture did. However, the question can be asked, “Why, if there is an increased Caucasian influence in these cultures, is there not a decreased incidence in protostylid in the deciduous dentitions of these groups to go along with the decreased incidence of shovelling and the increased incidence of Carabelli’s cusp?” Perhaps this can best be answered by noting that in Hanihara’s study\(^{21}\) of the Japanese-American hybrid, the protostylid character along with the shovel character seemed to maintain its high Mongoloid frequency in these hybrids while the Caucasian characteristic of having a high frequency of Carabelli’s cusp seemed to overcome the Mongoloid characteristic of having a low frequency of expression of this character.

REFERENCES


Talon Cusp: A Clinically Significant Anomaly in a Primary Incisor from Pre-Columbian America

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Shafer, Hine, and Levy\(^1\) describe the talon cusp, a structure resembling an eagle’s talon, as a cusp projecting lingually from the cingulum area of a maxillary or mandibular permanent incisor. This cusp blends smoothly with the tooth except that there is a deep developmental groove where the cusp blends with the sloping lingual tooth surface. The cusp is composed of normal enamel and dentin and contains a horn of pulp tissue.

As reported by Mellor and Ripa\(^2\) in 1970, W.H. Mitchell\(^3\) presented a case history of a patient with a “... process of hornlike shape ...” protruding from the lingual surface. This 1892 report was one of the earliest references to the dental anomaly known as talon cusp.

Mellor and Ripa emphasized that this anomaly usually requires definitive treatment as it often poses

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Fig 1—Radiograph shows the extended cingulum forming the lingual cusp. Note resorption of root by its permanent successor.
Fig 2—Radiograph shows the extended cingulum forming the lingual cusp from a buccal-lingual view. Note presence of caries.

problems for the patient in terms of esthetics, caries control, and occlusal accommodation.

Mellor and Ripa also emphasized that this anomaly has been reported in permanent teeth only. The case being reported in this paper is that of a talon cusp appearing in a primary left maxillary central incisor in an individual from the Paracas culture, living approximately 2200 years ago in southern Peru. The tooth is from a mummy who died between the ages of 5 and 6 years.

Fig 3—Talon cusp from an occlusal view. Note attrition on the lingual cusp.

Fig 4—Lateral view of the talon cusp showing resorption on the root from its permanent successor.

It has been suggested by both Pindborg and by Schulze that the talon cusp may be the result of a fusion of teeth. If this is so, then this particular talon cusp would have to be the result of a fusion of the involved central incisor and a supernumerary tooth, perhaps a mesiodens, as the normal number of teeth were present. Indeed all the other primary incisors and all the permanent (unerupted) incisors were present and none of them presented any signs of a talon cusp.

The talon cusp or T-shaped incisor has been reported by Kraus, et al, by Jordan, et al, and by Schroeder and Green as occurring, although quite infrequently, in association with individuals with cleft lip and/or cleft palate. Although the deciduous teeth were studied by these authors, no reference was made to finding a talon cusp or T-shaped incisor. In our case, the mummy did not exhibit any bony cleft and it was impossible to see a soft tissue cleft as the area was devoid of soft tissue.

The clinical problems alluded to by Mellor and Ripa of esthetics and caries are self-evident in our case from the radiographs (Figures 1 and 2) and the photographs (Figures 3 and 4). The problem of occlusal accommodation is evident only from the de-
gree of attrition seen on the cusp as the mandible could not be recovered for an occlusal analysis.

Summary. The significance of this case report is primarily that for the first time the dental anomaly of the talon cusp is reported in the primary as well as in the permanent incisors; it is the earliest recorded case of a talon cusp. The fact that this anomaly appeared in the primary dentition without affecting the permanent dentition is also significant. As can be seen from this report, the clinical problems of esthetics, occlusal accommodation, and caries control require early diagnosis and clinical management. The talon cusp is an uncommon anomaly which has appeared for centuries in the primary as well as in the permanent dentition.

REFERENCES


Paleoserologic Studies: ABO and Histocompatibility Antigens in Mummified American Indians

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The first genetic polymorphism to be described in man was the ABO blood group system. This system proved to be present as a membrane antigen of the cells of almost all organs of the body. In this it not only simulates histocompatibility antigens but also helps to determine ABO compatibility between organ recipients and their donors. The presence of the ABH and HL-A antigens in tissues and their stability on storage allows typing mummified bodies despite the passage of thousands of years.

The possibility that the ABO blood groups might be associated with diseases and subject to natural selection was considered soon after their discovery by Landsteiner, while the Herszfelds were the first to use the ABO blood groups as markers for studying ethnic differences as an aid to the study of evolution. Since retrospective paleoserologic studies of human populations using their remains are possible only when ABO groups are present on tissue cells of the organs, the discovery of the HL-A antigens was a welcome additional means of studies in mummies. This is mainly because the HL-A system proved to be the most highly polymorphic antigen system in man—a most helpful characteristic in studies of natural selection and evolution in human populations.

The paleoserologic studies reported here have been carried out to determine the frequency and distribution of the ABO and HL-A antigens in mummified bodies belonging to various cultural groups. The information is useful in the study of evolution of the American Indians.

Materials and Methods.

Mummified Tissue Samples. One hundred and eleven samples consisting of fragments of muscles from various parts of the bodies of mummies, but mainly from the psoas area, were tested; the mummies were obtained from known cemeteries which were excavated scientifically by archeologists and were dated by 14C in 20 cases. The mummies were placed in four groups: (a) the pre-Columbian, pre-Ceramic, (b) the pre-Columbian, Ceramic, (c) Chilean Colonials, and (d) Peruvian Colonials; the pre-Columbian mummies were further divided into the cultural groups: Paracas, Nazca, Huari, Inca, and Ica.

ABO Grouping Sera and Cells
The standard agglutination-inhibition technique was applied to determine the presence or absence of the A and B antigens or both in the mummified tissues. This has been previously described in detail.1

HL-A Typing
The lymphocytotoxicity-inhibition test was used to type the mummies. The procedure employed by Stastny8 was followed with some modifications.

The tests were performed on 109 of the samples only. Insufficient material prevented typing two of the tissues which belonged to the Ceramic group.

The tissues were typed for the following anti-

**Materials.**

3. **Tris-NH₄Cl.** Mix 1 part Tris Buffer (a) in 9 parts NH₄Cl (b).
   a. **Tris Buffer.** #T-1503 Trismat Base. Sigma Chemical Company, P.O. Box 14508, St. Louis, Mo. 63178.
      Use: 20.6 gm Tris/1000 cc distilled water. Make up a flask 1/2 to 3/4 volume and adjust pH with concentrated HCl to pH 7.2 to 7.4 (starting pH will be about pH 11.00). Do at room temperature. Transfer to volumetric flask and add distilled water to desired volume.
   b. **Amonium chloride.** Use 0.83 gm NH₄Cl/100 cc distilled water.
4. a. **Nylon.** E. I. DuPont de Nemours Company, Wilmington, Del. 19801. #67030 100% Nylon, staple, semi-dull, 1 to 1/2 inch length, 3 denier, type 200.
   b. **Dupanol.** #241900, Dupanol RA. Liquid 1–356. E. I. DuPont de Nemours Company, P.O. Box 1909, Charlotte, N.C. 28201.
      Use: heat to 65°C to 70°C for 30 minutes the following: 200 gm nylon, 4 liter water, and 20 cc dupanol. Stir continually to prevent scorching. Rinse overnight in tap water. Rinse thoroughly in distilled water seven or eight times. Let air dry. Comb and brush nylon to make fibers separate. Weigh out 0.7 gm of combed nylon and pack firmly into a small pasteur pipette. Cap with small rubber serum stopper.
   c. **Serum Stoppers.** #8826 small rubber serum stopper. 5 X 9 mm EDP No. 8753-D22. Arthur H. Thomas Co., P.O. Box 779, Philadelphia, Pa. 19105.
5. **Trypan Blue.** #TX 1580. General Scientific Corp., P.O. Box 2V, Richmond, Va. 23205. Use: 1 gm/100 ml distilled water, filtered = 1% stock solution. For daily use: dilute 3 ml of 1% stock solution with 7 ml of 2% EDTA solution = 0.3% Trypan (occasional filtration of stock solution is needed).
6. **EDTA.** #1-8993 Disodium EDTA, Dihydrate VWR. P.O. Box 5195, Baltimore, Md. 21203.
7. **Microplates (60 well plates) #3034 Falcon Microtest plates.** Arthur H. Thomas Co., P.O. Box 779, Philadelphia, Pa. 19105.
8. **Rabbit Complement.** Grand Island Biological Co., 3175 Staley Road, Grand Island, N.Y. 14072.
    Use: Hypaque 37.77% (with 0.1% Na Azide). Make up 1000 ml in vol. flask. Take 755.4 ml of 50% Hypaque and add 1 ml of 10% Na Azide. Top up to 1 liter with distilled water and mix thoroughly with magnetic stirrer.
11. **Ficoll.** #F-4375 Sigma Chemical Co., P.O. Box 14508, St. Louis, Mo. 63178.
    Use: Ficoll 9% (wt/vol) (with 0.1% Na Azide). Make up 3000 ml in vol. flasks. In 3000 ml flask put 270 gm Ficoll, 3 ml of 10% Na Azide, top up to 3 liters with distilled water. Mix 1/2 hour with magnetic stirrer.
12. **Ficoll-Hypaque.** Take 1 part Hypaque 37.77% (50 ml) with 3 parts Ficoll 9% (1500 ml). Mix one hour, check and adjust density with hydrometer in a 250 ml graduated cylinder [optical density (O.D.) 1.077 to 1.079]. Store in dark bottles and refrigerate.
13. **Membrane Dializer.** Union Carbide Corporation, Food Products Division, 6733 West 65th Street, Chicago, Ill. 60638.
14. **Albumin Stock Solution.** Stock No. 905-10. Sigma Chemical Co., P.O. Box 14508, St. Louis, Mo. 63178.
18. Solution A. 20 gm Na₂CO₃, 4.0 gm NaOH, 0.2 gm Na, K, tartrates, Dilute to 1 liter with distilled water.
19. Solution B. 5 gm CuSO₄, 5 H₂O. Dilute 1 liter with distilled water.
21. Panel of H L-A antigens prepared from donors at the Department of Surgery, Medical College of Virginia, Richmond, Va.

Methods.

A. Cell Preparation.

1. Collect 10 cc of heparinized blood (25 units hep/ml blood) and pass it through a column containing 0.5 to 1.0 gm of nylon into 10 ml test tube. Then wash the column with barbital buffer for maximum cell yield. Addition of blood and washing are performed at room temperature.
2. Add an equal volume of barbital buffer and mix, leaving enough room in tube for the addition of 2 to 3 ml of Ficoll-Hypaque.
3. Layer cells over 2 to 3 ml of Ficoll-Hypaque.
4. Centrifuge at 2800 rpm for 15 to 20 minutes using International Centrifuge.
5. With pipette remove lymphocytes from the interface between the blood plasma and Ficoll-Hypaque, place in a 10 × 75 mm tube, then wash cells with barbital buffer in a table centrifuge spinning at 1400 rpm for six minutes.
6. Remove any red blood cells by adding warm Tris-NH₄Cl for five minutes. Spin cells at 1000 rpm for six minutes.
7. Reconstitute cells in McCoy's media with 5% fetal calf serum to 2 million cells per ml and store at 4 C. These cells are usable after a maximum of four days of storage.
8. Test for cell viability by addition of a small amount of 1% Trypan blue in 0.5 cc of cell suspension and look for blue cells (dead cells) under the microscope. This procedure should be done at the time of testing. If cell viability is less than 90% to 95%, discard the cell suspension.

B. Preparation of Mummy Extracts.

1. Press the mummy tissue through a stainless steel sieve to obtain a fine powder.
2. Extract 2 gm of tissue powder twice in 10 cc saline with constant stirring at 37 C for 30 minutes.
3. Combine with two extracts and transfer them to a dialysis membrane tube. Immerse the membrane in 4 C distilled water overnight.
4. Use the dialized fluid, rich in protein, for protein determination as follows:
   a. Prepare standards (three each) containing 200 mg, 500 mg, and 1000 mg of Bovine Serum Albumin.
   b. Prepare two 0.1 ml aliquotes of each tissue extract.
   c. Bring volume of all tubes (standard and samples) to 1.0 ml using distilled water.
   d. Prepare solution C by mixing 50 parts of solution A to 1 part of solution B (see Materials for solutions A and B.).
   e. Add 5 ml of solution C to each tube.
   f. Prepare Folin Howerey reagent (Folin-Ciocalteu) by adding 5 ml phenol reagent 2N solution to 7 ml distilled water.
   g. Quickly add 0.6 ml of reagent to each tube and shake vigorously.
   h. Read at 420 mµ after 30 minutes, using spectrophotometer.
   i. Plot optical density (O.D.) vs concentration.
   j. Blank contains 1 ml H₂O, 5 ml solution C, and 0.6 ml phenol reagent.
5. Each sample is then freeze-dried and dissolved in Dulbecco's Modified Eagle Modified media.

C. Lymphocytotoxicity Inhibition Procedure.

1. Prepare a stock solution containing 24 mg mummy protein/ml. This stock solution is then used to prepare three working solutions, containing 6, 12, and 18 mg/ml respectively.
2. Titrate the antisera to be used using lymphocytes known to carry the corresponding HL-A antigens to determine the endpoint
which is to be used as the working antiserum.

3. Add 1 lambda of antiserum and 1 lambda of mummy tissue extract with protein concentrations of 18, 12, and 6 mg/ml into separate wells of the Falcon with a Hamilton syringe. The mixture is incubated for one hour at 22 C and then incubated overnight at 4 C.

4. Next day, 1 lambda of cell suspension is added to the above mixture and left to incubate at room temperature for 30 minutes. (Use a thin wire to mix volumes not mixed in the cell dispensing process).

5. The wells are then filled with barbital buffer, using a thinly drawn Pasteur pipette, and allowed to settle for ten minutes. Remove buffer by flicking the plate with a quick motion of the wrist.

6. Five lambda of rabbit complement which is previously titered are then added to each well. Make sure volumes are mixed. Plates are incubated at room temperature for one hour.

7. The complement must be removed by flicking the plates before staining the cell for testing. Using a thinly drawn Pasteur pipette, fill each well with a drop of trypan blue in EDTA. Let stand for ten minutes to allow cells to settle. Flick well once.

8. The wells are filled with barbital buffer and allowed to settle ten minutes.

9. Add cover glass. Read.

10. The determinations are made by placing the plate under an inverted phase microscope at 150× (10× objectives, 15× ocular) and judging the percentage of inhibition using the following formula:

\[
\text{% inhibition} = \frac{\text{% cell killed in presence of inhibitor}}{\text{% cell killed in absence of inhibitor}} \times 100
\]

11. The following controls were added to each test system, which consisted of target lymphocytes incubated with:
   a. antiserum without mummy antigen.
   b. with antiserum and mummy antigen, but without complement.
   c. with complement alone.
   d. with mummy antigen alone.

   All test and controls should be made in duplicate.

12. If percentage inhibition is low or absent, the amount of protein concentration should be increased for a higher percentage inhibition (protein concentration in mummy tissue extracts does not represent antigen concentra-

Table 1

<table>
<thead>
<tr>
<th>Populations</th>
<th>Number Tested</th>
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<th>B</th>
<th>AB</th>
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* Number tested not given
Table 2

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<th>Number/Percent of HL-A Antigens Detected</th>
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<td>Peruvian</td>
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<td>16/35.56</td>
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Results.

ABO Typing

The results of testing the 111 mummies by the agglutination-inhibition technique are given in Table 1 as a percentage distribution of the ABO groups among the four groups to which the mummies belonged. For comparison purposes, we have included in this table the percentage distribution of the ABO groups in seven contemporary American Indian groups.

HL-A Typing

Table 2 shows the number of mummies in each group that gave positive tests for 0, 1, 2, 3 or 4 HL-A antigens. Positive results for at least one histocompatibility antigen were obtained in 75 (68.8%) of the 109 mummies tested for 16 HL-A antigens. All samples from the pre-Ceramic group, which were the oldest to be tested, showed positive reactions with one or more of the 16 HL-A antisera employed. However, 12 of the 38 pre-Columbian Ceramic, 6 of the 18 Colonial Peruvian, and 16 of the 45 Colonial Chilean groups showed none of the 16 antigens for which they were tested. Thus 31.2% of the mummies were nonreactive.

The amount of tissue needed to neutralize an HL-A antiserum varied from mummy to mummy. Only 6 mg/ml of antigen from certain mummies were needed to completely inhibit a certain antiserum while other mummies were able to do so only with the highest concentration of the antigen (24 mg/ml). None of the powders surrounding mummies produced a positive inhibition test.

The percentage distribution of the HL-A antigens in the 75 positive mummies is given in Table 3. The reported percentage distribution of these antigens in seven contemporary American Indian tribes is given in Table 4 for comparison purposes.
Table 4

Frequency in Percent of 16 Antigens in Seven American Indian Tribes, Eskimos, Easter Islanders and Caucasians

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**Discussion.**

There are several basic types of population studies using genetic markers, one of which makes use of differences in gene frequencies to assess the relationships between populations and so to trace phylogeny. It is generally agreed that the use of gene frequencies for well-defined polymorphic genetic markers provides the only satisfactory approach to the study of evolutionary relationships between populations. The more closely related are two populations, the more similar their gene frequencies are expected to be. The frequencies detailed in this study allow us to make conclusions as to the evolution and possibly the migration of the ancient Indian tribes.

Determination of the ABO blood groups and HL-A types and their distribution in various ethnic populations have been the subjects of many reports. However, similar studies on mummified populations are scarce and they were made on small samples compared to the number examined in this report.

The presence of the B and A antigens in the Paracas Indians of the oldest pre-Columbian Ceramic group has been reported by Boyd. However, as indicated in Table 1, with time the pre-Columbian Indians began to lose the B gene resulting in almost complete absence of the antigen in the more recent populations such as the Peruvian and Chilean Colonial descendents of these people. Boyd suggested that the group B might have been eliminated by natural selection. Earlier studies from our laboratories in which the mummies were grouped according to geographic area tended to support this postulate, as it showed a gradual decline in frequency and concomitant increase in the proportion of group O as one moves south from the provinces of Nazca and Pisco in the Department of Ica in Peru to Chile.

In all cultural groups originating in various excavation sites some extracts were reactive. Unexpectedly, 100% of the specimens from the pre-Ceramic group (the oldest, about 2500 BC) were reactive, while the more recent Ceramic and Colonials showed varying degrees of nonreactivity. However, this might have been due to the small sample of the pre-Ceramic group.

The absence of detectable HL-A antigens in 31.2% of the mummies is probably related to denaturation of the antigens, because of poor preservation. On the other hand, it may be partly related to the failure to use antisera with additional specificities; another contributory factor is the presence of histocompatibility antigens yet to be discovered. These factors and homozygosity could be the reasons underlying the detection of less than four antigens in some of the remaining 68.8%.

The reaction of those mummies that showed more than one antigen was in concordance with the rules of inheritance of the antigens of the first and second segregant HL-A alleles. In other words, at no time was there inheritance of more than two antigens of either series of alleles.

As in the case of ABO, there is a fair similarity in the frequency of the HL-A antigens in the mummified prehistoric and in the contemporary American Indian populations. Like Stastny, we found HL-A1, HL-A3, HL-A7, HL-A8, and HL-A12 either absent or of low incidence (4% or less) in the pre-Columbian
mummies. In addition, we found W14 to be absent in all mummies tested. This distribution pattern is similar to that found among contemporary North and South American Indians as well as in Eskimos. In contrast, with the exception of W14, Europeans have a significantly higher incidence of these antigens. In fact, some of these antigens, for example, HL-A1 and HL-A8, have been shown to occur almost exclusively in Europeans. The similarity between pre-Columbian and present-day Indians in contrast to Europeans can also be seen from the relatively higher incidence of HL-A2, HL-A5, W19, and W28 in the Indian groups compared to Europeans. These results are also in agreement with those of Stastny. Furthermore, like most contemporary American Indians, HL-A11 was absent in all but 12% of the pre-Ceramic group. The Huacho group thus has an HL-A11 distribution similar to that of the Ixil Indians in whom the antigen is present in 10%. In Europeans, the frequency is similar (11%), while it is prevalent among the Easter Islanders (47%). Significant dissimilarities between ancient and contemporary Indians include the much higher distribution of W15 among the Warao, Quechua, and Aymara tribes (34% to 71%) than in the mummies in which only 8% had the antigen. There were also differences in the distribution of some antigens between the pre-Ceramic and the Ceramic and Colonials. HL-A11, HL-A13, W17, and W19 were present in much higher frequency in the pre-Ceramic than in the Ceramic group. The frequency of most antigens in the Chilean and Peruvian Colonials was similar. However, HL-A12 was significantly higher in Chilean (25%) than in Peruvian Colonials (7%), while HL-A13 was absent in the former, but present in 10% of the latter group. Unlike Stastny, we did not find HL-A9 to be of a higher frequency in the mummies than in the Europeans.

Summary.

One hundred and eleven mummies were ABO typed by the antibody absorption test. The mummies belonged to the pre-Columbian pre-Ceramic, the pre-Columbian Ceramic, the Colonial Peruvian, and the Colonial Chilean cultural groups. The frequency of the A, B, AB, and O blood groups was found to be similar to that among contemporary American Indians. Although the B and AB groups were found among early pre-Columbian Indians, the B antigen became almost extinct in the Colonial mummies. The group O constituted the majority among all Indians (pre-Columbians and Colonials). There was suggestive evidence that with time the pre-Columbian Indians began to lose the B gene resulting in complete absence of the antigen in more recent Indian populations. Of the 111 mummies, 109 were typed for 16 HL-A antigens using a modified lymphocytotoxicity-inhibition technique. Analogous similarities between the distribution of several HL-A antigens were found between the mummies and contemporary American Indians. HL-A1 and HL-A7 were absent in all mummies and HL-8 and HL-A11 present in low frequency only in the Ceramic and pre-Ceramic groups, respectively. Frequencies significantly higher than in Caucasians were found for HL-A2, W19, and W28 in all but the Chilean Colonial mummies. These antigens are also of relatively high frequency among most contemporary American Indians.

REFERENCES


Treatment of Head Wounds in Pre-Columbian and Colonial Peru

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ALEJANDRO PEZZIA, PH.D.

Curator, Regional Museum of Ica, Ica, Peru

As is frequently the case, art objects often depict the life in a particular civilization, thus giving a visual record of a people where the people themselves have disappeared. Peru is one of the areas of the world where art depicts the life of the people while the people themselves are present in the form of mummies to confirm much of what is seen in art. A number of ceramic vessels have been found depicting one man working on the skull of another with a knife. That such actions were possibly surgical was documented in 1865 when Squier was given a skull with a trephined opening made during life. Continued documentation of such operations has been reported in the literature, but the best studies are in Spanish. This paper is a study of the material existing in the Regional Museum of Ica, Ica, Peru, and a review of selected authors' interpretations of these operations.

Materials and Methods. The material used was from 288 individuals of a known cultural association and cemetery, from the Regional Museum of Ica, Ica, Peru. The skulls were examined visually and, where deemed necessary, by x-ray as well.

Results. Thirty-nine of the 288 skulls showed recent fractures due to trauma and five of these had visible evidence of additional long-healed fractures untreated surgically. Six skulls without fractures had evidence of some type of bone disease unrelated to trauma.

Twenty-four skulls had been trephined or treated surgically by cutting or scraping. Thirteen of these skulls showed clear evidence that the surgery was due to fracture and one that it was due to disease. Ten skulls had evidence of surgery with no clear evidence remaining for the cause of the surgery.

Table 1 gives the cultural distribution of the material, the pathology when evident, and the surgical treatment. The Paracas culture had six out of eight individuals with an obvious reason for the skull surgery. The Nazca culture had only four out of nine individuals with reasons for the surgery. While the number of skulls was similar to the early Paracas and Nazca cultures, the frequency of surgical operations was reduced in the later Huari and Ica cultures, and among the Inca skulls in this collection no surgery was seen.

The surgical techniques used are listed in Table 2. The circular cutting technique illustrated in Figure 1 was the most common technique used in the earliest cultural group (Paracas). This technique was also used by the later Huari and Ica cultures. The operation had a 50% survival rate, but one survivor had developed osteitis and died before healing occurred. The scraping technique seen in Figure 2 was used in

Supported by a grant from the National Geographic Society. Correspondence and reprint requests to: Dr. Marvin J. Allison, Department of Pathology, Medical College of Virginia, Box 696, Richmond, Virginia 23298
Table 1
Cultural Material Used and Its Pathology and Treatment

<table>
<thead>
<tr>
<th>Culture</th>
<th>No.</th>
<th>Total</th>
<th>Surgically Treated</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paracas</td>
<td>60</td>
<td>10</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Nazca</td>
<td>41</td>
<td>7</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Huari</td>
<td>67</td>
<td>9</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Ica</td>
<td>66</td>
<td>6</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Inca</td>
<td>54</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>288</td>
<td>39</td>
<td>13</td>
<td>6</td>
</tr>
</tbody>
</table>

The Paracas culture with no deaths in two individuals who had been treated. It was more commonly seen in the Nazca culture, where again survival (four out of five) was good, and was noted later in the Ica culture. The nine operations performed using the scraping technique had an overall survival rate of 78%, and this was deemed to be the best technique. There was one case of post-operative osteitis in this group and the individual died before the wound healed. There was also some type of bone disease treated by multiple scraping over an undetermined period of time (Fig 3). The crosscut sawing surgical technique shown in Figure 4 was most common in the Nazca culture, but there was only one survivor out of the four individuals examined, and this survivor of the surgery developed osteitis and died. The same is true of the Huari survivor illustrated in Figure 5. The original trephination for a fracture is on top of the head. Apparently, osteitis developed and a second operation was performed at the left temporal area, probably related with a large pocket of pus. This second operation resulted in almost instantaneous death, as no sign of healing is seen and a large fragment of bone apparently came out with the operation plug, producing a hemorrhage from the middle meningeal artery.

The drilling technique was seen in only two individuals from the Huari culture (Fig 6) and both of these individuals died during or shortly after surgery.

The most common bones trephined were parietais, frontal, occipital, and temporal in that order. The frontal bone operations generally removed less bone, but resulted in the poorest survival. Survival might have been related to the amount of bone removed, but using the circular cut technique, survival occurred with the removal of a 3-inch diameter plug of bone (Fig 7), so size is obviously not the only factor.

Discussion. More trephinations have been done in ancient Peru than in all of the rest of the ancient world combined. The suggested reasons for this type of surgery are numerous—trauma, disease, epilepsy, headache, and ritual to name a few; but whatever the reason such operations, considered serious and dangerous in most parts of the world, were quite commonplace in Peru. The present study contains all of the surgical techniques known. Over half of the cases still showed evidence of the underlying disease for which the operation was performed, and the recovery and low infection rate were better than might be expected for surgery done under such conditions even in modern times.

Table 2
Surgical Techniques and Survival for at Least 6-8 Weeks

<table>
<thead>
<tr>
<th>Culture</th>
<th>Circular</th>
<th>Scrapping</th>
<th>Crosscut Sawing</th>
<th>Drilling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lived</td>
<td>Died</td>
<td>Lived</td>
<td>Died</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lived</td>
<td>Died</td>
</tr>
<tr>
<td>Paracas</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Nazca</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Huari</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ica</td>
<td>1</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>4</td>
<td>4</td>
<td>7</td>
<td>2</td>
</tr>
</tbody>
</table>
surgery. Head lesions in these groups were also more common. The Huari culture had only half as many individuals who had undergone surgery, and the Ica culture even less than any other group. No individuals from the Inca culture or the colonial period had had surgery in this series. It is of interest that in the Paracas, Nazca, Huari, and Ica cultures, the surgery was associated at least in part with disease or fracture of the skull. Surgery of Inca skulls may be seen in the Regional Museum of Cuzco and is reported in the literature on the basis of cemetery location and skull deformity, but most earlier investigators neglect to mention the cultural groups providing the material. This major drawback of many earlier studies is a result of using material from random surface finds or obtained from grave robbers.\textsuperscript{8,9} In order to have good documentation of cultural association, material must be excavated scientifically, as a single cemetery may have a mixture of two or more cultures.

This study included material illustrative of all four techniques—circular cutting, scraping, crosscut

The amount of material in the Regional Museum of Ica examined for trephinations was about the same in all of the cultural groups; yet the earlier cultural groups (Paracas and Nazca) had the most

Fig 1—Large trephined opening illustrates the circular cutting technique (top). Type of instrument used is the obsidian blade (bottom).

Fig 2—Small irregular opening seen at center made by scraping with an obsidian blade.
Fig 3—While most skull surgery was associated with trauma, some was done for disease. This skull was scraped at different intervals over a long time period.

Fig 4—The crosscut sawing technique done in the temple region resulted in almost immediate death, possibly due to rupture of the middle meningeal artery. The bone had extensive osteitis due to a previous trephination and fractured when the cut section was pried out.

Fig 5—The crosscut opening made at center of skull was related to trauma. Unfortunately, infection developed and the patient died.

sawing, and drilling. The Paracas culture (600 BC–100 AD) used primarily the circular cutting technique, one that gave a more or less round piece of bone. Some authors have suggested that this method was used initially to collect bone discs from dead men’s skulls, to be used as talismans, and that from this practice surgery of the living developed. Such a theory is questionable, as circular cutting is concurrent with that of scraping where no disc of bone is removed. It is more logical to think of skull surgery as originating from removing splinters of bone from a wound and scraping the bone smooth as a form of debridement to promote healing. During the colonial period, this form of skull surgery was described on several occasions, but no evidence of trephining has been found in the early colonial material; the present study had no trephining in the Inca culture, although we know that it was practiced by the Incas in other localities. The crosscut technique was first seen in the Nazca culture (100 BC–800 AD), essentially a coastal
one, that followed the Paracas culture. In the last 200 years of the Nazca culture, there was evidence of close contact with the mountain culture originating around Lake Titicaca. This mountain culture eventually developed into the Huari culture, and around 800 AD their warriors overran the coast and northern mountains, forming an empire. It is possible that the Nazca skulls exhibiting the crosscut technique were from individuals of the late Nazca period, since they are from a highland location rather than a coastal one and this technique is thought to be of mountain origin as is the rare drilling technique. The Huari culture (800 AD–1200 AD) has examples only of the crosscut and drilling techniques. The Ica culture (1200 AD–1450 AD) which followed upon the dissolution of the Huari empire used only the circular and scraping techniques.

Details of methodology are scant, but speculations abound as to anesthesia, suturing, use of protective plates, and other practices. One protective plate of gold over the operative site was reported by Tello, and several reports about the use of pieces of gourd are to be found in the literature. Bandages were known and one made with the equivalent of fine surgical gauze was found in place on a head wound of unknown type. Tourniquet-type cords were also reported, but whether they were used to control bleeding is not certain. Cauterization of wounds was practiced, but again its purpose is unknown. Closure of the skin flap by sutures was performed. Thus, it is possible to form some picture of operative practices, but we are left in the dark concerning the use, if any, of anesthesia and the medical treatment of the healing wound. Most evidence points to the fact that the majority of surgical wounds did not become infected and that successful recovery was probably as good as could be expected in traumatic head wounds even today. In European medicine, trephination of the skull in the 18th century had reached a point of nearly 100% fatality and was discontinued. Some writers would like us to believe that antiseptics were used in Peruvian cultures, based on the supposed use of Peru balsam, tanin, saponins, and “acide cinnamique” in embalmings of the dead. Unfortunately, studies of material from all major cultures in the Regional Museum of Ica fail to show any such materials used in embalming. At best, the occasional mummy will have a red or black face paint consisting of a heavy metal salt. Such material is not found on other parts of the body. The lack of infections is probably due to absence of virulent, wound-adapted agents. This may be due to the absence of hospitals or other institutions which serve to transfer these agents and the absence of a type of warfare that would encourage active

Fig 6—Use of the drilling technique for an unknown reason. Note hole at left was not finished.

Fig 7—This healed lesion made by the circular cutting technique had a very large plug of bone removed.
battlefield surgery with its resulting transfer of bacteria from one patient to another. It would appear that wound infection problems in Europe are fairly recent, dating from the era of the Napoleonic wars.\textsuperscript{11}

A further area of discussion noted in the literature is the problem of judging the length of survival. The healing of trephinations can be recognized by a smoothing over of the cut surface, but the time and steps in this process are not clearly described. It has been reported that modern trephined openings in the skull have had complete closure with restoration of the cranial vault,\textsuperscript{12} yet other writers claim that little or no callus is formed and the wounds remain open. Furstenburg\textsuperscript{12} suggests that closure is stimulated by deposit of bone debris on the dura; if this is true, scraping and sawing techniques should provide enough bone debris to stimulate closure in small wounds. Lastres and Cabrieses\textsuperscript{3} outline the steps in healing as seen grossly on dried bone:

1. No sign of a biological reaction means almost immediate death.
2. A discrete ring of superficial osteoporosis around the wound appears from one to four weeks.
3. Destruction of necrotic bone around the edge of the wound due to osteolysis with separation of irregular fragments and sequestrum formation occurs. These tend to fall off and be lost during the preparation and cleaning of the skull for examination in the museum.
4. The edge of the wound reaches an equilibrium and calcium is deposited. New bone forms radial striations and eventually the edge consolidates. This latter reaction, together with 3, does not take place before a number of months have elapsed.

These repair processes are influenced by many factors including the condition of local tissues, topical therapy, infection, and if infection occurs, the etiological agent and often the immunological reactions. Thus it is very difficult to put a time sequence on the healing of a given lesion due to the long list of unknown factors in any given paleopathological specimen.

We would like to see a review on a cultural basis of all documented material with attention being given to all aspects of skull surgery and its sequelae. We feel that such studies might be most informative in tracing the development of this interesting operative technique among primitive peoples.

REFERENCES

SCRIPTA MEDICA
Hyperviscosity Syndrome: Natural History in a Patient with Sjögren's Syndrome

MARION WALLER, PH.D., WILLIAM EDWARDS, M.D., FRANKLIN MULLINAX, M.D., A. JEANNE HYMES, PH.D., AND NELLIE CURRY

Division of Immunology and Connective Tissue Diseases, Department of Medicine, Medical College of Virginia, Health Sciences Division of Virginia Commonwealth University, Richmond, Virginia

Serum protein abnormalities can be responsible for elevations of serum viscosity. When clinical disease results, this condition is termed hyperviscosity syndrome. Immunoglobulin complexes are a prominent cause of this syndrome. The acute illness in a patient with Sjögren's syndrome, IgG-IgG complexes, and serum hyperviscosity was described in a previous report. After subsequent five-year follow-up, it has become apparent that the acute hyperviscosity syndrome in this patient was but one phase of a prolonged, perhaps life-long, illness. This five-year follow-up, which included observation of the effects of steroid therapy on the underlying disease process, is the subject of this report.

Materials and Methods. Serum relative viscosity was determined by the method of Fahey, Barth, and Solomon, using freshly obtained serum at 37°C in an Oswald viscometer (Induchem Glass Co., Vineland, N. J.) of 5 ml capacity. Total protein concentration of serum was determined by the biuret technique. Serum protein electrophoresis was done on cellulose acetate strips in the Beckman Microzone Cell, Model R 101 (Beckman Instruments, Inc., Fullerton, Ca.). These measurements along with the serum electrophoresis were used to calculate the gamma globulin in grams per hundred milliliters. Rheumatoid factor titers were determined by the sensitized human cell test as previously described.

Sedimentation patterns of serum proteins were determined with a Beckman Spinco Model E analytical ultracentrifuge equipped with electronic speed control, rotor temperature indicator control, and schlieren optics. Sera were diluted 1:4 with PBS (0.13M sodium chloride, 0.02M sodium phosphate, pH 7.4) and dialyzed against PBS overnight. Runs were performed with standard and wedge double sector cells at 20°C and 60,000 rpm and photographs were taken at 32 and 64 minutes after operating speed was reached.

Case Report. The patient, a 56-year-old black woman, has been seen repeatedly at the Medical College of Virginia Hospitals during the past 49 years (Table 1). She presented first in 1927 because of abdominal pain and vaginitis which were apparently attributable to gonorrhea. In 1934, she was treated for secondary syphilis manifested by rash, condylomata, and a 4+ Wasserman reaction, although previously the Wasserman test had been negative; she has remained sero-fast. Alopecia developed in 1956 and chest pains, myalgias, and arthralgias were her main complaints in 1963. These unexplained pains recurred in 1964 and in 1965. In 1966, after a four-month period of chest pain, an infiltrate in the left lower lobe of the lung was detected by x-ray; the white blood count was then 3500/mm³. The pneumonic process, thought to be a viral pneumonia, subsided uneventfully.

The patient was referred to the Arthritis Clinic in 1967 because of a five-month history of morning
stiffness and persistent hand, shoulder, ankle, and foot pain. There was obvious synovial thickening; a rheumatoid factor test (sensitized human cell test) was positive with a titer of 1:640, an antinuclear antibody (ANA) test was weakly positive, and lupus erythematosus cell tests were negative. A diagnosis of definite rheumatoid arthritis by American Rheumatism Association criteria was made. In 1968, Sjögren's syndrome evolved with dryness of the eyes and mouth, parotid gland enlargement, progression of arthritis, and a positive Schirmer's test. At that time, the serum total protein was 8.0 gm% with 19.7% gamma globulin.

Vertigo and recurrent nosebleed first occurred in 1969 when the total serum protein was 11.2 gm%. Hyperviscosity was first suspected and detected in May, 1970, when headaches, blurred vision, further nosebleeds, exertional dyspnea, and paroxysmal nocturnal dyspnea occurred. The course of the acute hyperviscosity syndrome associated with polyclonal gammopathy, IgG-IgG complexes, and extraordinary titers of rheumatoid factors was presented in the earlier report. Since 1971, the hyperviscosity syndrome has not recurred, but the clinical problems of underlying connective tissue disease, recurrent infections, and steroid-induced complications including septic necrosis of the femoral heads have remained.

**Results.** Throughout the five-year period from 1970 to 1975, there has been a remarkable correlation between gamma globulin levels, rheumatoid factor titers, serum viscosity, and ultracentrifuge patterns (Fig 1, Fig 2A and 2B). When globulin levels are high, rheumatoid factor titers and serum viscosity are also elevated, and intermediate complexes become more prominent in the analytical ultracentrifuge patterns. Despite these parallel changes, it is apparent that the hyperviscosity has not been a clinical problem in the past four years. During this later period, the highest recorded relative viscosity was 2.7, a value not associated with hyperviscosity symptoms.

Management of this patient's illness has been difficult. In the first phase of therapy, cyclophosphamide and penicillamine produced no apparent benefit. Since January, 1971, prednisone has been the only immunosuppressive agent used. There has been an inverse correlation between prednisone dose and laboratory evidence of serum protein abnormalities. This impressive effect of prednisone therapy was most clearly apparent after the three periods in which the patient decided to stop her medications. The most prolonged period of interruption was the last three months of 1973. Although she had been receiving only 10 mg of prednisone daily, this dosage was apparently effective in partially normalizing serum protein abnormalities. After three months without therapy, rheumatoid factor titers, gamma globulin levels, and serum viscosity clearly increased. Again, intermediate complexes were prominent in the sedimentation profile. (See pattern 1-7-74 in Fig 2B.) More recently, the prednisone dosage has been maintained at 5 to 10 mg daily with satisfactory control of serum protein abnormalities.

**Discussion.** The most striking features in this case of Sjögren's syndrome have been the long-standing nature of the underlying disease process, the dramatic but relatively short-lived hyperviscosity syndrome, and the effect of prednisone therapy.

Any relationship of earlier illnesses, including syphilis, with a long-standing sero-fast state to the present connective tissue disease is problematical. Alopecia, however, is almost certainly part of the present disease. The alopecia was first noted in 1956,
WALLER ET AL: HYPERVISCOSITY SYNDROME

Fig 1—Five-year documentation of clinical events and laboratory measurements in patient with hyperviscosity associated with Sjögren's syndrome. Arrows refer to patterns on Fig 2A and 2B.
Fig 2A—Serum electrophoretic patterns and ultracentrifuge patterns of serum samples taken over a five-year period following hyperviscosity syndrome. Direction of sedimentation is to the right. Photographs taken on dates indicated at 60,000 rpm and 20°C.
11 years before she developed seropositive arthritis and a positive ANA, and 13 years before the first symptoms of hyperviscosity.

After approximately one year in which hyperviscosity symptoms dominated the clinical picture, the patient has remained free of those symptoms for four years. Thus, the dramatic clinical occurrence of a hyperviscosity syndrome and attendant therapeutic problems need not imply that the patient’s basic illness is of recent origin or that the hyperviscosity syndrome will be a persistent problem.

Prednisone therapy has been effective in the control of both serum protein abnormalities and symptoms of hyperviscosity. Probable side effects of steroids including aseptic necrosis of the femoral head and infections have presented emphatic evidence that
in this patient's case steroid therapy also has been harmful. Despite these side effects, her current relative well-being indicates that the steroids are useful therapeutically and that in long-term management the dosage can and must be maintained at a low level. The effectiveness of low dosage in this case may be attributable in part to prolonged steroid action because of its abnormally slow metabolism by a cirrhotic liver. Cessation of prednisone therapy was rapidly reflected in increased levels of gamma globulins, serum viscosity, and rheumatoid factor levels.

Pharmacologic effects of adrenal steroids on serum immunoglobulins and immunoglobulin metabolism in normal volunteers were reported by Butler and co-workers. A three- or five-day course of methylprednisolone, 96 mg daily, produced marked decreases in serum IgG levels which persisted for at least three months. These effects were largely attributable to inhibition of IgG synthesis. Levels of IgA were also decreased, but IgM was not affected. These pharmacologic studies of steroid effects provide a rationale for steroid usage in patients with undesirable effects of IgG, such as IgG-IgG complex formation.

The immunologic and physiochemical events that presage and maintain the hyperviscosity syndrome are poorly understood. In 1968, our patient had a normal electrophoretic pattern and a normal percentage of gamma globulin. In 1969, the total serum protein was found to be 11.2 gm% and nosebleeds were a recurrent problem. Hyperviscosity was first suspected in 1970, when the full clinical pattern of vertigo, headaches, blurred vision, and dyspnea made their appearance.

Bjørneboe and Jensen studied a case of myelomatosis with normal colloid osmotic pressure in spite of extremely high serum protein concentration and postulated that extremely high levels of protein led to aggregation (complexing) of the protein molecules which in turn led to hyperviscosity. The studies of Pope et al. on the hyperviscosity syndrome in rheumatoid arthritis due to intermediate complexes formed by the self-association of IgG-rheumatoid factors would seem to strengthen this concept. Our study shows that the presence of intermediate complexes waxes and wanes with the level of immunoglobulins. In the samples from November and December, 1971, and January, 1972, there are practically no demonstrable intermediate complexes in the patient's serum; one of the lowest levels of gamma globulin and with a viscosity of 1.8 occurred at the same time.

The possibility that intermediate complexes represent compensatory responses to maintain the osmotic equilibrium in face of extremely high levels of globulins cannot be completely dismissed.

On the basis of the response of this patient, one might recommend that the hyperviscosity syndrome of connective tissue disease be managed initially with plasmapheresis, followed by long-term treatment with progressively decreasing doses of adrenal steroids.

REFERENCES


KLAUS RANNIGER, M.D.

1926—1976

Klaus Ranniger was born in Ahrensburg, Germany, on July 4, 1926. He died on March 30, 1976, in Denver, Colorado, prematurely stricken in the prime of his career at the age of 49.

Dr. Ranniger received his M.D. in 1951 from the University of Kiel, Germany, where he also served as an intern (1951–1953) and as a resident in internal medicine (1953–1954). From 1954 to 1955, he served as a Fellow in radiology at the University of Cologne, Germany.

In 1955, he immigrated to the United States to join the Radiology Training Program at the University of Chicago and was certified by the American Board of Radiology in 1958.

During the period 1958–1959, while serving as Chief Resident and later as Instructor in the Department of Radiology, he organized a section which subsequently became one of the leading centers for teaching and diagnosis of cardiovascular radiology in the country. In 1968, he was promoted to full Professor of Radiology and Medicine and in 1971, became Director of the Division of Diagnostic Radiology.

During these years, Dr. Ranniger also served as a Research Scholar in vascular radiology at the University of Lund, Sweden, as well as Visiting Professor at the University of Munich, Germany.

After 17 years of distinguished service at the University of Chicago, he assumed the Chairmanship of the Department of Radiology at the Medical College of Virginia where he built up a strong department, providing an atmosphere which fostered academic accomplishment and learning. His experienced guidance and the respect for his knowledge were perpetual stimuli to his departmental faculty and residents.

A member of many national and international societies of radiology and a Fellow on the Council on Radiology of the American Heart Association, Dr. Ranniger was a distinguished medical author who had published almost 100 articles, chapters, and monographs in the medical literature and presented almost 50 papers and exhibits at major scientific meetings. He was also an editor for the Encyclopedia of Medical Radiology, a reviewer of many radiology texts for the Annals of Internal Medicine, and an examiner for the American Board of Radiology.

The staff of the Medical College of Virginia appreciates the dedication and selfless devotion which Dr. Ranniger gave to the hospital and extends its deepest sympathies to his wife and two children.
A service to medical education from A. H. Robins:
Excerpted from Volume 2 of the G.I. Series
on physical examination of the abdomen:

Normally palpable organs:
the edge of the liver descending, on inspiration, below the costal margin (A); the lower pole of the right kidney (B); the abdominal aorta (C); the descending colon and the sigmoid (D); the ascending colon (E); and occasionally the bladder (though rising of this organ beyond the pubis does not necessarily indicate disease).

Impossible to outline, unless diseased, distended or enlarged: the gallbladder, pancreas, stomach, small intestine, transverse colon and spleen.
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Impossible to outline, unless diseased, dislocated or enlarged:
- the gallbladder, pancreas, stomach, small intestine, transverse colon and spleen.

Spasm reactor?

Donnatal!

Brief summary: Adverse Reactions: Blurring of vision, dry mouth, difficult urination, and flushing or dryness of the skin may occur on higher dosage levels, rarely on usual dosage. Contraindications: Glaucoma, renal or hepatic disease, obstructive uropathy (for example, bladder neck obstruction due to prostatic hypertrophy), or hypersensitivity to any of the ingredients.
brief summary. Adverse reactions: Blurring of vision, dry mouth, difficult urination, and flushing or dryness of the skin may occur on higher dosage levels, rarely on usual dosage. Contraindications: Glaucoma; renal or hepatic disease; obstructive uropathy (for example, bladder neck obstruction due to prostatic hyper¬trophy); or hypersensitivity to any of the ingredients.