

Abstract

Introduction: The craniovascular system is part of the vascular network of the head, and includes the middle meningeal vessels (*arteria meningea media* and *vena meningea media*; MMV), dural venous sinuses (*sinus durae matris*; DVS), emissary veins (*venae emissariae*; EV) and diploic veins (*venae diploicae*; DV). These vasculatures leave marks in the skull in form of imprints on the inner surface of cranial vault bones (MMV, DVS), channels within the bone diploe of cranial vault bones (DV), and cranial foramina (EV). Craniovascular traits can be studied in osteological samples, and thus provide an opportunity to investigate the physiological processes associated with blood circulation in past populations. Craniovascular features can also supply information about evolutionary adaptations, inter- and intra-population differences, and individual life history. Moreover, a knowledge of the anatomical variants can be useful in medicine and surgical practice.

Objectives: The aim of this thesis was to specify a methodological approach for the measurement and evaluation of craniovascular traits, and then to analyse the morphological variability of the craniovascular system in adult individuals with normal cranial anatomy from several different populations with regards to the cranial size, sex, and age. Then, changes in the craniovascular morphology of individuals with cranial dysmorphologies due to craniosynostoses (CS) and artificial modifications (ACM) were also investigated. Lastly, a case study of the DVS in a Neanderthal endocast from Gánovce (Slovakia) was included.

Material and methods: Craniovascular traits were evaluated and measured in osteological samples from recent (Czech and Italian) and archaeological (Argentinian) human adult populations, in their physical forms (skulls), 3D models, and in CT images. The sample also contains individuals with CS (Czech collection) and individuals with ACM (Argentinian collection). The methodology was based on previously published and some newly designed approaches.

Results: An overview of the prevalence of the craniovascular features and of their metrics was provided for each sample. The craniovascular morphology was in general not influenced by cranial dimensions, sex, or age, except for the mastoid emissary foramina, which seemed to be affected by cranial width and mean size, and were also often larger in males than in females. There were population differences in the antero-posterior distribution of MMV within the endocranium, the pattern of the confluence of sinuses, the occurrence of the imprints of enlarged occipito-marginal sinuses, and the frequency and size of emissary foramina. When compared to individuals with normal anatomy, individuals with CS displayed altered craniovascular

morphology, e.g. the different anterior-posterior organisation of the MMV, higher occurrence of enlarged occipito-marginal sinuses, more numerous and larger emissary foramina, and different spatial dispersal of the DV. In contrast, individuals with ACM presented only somewhat smaller emissary foramina. The analysis of a Neanderthal endocranium from Gánovce showed that this individual had an unusual pattern in the confluence of sinuses.

Discussion: The results suggest that the morphology of the DVS and EV is mostly determined by function (e.g. the enlarged DVS and EV may probably increase the intracranial pressure in CS), while the morphology of the MMV and the DV appears to be a result of structural (re)organisation within the meninges and bone (e.g. passive topological adjustments of the MMV and the DV to growth strains of the neurocranium in CS). However, also thermoregulatory function of the craniovascular system may be relevant during ontogeny and in pathological conditions (as in CS). Genetic, epigenetic and environmental factors create intra- and inter-population variability, but it is not yet clear to what extent craniovascular morphology is influenced by e.g. climate, altitude, geographical distances, or migration flow.

Conclusions: In this thesis, the variability of the craniovascular features in adult individuals from several osteological collections was analysed, and then changes in the craniovascular morphology in adult individuals with CS and ACM were described. Based on this research, some functional and structural aspects of the craniovascular system were discussed.

Keywords: craniovascular morphology, endocranial vascular traits, craniosynostosis, artificially modified skulls, middle meningeal artery, dural venous sinuses, emissary veins, diploic veins