PALEOPATHOLOGY: AN ARCHAEOLOGICAL APPROACH OF DISEASES

PALEOPATOLEJO: HASTALIKLARA ARKEOLOJİK YAKLAŞIM

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ABSTRACT

Paleopathology is an holistic science that shares methods and concepts with biological anthropology and biomedical sciences and that belongs to archaeology by its approach (study of diseases in the past). Following the development of archaeology, paleopathology moved its research interest from isolated cases to reconstruction of life conditions of past populations in their environment. We illustrate here, by taking some examples in the field of human infections, this archaeological approach of diseases.

ÖZET

Paleopatoloji, yöntem ve kullanıldığı kavramlar açısından biyolojik antropoloji ve biyomedikal bilimlerle, yaklaşımdan önce iki şekilde hastalıkları incelenmesi bağımlı olarak, arkeolojiyle ortaklaşan bir bilimdir. Bir bilim alanı olarak arkeoloji gelişirken, paleopatoloji de dar bir alanda kalınmakta, diğer bilim alanlarıyla bütünleşerek geçmiş toplumlarının yaşamlarının anlaşılmasına katkıda bulunmaya yönelmiştir. Bu yazıyla, insanlarla görülen enfeksiyonlardan bazı örneklerle hastalıkların ele alınması, paleopatoloji ve arkeoloji açısından değerlendirilmeye çalışılmıştır.

INTRODUCTION

The best definition of Paleopathology remains the first one, given in 1913 by Sir Marc Armand Ruffer (1859-1917), who carried out pioneering work in this field, that he introduced as being “the science of diseases which can be demonstrated in the human and animal remains of ancient times”. Ruffer started in Egypt his pioneering work in paleopathology conducting his researches on Egyptian mummies of all periods. By identifying eggs of Schistosoma bilharzia in mummy kidneys, Ruffer can be considered as well as the father of paleoparasitology (Ruffer 1910). After Ruffer death, his wife and his
colleague Roy Moodie referenced and published his scientific contributions in a collected volume (Ruffer 1921).

Even if, according to Møller-Christensen, “the word "palaeopathology" means literally: the science of very ancient diseases", paleopathology is not the study of ancient diseases and cannot pretend to be (Møller-Christensen 1972). Ruffer was correct by defining the discipline as the science of diseases which can be demonstrated on ancient remains, meaning that the diseases which can be evidenced on bioarchaeological material correspond to the pathological conditions that we are able only to recognize, that is to say the diseases we know. We have therefore to consider that paleopathology is mainly studying on ancient remains the pathological expressions of present diseases or, if not, those of the diseases that are recent enough to be still known. For that reason paleopathology has to be considered as the study of diseases in the past instead of the study of diseases of the past (Dutour 2011).

SUBJECT AND METHODOLOGY

Such as biological anthropology (which is the most humanistic of the biological sciences and the most biological of the human and social sciences) paleopathology belongs to different scientific fields and shares concepts and methods with the other disciplines belonging to these fields. Consequently, even if paleopathology can be considered as a more specialized discipline than biological anthropology, because of its main interest on pathological states (that can be considered either as a part of the normal variability or as a specific entity – see Canguilhem 1966), it must share the holistic approach that characterize anthropological sciences. In this perspective, I have recently developed a new approach in paleopathology that I named “aB3”, standing for “ancient Bones, ancient Books and ancient Biomolecules” (Dutour 2008a, 2008b). This multidisciplinary and integrative approach combines different objects and methods used in archaeology and bioanthropology with the ones used in historical sciences, as well as with those developed by biomedical sciences, including medical imaging and molecular biology.

ARCHAEOLOGY

Before the rise of modern archaeological sciences, archaeology was mainly focusing on the object itself, instead of integrating it in its archaeological context. In this perspective, ancient human or animal remains, such as fossil bones or mummies, were mainly considered as valuable items for museums or personal collections. This outdated view had some influences on paleopathology which mainly focused till the first part of the twentieth century on single remarkable cases, some of them taking place in a sort of “cabinet of curiosities” for paleopathology. Modern archaeology is presently providing for anthropological and paleopathological studies both human remains and the way to put them into their specific context, which is chronological and environmental. Reconstruction of paleoenvironmental conditions is indeed of fundamental importance for studying the diseases among ancient populations, as most of the diseases, human or animal, are under environmental constraints. Numerous markers, geophysical and biological, can be analyzed for reconstructing past environments. It should be noted that if some specialized fields such as palynology or archeobotany, for instance, are quite well developed among paleoenvironmental sciences, other such as paleoparasitology are only defended by a very few number of specialists in the world (Bouchet et al. 2003), in spite of its anteriority dating from the very emergence of paleopathology, as I mentioned above (Ruffer 1910).

This integrative way to replace the human remains into their context, chronological, cultural and environmental by using archaeological methods, allows the paleopathologists to apply to their data the efficient concept of pathocenosis. Pathocenosis is a concept introduced in the field of paleopathology and history of diseases by Dr. Mirko Drazen Grmek (1924-2000), who was a reputed historian of medicine and paleopathologist at the Ecole Pratique des Hautes Etudes. Considering the fact that the history of diseases was classically studied analytically, by examining them separately and consequently putting aside the relationships and interactions that these diseases could have between them, this author developed a synthetic approach, introducing in 1969 his concept of pathocenosis (Grmek 1969).

This concept is based on three assertions: 1) the pathological states within a given population over time and space, represent a whole called patho-
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cenosis; 2) the frequency and distribution of each disease depends, in addition to various endogenous and environmental factors, on the frequency and distribution of all the other diseases; 3) pathocenosis tends towards a balance state, particularly in case of stable ecological situation. Pathocenosis defines the synchronic relations between diseases at a given period. For naming the diachronic changes of these relations, the author suggested the expression of “pathocenosis dynamics”. This evolutionary perspective identifies, besides periods of equilibrium, periods of changes such as agricultural revolution of the Neolithic, development of the cities, several periods of great migrations, industrial revolution, colonial expansions, representing large balance shifts all having had significant effects on diseases frequencies and distributions.

One of the major interests for introducing this concept in paleopathology is to test the validity of assumptions on diseases supposed to characterize pathocenosis, depending on periods and geographical areas. For example, it appears that the seeming absence of tuberculosis in pre-Columbian American pathocenosis and the seeming absence of syphilis (or treponemal diseases) in pre-contact European pathocenosis do not represent valid models, because these two diseases co-evolved with human populations and were consequently most probably present before the 15th century in the pathocenoses of the two worlds.

BIOLOGICAL ANTHROPOLOGY

Besides archaeology, biological anthropology brings valuable information concerning the archaeological populations, which are most frequently represented by a sample of skeletonized individuals. Determination of individual parameters (such as sex and age) is informative not only for paleopathological investigations at individual level, as several diseases are age and/or sex-dependent, but also at population level. The distribution of individual parameters among the skeletal sample provides information on its structure. This approach is commonly named paleodemography, even if this type of “demography” of skeletal sample is highly depending on numerous uncontrolled biases and quite far from what is demography of living populations. It is however useful for paleopathologists to have some ideas about the sample structure of the past population they are working on. For instance, acute epidemics, such as plague or smallpox, do not leave imprints on bones, but have had specific impact on populations that can be revealed by the structure of the skeletal samples (Dutour et al. 2007). Biological anthropology associated with archaeology had developed since three decades specific concepts and methods in a specialized subfield recently named archeoanthropology (Duday 2004, 2009). It brings a specific anthropological experience on the archaeological field, which is of a great value for burial excavation. This approach has a growing interest in paleopathology, as it becomes clear that numerous pathological changes, frail or minor, can be destroyed during or after excavation and thus can disappear from the skeletal records, in the way going from the field to the laboratory. These “evanescent” pathologies that can be only observed on the field during excavations necessitate the development of specific methods in paleopathology, which should be introduced on the archaeological field (Dutour 2011). The knowledge of taphonomy initially introduced to palaeontology (Efremov 1940) has been extensively integrated with biological anthropology training and practice. It is of a great interest for paleopathology as well (Perez 2006), not only for getting information about the preservation state of the ancient material under study, which is obviously impacting on the accuracy of the retrospective diagnosis, but also for avoiding misinterpretations, as taphonomical processes can mimic real pathological conditions in a way that can be very tricky even for an experienced paleopathologist. This was clearly underlined by Calvin Wells who gave the name “pseudopathology” to this permanent trap in paleopathology (Wells 1964, 1967).

Medical Sciences

The diagnostic process used in clinical practice can be transferred to paleopathology, with some peculiarities. Paleopathologist notes on ancient remains a set of signs, resulting from direct observations and from further analysis. Among them, medical imaging takes a special place. Indeed, the use of X-rays for establishing diagnosis on ancient material, so-called “paleoradiology”, is dating from the end of the 19th century. Koenig was the first to use radiology in 1896 in Frankfurt, for examining human and animal Egypt-
ian mummies, only few months after the discovery of X-rays by Roentgen in 1895 (Chhem and Brothwell 2007). Now computerized tomography is commonly used in paleopathology and 3D reconstructions has a growing interest (Coqueugniot et al. 2010).

Molecular biology is now usefully used for retrospective diagnosis of infectious diseases, as a new subfield, called "paleomicrobiology" (Raoult and Drancourt 2008).

Counting and comparing the frequency of different paleopathological conditions among skeletal archaeological samples has been called "paleoepidemiology" (Waldron 2007).

In comparison with modern clinical practice, I consider that four points can summarize the specificities and the difficulties of paleopathological diagnosis: 1- it is retrospective, that is to say that it is necessarily done far from the occurrence of the disease (and of course far from the patient’s life): this implies that most of the time the paleopathologist cannot have any access to the history of the disease neither to the patient's biography (excepting for the paleopathology study of known historical people); 2- it uses modern diagnostic criteria, that is to say that when working on ancient remains by using current medical knowledge, paleopathologist is making the assumption of stability or invariance of the signs of the disease over time. This may be true for some diseases or pathological conditions, but this may be totally wrong for other diseases that have disappeared before the 20th century and that are therefore unrecognizable by using modern medical semiology. It is also wrong for diseases that still exist, but whose pathological expressions in the past have been different, due to the changes that modern medicine has made to their natural expression; 3- it is limited by the scarcity of pathognomonic lesions: due to the fact that the bone tissue has only two possibilities for expressing a pathological condition (osseous destruction or construction), it is therefore understandable that as diseases can be expressed in the same way on the bone, particularly if they have the same origin (eg infection) it may be difficult to differentiate them. In few cases only, specific signs, called pathognomonic, allow paleopathologists to establish accurate diagnosis; 4- it must avoid the haunting trap of pseudopathologies, as mentioned above.

Historical Sciences

Due to the fact that diseases have evolved, present clinical knowledge may not be the most appropriate information to investigate diseases in the past. Old clinical descriptions, dating from the end of the 19th century, a time when the clinical knowledge was modern but the therapeutics was not, may be more appropriate because the natural expression of diseases was not so strongly influenced by a modern preventive and curative arsenal. Ancient medical books are therefore invaluable sources in understanding the past of diseases, because they know skeletal pathologies on ancient bones that modern medical books ignore: I have called “forgotten diagnoses” these clinical expressions of diseases that totally disappeared from our current medical knowledge and that can be re-discovered on paleopathological material (Dutour 2008b).

RESULTS

I will document here some examples of collaborative researches we developed since the early 90's in the field of archaeology of diseases and more specifically concerning the past of the infectious diseases. This issue can be approached by different ways, starting from the common evolutionary concept that a better knowledge of the past of infections is a key for understanding the present and future of these diseases.

Along such lines, starting from an archaeological discovery we made in Provence and that suggested the presence of venereal syphilis during the Late Antiquity (Pálfí et al. 1992) and in spite of the hardness of the debate on the origin of this disease, it has been decided to make a pluridisciplinary synthesis on this topic held in Toulon (France) in 1993 (that brought together international specialists from various fields: archaeology, history, anthropology, medicine, molecular biology…). It opened up the minds to alternative hypotheses; suggested to diagnose, on adult skeletons, treponemal diseases instead of venereal syphilis; allowed a first attempt to amplify treponemal DNA from ancient bones and published for the first time an international multidisciplinary synthesis on the fascinating history of syphilis (Dutour et al. 1994). To go on with this experience, in order to establish a regular link between the "specialists of the past" (archaeologists, historians, paleopatholo-
gists) and the “specialists of the present” (physicians, epidemiologists) for exchanging on these questions, the international network ICEPID (International Congresses on Epidemiology & Paleoepidemiology of Infectious Diseases) was created by György Pálfi and I. This network allowed us to organize, in a same manner, 3 others international congresses: on tuberculosis in Szeged in 1997; on leprosy in Bradford in 1999 (in collaboration with Bradford team) and on plague in Marseille in 2001, all published as international multidisciplinary syntheses on the past and present situation of these infections (Dutour et al. 1994; Pálfi et al. 1999; Roberts et al. 2002; Signoli et al. 2007).

Regarding tuberculosis, the meeting held in Hungary in 1997, allowed us to make the first synthesis about the molecular identification of ancient mycobacterial DNA, as well as the possibility to identify other biomarkers of the tuberculous infection, such as mycolic acids on archaeological material. It gave also the opportunity to illustrate the “forgotten diagnoses”, by showing how paleopathology can re-discover clinical expression of diseases that totally disappeared from our current medical knowledge. Baker described (Baker 1999), for the first time in paleopathological literature, particular vertebral lesions she observed in some vertebral columns of four osteoarchaeological series. Her hypothesis, based on the co-occurrence of these vertebral changes with other pathological conditions indicating TB, was that these lesions might be of tubercular origin and represent early manifestation of vertebral tuberculosis. At the time of publication, a pioneering medical work published in 1888 was simply ignored. Indeed the “superficial vertebral tuberculous osteoperiostitis” (ostéopéritiose tuberculeuse vertébrale superficielle) was described by the French physician Victor Ménard in his book “Tuberculose vertébrale” as one of the clinical expression of tuberculous vertebral infection, beside classic Pott’s disease (Ménard and Lannlongue 1888). This very precise description of quite different and much more aggressive clinical manifestation of vertebral tuberculosis, rapidly lethal, totally disappeared from modern literature on skeletal tuberculosis (it was last mentioned in 1932 by Sorrel and Sorrel-Dejerine; Sorrel 1932) probably because of the efficiency of modern treatment that has been introduced afterwards. Consecutively, we had the opportunity to confirm the frequency of these vertebral lesions in paleopathology, especially in younger age groups, as well as to confirm, for the first time, its tuberculous origin on paleopathological cases by using molecular biology (Haas et al. 2000). This underlines, as mentioned above, the interest of using old (but modern) medical knowledge still available as paleopathological reference.

Regarding leprosy, it is only after the publication of the proceedings of Bradford meeting in 1999, that I was invited to appraise in Italy a very convincing case (Mariotti et al. 2005) that should be considered now as the oldest skeletal evidence of leprosy on a Celtic warrior from the 4th-3rd century BC. This osteoarchaeological evidence underlines the antiquity of this disease in Europe, which is historically known in ancient Asia (literary evidences in India and China go back to around 500 BC); no osteoarchaeological evidence has been yet reported for Asia. The European historical descriptions are more recent, dating from Roman times: Celsus -25 BC-37 AD; Aretaeus from Cappadocia -1st century AD (Cordell 1909). This observation should increase cross-studies between archaeological and historical data in order to test the “historical-ostearchaeological correlation”.

As for plague, our archaeological research allowed us to carry out pioneering works on molecular identification of *Yersinia pestis* from 1722 plague mass grave we excavated in Marseilles (Drancourt et al. 1998). This first molecular identification confirmed that these 18th century mass graves attributed to historical plague epidemics were really due to plague, and not to another pathogen. More recently, we have excavated in Lithuania an 1812 Napoleonic mass grave which allowed us to identify for the first time the molecular signature of infection by the agent of typhus, *Rickettsia prowazekii* (Raoult et al. 2006).

Since the last ICEPID meetings, new advances have been made on the archaeology of some infections. Concerning the origin of syphilis, the question is still open. As the debate was remaining controversial about the osteoarchaeological evidences, with no real possibility to find a consensus, it has been supposed that the final answer must belong to the molecular phylogeny. In 2008, Harper et al. made the first attempt to use a phylogenetic approach to
solve the question of the origin of syphilis, by analyzing genetic polymorphism on a collection of pathogenic Treponema strains, they conclude that venereal syphilis arose relatively recently in human history and that these genetic data provide support for the Columbian theory of syphilis's origin (Harper et al. 2008). However this conclusion was immediately invalidated by other experts claiming that the material and the methodology used was not the best choice when trying to resolve the decades-old debate concerning the origin of venereal syphilis and that firm conclusions should not be based upon these results (Mulligan et al. 2008).

As for the history of tuberculosis, on the contrary, significant advances have been made in the last decade by using molecular phylogeny (Brosch et al. 2002). The previous model was explaining the origin of tuberculosis by a transmission to humans from cattle during the emergence of agriculture, 8000 or 9000 years ago. This model is now totally modified. It has been indeed demonstrated, according to Gutierrez that “human tuberculosis did not arise from cattle, because species that make up the M. tuberculosis cluster share a common ancestor some 35.000 years ago” and “probably derive from a common prototuberculosis species that arose about 3 million years ago” (Gutierrez 2007). About its geographical origin “like man, tuberculosis bacteria came from East Africa” and “expanded with the human emigration wave all around the world, around 35.000 years ago”. The evolution and spread of tuberculosis and of man appear therefore to be intimately associated as “the genetic relationships among strains of tuberculosis mirror the relationships among people deduced from mitochondrial DNA, suggesting that they arose and evolved together”.

CONCLUDING REMARKS

Paleopathology clearly rooted in the field of archaeology, and followed the development of this latter. “New Archaeology” has developed more interest in processes rather than in facts and operates globally on a contextualized way, for testing hypotheses about the interactions between biology and culture in human archaeological populations.

In this way, bioarchaeology integrates the pathological dimension in the study of ancient populations lifestyles and paleopathology is clearly recognized by the North American bioarchaeologist as part of their field. The study of pathological changes on the skeleton, considered at the population level, allowed them to highlight some aspects of environmental context, behaviour and activities, division of labour based on age and sex, social and nutritional status as well as global health among past populations. All these paleopathological topics take part in the bioarchaeological field, mainly developed in North American Universities, as bioarchaeology has a different meaning in Western Europe (Dutour 2011).

New approaches in paleopathology focus now on the collection of pre-therapeutic clinical data (medico-historical references), on the improvement of retrospective diagnosis by 3D imaging techniques and on the evaluation of susceptibility/resistance of ancient populations to diseases, by reconstructing paleodiet (isotopes and trace elements) and by characterizing the genetic pattern (aDNA).
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