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The need to update reference values for organ weights in the adult population: a review and future directions

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SUMMARY
This review article highlights the crucial role of organ weights and dimensions as key indicators in forensic diagnosis. Organ weight changes serve as valuable markers for pathological conditions, aiding forensic doctors in interpreting autopsy findings. The review emphasizes the importance of precision in establishing organ reference values, considering factors like population-specific norms and correlations with body parameters. Furthermore, it explores the impact of obesity on organ weights, emphasizing the need for updated databases that accurately reflect diverse populations. The article underscores the inadequacy of relying on outdated sources and advocates for creating a comprehensive and updated database of organ weights and dimensions for the local population, essential for accurate forensic interpretations.

Keywords: organ weights – organ dimensions – reference databases – obesity

Potreba aktualizácie referenčných hodnôt hmotností orgánov u dospelej populácie: prehľadový článok a smerovania do budúcnosti

SÚHRN
Tento prehľadový článok zdôrazňuje kľúčovú úlohu hmotnosti a rozmerov orgánov ako základných ukazovateľov pri diagnostike v súdnom lekárstve a patológii. Zmeny hmotnosti orgánov slúžia ako základné markery patologických stavov a pomáhajú súdnym lekárom a patológom pri interpretácii nálezov z pitvy. Prehľad zdôrazňuje dôležitosť presnosti pri stanovovaní referenčných hodnôt orgánov, berúc do úvahy faktory, ako sú špecifické referenčné hodnoty pre populáciu a rovnako tak korelácie s telesnými parametrami. Okrem toho skúma vplyv obezity na hmotnosti orgánov, pričom zdôrazňuje potrebu aktualizovania databáz, ktoré presne odrážajú rôzne populácie. Článok podčiarkuje nedostatočnosť spoliehania sa na zastarané zdroje a obhajuje vytvorenie komplexnej a aktualizovanej databázy hmotností a rozmerov orgánov pre lokálnu populáciu, ktorá je nevyhnutná pre presnú forenznú interpretáciu výsledkov pitvy.

Kľúčové slová: hmotnosti orgánov – rozmery orgánov – referenčné databázy – obezita

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ORGAN WEIGHTS AS A KEY INDICATORS IN FORENSIC DIAGNOSIS

In today's era of medical advancement and personalized healthcare, detailed knowledge of the weights and dimensions of internal organs plays an indispensable role for forensic doctors and pathologists. Such reference values for organs are useful in determining whether an organ is normal or pathological. In many diseases, changes in the weight of internal organs have been demonstrated, with some pathological conditions causing an increase in weight, while others lead to organ shrinkage and a subsequent decrease in weight (1,2). The first indicator of organ abnormality is precisely its size and weight. The accurate determination of organ weights is a crucial factor, providing a significant indicator of the normal or abnormal state of a given organ. This thorough analysis of organ weights is an invaluable tool in the diagnostic process, allowing forensic doctors and pathologists to correctly interpret autopsy findings regarding the cause of death (3).

One example is the increased weight of the heart, which can be an indicator of myocardial hypertrophy, as its symptoms are often challenging to recognize macroscopically and microscopically (4). Exceeding the reference value, increased lung weight may suggest the presence of pathology, such as heart failure associated with fluid accumulation or pneumonia. Conversely, decreased lung weight may indicate various diseases, including tuberculosis. Changes in kidney weight can reflect renal toxicity, tubular hypertrophy, or chronic progressive nephropathy (5). In the field of forensic pathology and clinical medicine, any deviation from the normal weight of an internal organ signals the presence of pathology in that organ or a compensatory mechanism in response to the stress applied to the organ. For instance, in the case of increased pulmonary resistance, the right ventricle of the heart may enlarge to cope with the increased pressure required to pump blood through the pulmonary circulation. Such organ adaptations provide valuable information about pathological conditions and their causes (6). In the same way, increased physical activity causes several changes in the human organism in terms of adaptation to the given activity, such as the heart, whose basic task is to ensure effective circulation. Such increased need may accentuate functional or structural changes (7).

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Accurately determining organ weights is an effective diagnostic criterion during autopsies, especially when a clear and known norm exists. Organ weight analysis provides the doctor with crucial information about the origin and development of the disease. Weighing organs thus becomes an integral tool in the diagnostic process, helping to approach a thorough understanding of pathological processes and their impact on the individual (3).

PRECISION IN ORGAN WEIGHT REFERENCE VALUES

Determining increased or decreased weight of an internal organ is only possible if there is an accurately established reference value, which is a record of the weight of a specific internal organ that can be compared to the current weight. Establishing norms for organ weights is based on comparing them with these reference data, making it crucial for these data to be as representative and accurate as possible. Their accuracy ensures that the reference size and weight provide a reliable indicator of the normal value. The weight of internal organs proves to be a useful diagnostic measure in interpreting autopsy results, especially when the weights of internal organs are compared to relevant reference values. Accurately establishing norms for organ weights in a given population context is therefore essential for a reliable interpretation of results (8,9).

There are several methods for creating reference values for organs. The first involves creating reference tables for a specific population. This means that the average weight and dimensions of organs, serving as reference information, should be obtained by weighing and measuring organs and subsequently calculating the arithmetic mean from individuals in that population. Another method that can be used to define reference values is correlating the weight of internal organs with body length and overall body weight. In this case, it primarily involves comparing reference values with an individual's height, based on which a precedent is then established that an individual with a specific height should have specific organ weights and dimensions for their category (9). Recent studies have confirmed the correlation between the weight of internal organs and overall body weight. It has also been demonstrated that, on average, men have greater internal organ weight compared to women. A Korean study focused on examining the relationship between organ weight and overall body weight and concluded that organs such as the heart, spleen, and thyroid gland in men do not differ from those in women. However, other organs are heavier in men. Further research has been conducted to identify the relationship between the weight of internal organs and factors such as height, body weight, body mass index (BMI), and age. Histopathological examinations and their significance in autopsies and medicolegal cases are still considered immensely important. According to the literature, we also learn that the weight of all organs, except the heart, decreases with advancing age. In the case of post mortem changes, such as decomposition and death due to various diseases, fire, or drowning, their impact on organ weights is equally significant (3,10).

BODY MASS INDEX AND OBESITY

In 2016, the World Health Organization (WHO) presented a projection revealing that 1.9 billion adults, individuals aged 18 and older, are overweight (BMI = 25 – 29.99 kg/m^2), with over 650 million adults suffering from obesity (BMI ≥ 30 kg/m^2). Obesity has been identified as a factor increasing the likelihood and intensity of various chronic diseases and as a risk factor for mortality (11-13). Pathological processes associated with diseases affect the weight and overall function of multiple organs, becoming evident to pathologists and forensic doctors conducting autopsies on individuals with overweight and obesity. Doctors use organ weights as a critical indicator to understand the pathological effects of different diseases. Therefore, it is crucial for pathologists and forensic doctors to have information during autopsies about the impact of obesity on organ weight, enabling them to distinguish changes in organ weight and dimensions associated with obesity from other pathological changes related to disease. Most reference values for normal organ weights are derived from autopsies performed on forensic populations. This approach is designed to minimize the potential influence of chronic diseases that could affect organ weight. Often, these patients are younger, and the impact of aging on organ weight is frequently overlooked (14,15).

Recently, new organ weight tables have been created from a large forensic population in France. However, it should be noted that while these databases included information on obese patients, they did not include individuals with a BMI higher than 40 kg/m^2 (16). On the other hand, there were no published studies for a long time that addressed the impact of obesity on organ weight in the general population of older patients with multiple chronic health problems, even though older patients with obesity and overweight constitute the majority of individuals undergoing autopsy in a hospital setting. However, a recent study by Mandal et al. (2012) addressed the problem that existing organ weight tables used by pathologists and forensic doctors for patients undergoing medical autopsy do not illustrate the impact of obesity and age on organ weights. The results showed that both men and women experienced an increase in organ weight with higher BMI, but a decrease in weight with higher age in the case of the liver, spleen, and kidneys. In men, increased age was associated with increased thickness of the left ventricle wall, while increased BMI was associated with increased heart weight. In women, only BMI was associated with changes in heart weight. The authors argue that different effects of age and BMI on the heart between men and women increase the possibility that elevated BMI values may have a greater impact on cardiovascular causes of death in women than in men (15).

THE NEED TO UPDATE DATABASES

Currently, pathologists and forensic doctors often rely on references from the most recent databases, primarily American or Western European textbooks or guidelines. The problem with these sources of information is that they may not be suitable for every population when interpreting post mortem cases, potentially leading to incorrect conclusions. The weight of human internal organs is not determined solely by race, age, or gender but also depends on environmental and socio-economic conditions, which can vary significantly across different parts of the world (9).

In Western European countries and the USA, the importance of regularly updating databases is increasingly recognized. Molina and DiMaio (2012) point out that a long-cited and frequently used study on the weight and dimensions of the heart (Mayo Clinic study), which included 765 autopsy cases from 20 to 99 years old, is no longer current or accurate (17,18). Similar limitations apply to other older studies, such as Smith (1928) or Garby et al. (1993), especially regarding other organs (19,20). To appropriately and accurately assess the normal weight of internal organs, it is necessary to examine a population without any

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diseases and update the databases. Based on this need, four studies were published. Molina and DiMaio (2012) conducted a prospective study on healthy men who died suddenly due to a traumatic event, aged 18 to 35. In this study, they observed the normal weight of the heart and compared it with the results of past studies, including Smith (1928), Garby et al. (1993), as well as Aschoff (1924), Zeek (1942), Tanaka et al. (1979), and others (21-23). The results showed that the normal weight of the heart has changed over time, meaning that old databases of heart weight cannot be considered current and accurate. Many of the mentioned older studies also had design flaws, including the inclusion of patients with multiple diseases known to be associated with heart enlargement, such as cardiomyopathies, lung diseases, or illegal drug use. A similar approach was taken in the study by Molina and DiMaio (2015), where they conducted a prospective study on the heart weight of healthy women (24).

Molina and DiMaio (2012, 2015) also addressed the weights of other internal organs, such as the brain, lungs, liver, spleen, and kidneys (25,26). Throughout their research, they continued the established trend and examined the normal weight of these organs in healthy men and women. Their results were compared with the results of other studies, once again highlighting the imperfections of older research and finding discrepancies in their results. This reaffirmed the importance of updating databases of organ weights and dimensions.

Meanwhile in 2014, Jessica Vanhaebost and her colleagues developed a Heart Weight Calculator. This tool utilizes data such as gender, body height, and body weight to estimate the weight of the heart. The authors intended to offer technical assistance for predicting the normal weight of the heart. This innovation holds substantial promise for supporting pathologists and forensic doctors in the assessment of cardiac pathology (27).

SITUATION IN OUR POPULATION

In the past, the analysis and assessment of normal organ weights and dimensions in our population were based on publications by Professor Kutlík, such as "Histopatologický laborant" (1950) or "Patologicko-anatomická pitva" (1954). These sources provided pathologists and forensic doctors with basic information on autopsy techniques and organ weights. Even to this day, pathologists mostly prefer to draw upon the knowledge of Professor Herman Šikl, who, in 1953, published a work titled "Pathologicko-anatomická pitevní technika a základy diagnostiky" (Pathological-anatomical autopsy technique and fundamentals of diagnostics). His publication includes detailed descriptions of microbiological and virological techniques during autopsies, along with required tables and diagrams of organ weights and dimensions for both children and adults (28). These reference values for organs are still used and considered the most accurate in our population.

With regard to more recent sources of information, pathologists, forensic doctors, and even university professors rely on textbooks such as "Anatomie 1, 2 and 3" by Čihák (2011) or "Anatómia ľudského tela" by Mráz (2004; 29,30). However, many of these textbooks and databases base their information on outdated databases and publications, such as "Soustavná anatomie člověka 1 and 2" by Borovanský (1967) or publication by Josef Zrzavý (1978; 31,32). These publications describe organ weights and dimensions in populations. However, they do not differ from data of the 1960s and 1970s. It can be assumed that authors like Borovanský and Zrzavý drew information from older publications when creating reference values for internal organs. This underscores the urgency of updating this data in our population.

In many cases, forensic doctors and pathologists often seek information on organ weights and dimensions in foreign sources, such as de la Grandmaison et al. (2001) or Kitzman et al. (1988). However, it is crucial to emphasize that these values may not precisely reflect the population living in our territory, and their interpretation could be significantly distorted.

In 2013, a pilot study was initiated in Slovakia to investigate cardiac weight variations in cases of mortality attributed to medical conditions. The study underscored the imperative for a forthcoming comprehensive examination of myocardial morphology. This prospective study also aims to establish criteria for determining optimal dimensions for the heart and maybe, in the future, other organs within the human body (33). Therefore, it is essential to create an updated and accurate database of organ weights and dimensions for our population. Such a database would significantly assist doctors in identifying pathology or the cause of death, contributing to more precise and reliable conclusions.

CONCLUSION AND FUTURE DIRECTIONS

In conclusion, this review highlights the crucial role of organ weights and dimensions as key indicators, providing crucial distinctions between healthy and pathological organs during autopsies. Establishing precise reference values for organ weights is essential for accurately interpreting autopsy findings. The study also underscores the necessity for new databases within our population, taking into account significant variations related to gender and age. The review strongly advocates for accurate, up-to-date databases to help diagnostic precision, supporting pathologists, forensic doctors, and researchers in understanding organ-related pathologies for more conclusive forensic diagnoses. In our upcoming research, we aim to gather data during the autopsies to create a new database of body organ weights and dimensions. We will focus on studying a healthy population without any diseases know to be associated with changes in organ weights and dimensions. Our approach involves measuring organ weights and dimensions, calculating averages, and exploring how these relate to factors like body height, body weight, age, and BMI. Additionally, we will assess subcutaneous fat thickness, which can maybe help with establishing reference values, especially in the context of BMI. Our main goal will be to create reference tables and databases specifically tailored to our population. This initiative aims to assist doctors in reaching more precise and reliable conclusions.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

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