Original article

Quantitative and morphological analyses of different types of human liver

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Abstract

Morphological variations in the human liver have been classified as congenital or acquired, although some may result from pseudo-injuries incurred during medical investigation. The present study comprises a systematic analysis of the anatomical variations exhibited by 61 formalinised and glycerinated adult human livers derived from a collection maintained at the Institute of Anatomy, Universidade Severino Sombra, Vassouras, RJ, Brazil. The vast majority of the organs analysed could be classified according to the seven morphological liver types previously established, although two additional liver types were identified and described. Detailed knowledge of anatomical variations in the human liver could be valuable in improving diagnostic procedures and in attaining a better understanding of pathological conditions associated with some liver diseases.

Keywords: human liver, anatomy, variations, morphology, liver types.

1 Introduction

The liver is responsible for a wide range of vital functions including blood detoxification and purification, synthesis of plasma proteins, production of bile, and the metabolism of carbohydrates, fats and proteins. In man, the liver is essential for survival since there is currently no artificial organ or equipment that has the capacity to compensate for the absence of liver function (GUYTON and HILL, 2006).

The complexity of liver function and its importance in body homeostasis has encouraged many anatomists to study the morphological features of the organ in considerable detail (BORGES, MACHADO, OLIVEIRA et al., 2002). Despite recent technological advances in the evaluation of liver parenchyma using imaging techniques, such as computed tomography or nuclear magnetic resonance (MEIRELLES, TIFERES and D'IPPOLITO, 2003), detailed studies of the macroscopic anatomy of cadaveric livers can still contribute to the identification of important anatomical variations. In many cases, such variations have enabled researches to understand specific responses to therapies that have been applied in the treatment of liver disease (BERTEVELLO and CHAIB, 2002; TRIVIÑO and ABIB, 2003).

The liver is the second largest single organ in the human body (after the skin) with a mass of around 1.5 kg in the average adult (MOORE and DALLEY, 2001). The organ typically measures 21-22.5 cm across its widest point, 10-12.5 cm from front to back, and 15-17.5 cm at its maximum vertical height (GRAY and WILLIAMS, 1995). In terms of gross anatomy, the liver may be divided into four lobes based on surface features. The falciform ligament, which is visible on the anterior side of the liver, divides the organ into the left and right anatomical lobes. Two additional lobes may be observed on the visceral surface, these being the superior caudate lobe and below this the quadrate lobe. From behind, the lobes are divided by the ligamentum venosum and the ligamentum teres (anything to the left of these constitutes the left lobe), whilst the transverse fissure (or porta hepatis) separates the caudate from the quadrate lobe, and the right sagittal fossa (over which runs the inferior vena cava) separates these two lobes from the right lobe. Each of the lobes is made up of lobules, veins from the centre of which join the hepatic vein and carry blood out from the liver. Various ducts, veins and arteries are present on the surface of the lobules that allow the inflow and outflow of fluids (GRAY and WILLIAMS, 1995; TRIVIÑO and ABIB, 2003).

The variations that have been observed in the anatomy of the human liver have been classified as congenital or acquired. Congenital changes in the organ are characterized by the following aspects: a) lobes separated by glands (considered to be a congenital variation by some anatomists); b) atrophy at some locations in the parenchyma; c) presence of only one lobe; d) presence of multiple lobes, typically involving numerous divisions (up to 16) of the right lobe; e) small lobes; f) peduncular lobes; g) lobes without division; and h) accessory lobes. Acquired changes in liver morphology are represented by the following characteristic features: i) linguiform lobes (Figure 1), ii) costal organ with very small left lobe (Figure 2), iii) deep renal impressions and "corset" type constriction (Figure 3), and iv) local inflammation of the organ or gallbladder (ROYER, 1959). It has recently been reported that some apparent morphological changes detected during advanced imaging examinations may actually be pseudolesions resulting from perfusion defects, focal fatty infiltrations and other causes, and may not

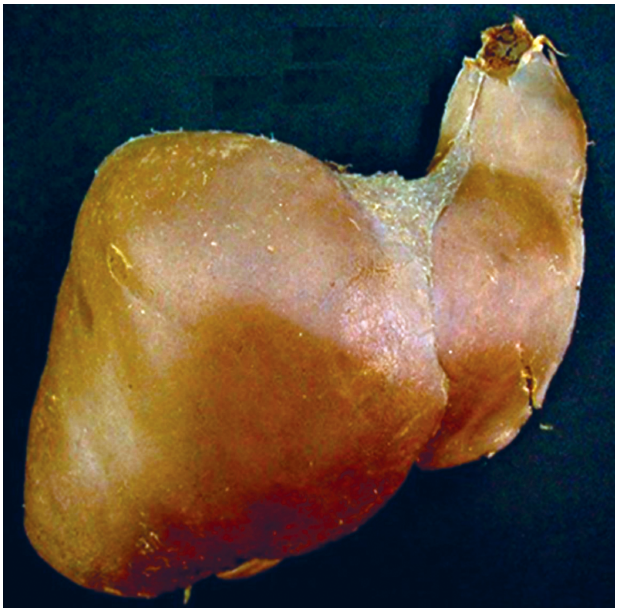

Figure 1. Type 5 liver with lingular process.

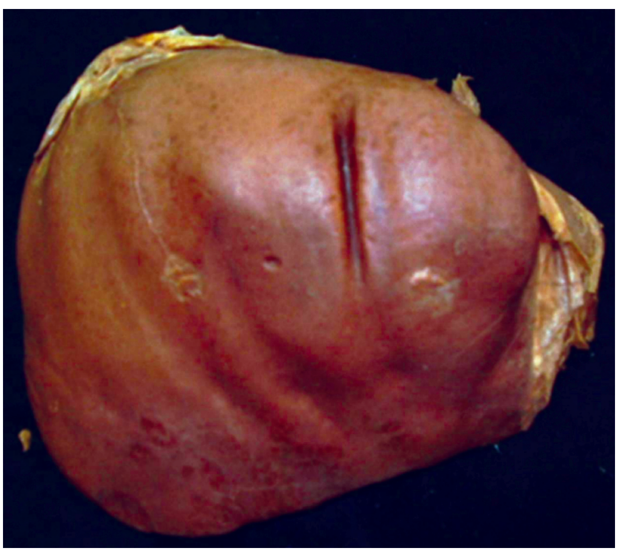

Figure 2. Type 2 costal liver with very small left lobe and deep impressions.

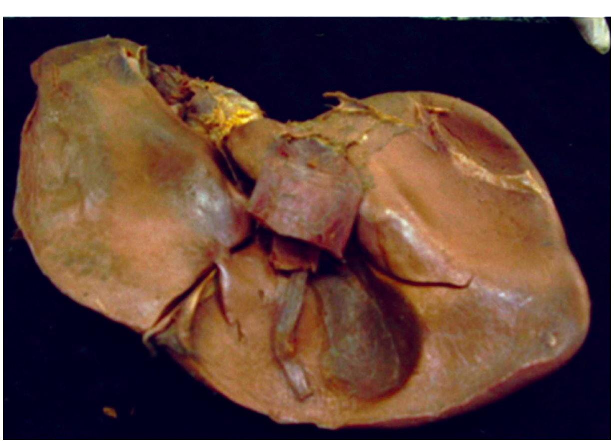

Figure 3. Type 6 liver with deep renal impressions and "corset" type constriction.

represent true parenchymatous lesions (MEIRELLES and D'IPPOLITO, 2003; MEIRELLES, TIFERES and D'IPPOLITO,2003).

The aim of the present study was to investigate the type and frequency of anatomical variations in a collection of cadaveric livers available at the Institute of Anatomy, Universidade Severino Sombra, Vassouras, RJ, Brazil. As a result of this analysis, livers presenting additional morphological changes have been identified and described.

2 Materials and methods

Details of the study were submitted to and approved by the Ethics Committee of the Universidade Severino Sombra. A collection of 61 livers that had been removed from adult human cadavers, fixed in 10% buffered formalin solution and then glycerinated (GRAY and WILLIAMS, 1995), were available at the Institute of Anatomy at the Universidade Severino Sombra (IAUSS). Each liver was weighed using a Filizola balance with a maximum tare of 5 kg, and only those with a mass ≥ 1.4 kg were considered to be adult cadaveric organs. Anthropometric measurements of the organs were recorded including height (measured from the bottom of the right hepatic lobe), transverse diameter (extending from the right side edge of the right hepatic lobe to the tip of the left lateral lobe) and thickness (from the front of the right hepatic lobe to the rear of the same lobe).

In order to perform a systematic analysis of the types of macroscopic variation present in the liver specimens studied, parameters associated with the normal morphological aspects of the organ surfaces (GRAY and WILLIAMS, 1995) were assessed. For this purpose, each liver was placed in the anatomical position to facilitate visualization of the diaphragmatic and visceral surfaces, and morphometric measurements were performed with the aid of a Mitutoyo digital calliper. Each liver was examined on two different occasions by two examiners, and the results obtained were compared and ratified. The distinct morphological characteristics observed were recorded on individual data sheets in a form appropriate for posthumous analysis. On the basis of these descriptions, the organs were classified into nine groups, seven of which (Table 1; types 1-7) corresponded to the morphological types (including the normal type) established by Netter (2000), whilst the remaining two (Table 1; types 8 and 9) were identified by two professors of anatomy at the University.

3 Results

The 61 liver specimens available at IAUSS presented a mean weight ± standard deviation (SD) of 854.7 ± 256.7 g. The distribution of the studied livers according to the nine morphological types is shown in Table 1. An absence of major anatomical variation was observed in 26 organs (42.6%; mean weight 668.4 ± 302.3 g), whilst the remaining 35 organs (57.4%; mean weight 878.0 ± 264.0 g) showed distinct variations in anthropometric parameters and morphological type (Table 2).

It is noteworthy that just 42.6% of the cadaveric livers present in the IAUSS collection were considered to be anatomically normal in appearance (i.e. classified as type 1), while 57.4% exhibited a range of morphological variations.

Table 1. Frequency distribution of morphological types of human livers available from the organ collection at IAUSS.

Organ type	Characteristic features	Nº of examples	Frequency (%)
1	Normal liver	26	42.62
2	Costal liver with very small left lobe and deep impressions	5	8.19
3	Liver with total atrophy of the left lobe	1	1.64
4	Transversal liver with a large left lobe	4	6.56
5	Liver with lingular process	13	21.31
6	Liver with deep renal impressions and "corset" type constriction	6	9.84
7	Liver with diaphragmatic impressions	4	6.56
8	Liver with right lobe very much smaller than the left	1	1.64
9	Liver with biliary vesicle invading the diaphragmatic face	1	1.64
Total		61	100

Table 2. Anthropometric data determined for human livers available from the organ collection at IAUSS.

Organ type	Weight (g)	Height (mm)	Diameter (mm)	Thickness (mm)
1	668.4 ± 302.3	145.9 ± 29.8	196.1 ± 22.6	86.2 ± 18.1
2	765.9 ± 453.8	143.1 ± 32.0	1186.9 ± 36.1	83.5 ± 13.2
3*	1460	222.8	194.1	116.8
4	696.0 ± 231.6	147.2 ± 24.2	215.9 ± 21.1	89.9 ± 6.2
5	794.0 ± 176.1	152.8 ± 22.7	202.4 ± 20.2	90.5 ± 15.3
6	963.3 ± 278.9	180.0 ± 16.1	204.6 ± 16.7	96.9 ± 7.0
7	795.0 ± 261.4	153.8 ± 27.1	212.4± 21.4	91.0 ± 12.6
8*	600.0	123.4	193.6	93.0
9*	950.0	115.2	191.6	78.2

Data are expressed as mean value ± standard deviation except for those pertaining to morphological types represented by single specimens (marked * in column 1).

These data suggest a high incidence of anatomical variation in the human liver. Unfortunately, no statistics relating to the frequency of occurrence of livers displaying gross variations in morphological character could be found in the literature in order to serve as a basis for comparison with the studied samples.

As revealed in Table 1, the majority (33/35; 94.3%) of the liver specimens presenting distinct anatomical variation could be readily classified within types 2 – 7 as described by Netter (2000). The single type 3 liver encountered in the present study, for example, showed complete atrophy of the left lobe giving the appearance of a single-lobed organ (Figure 4). According to Royer (1959), the absence of division of the liver, which makes it impossible to distinguish macroscopically between the right and left lobes, is related to a congenital morphological alteration. Additionally, type 7 livers with diaphragmatic impressions (Figure 5) have been described previously by Yoshimitsu, Honda, Kuroiwa et al. (2001) and Meirelles, Tiferes and D'Ippolito, (2003). These authors considered the diaphragmatic sulci to be accessory hepatic fissures caused by invaginations of the diaphragm.

Two liver specimens included in the present study could not be adequately described according to the classification of Netter (2000) and were considered as new variant types 8 and 9. According to the description of the normal liver (GRAY and WILLIAMS, 1995), the right lobe is typically larger and more bulky than the left. On this basis, the single liver (1/35; 1.64%) described as type 8 (Figure 6) must be considered as a morphological variation because the left lobe was very much larger than the right. Bezerra, D'Ippolito, Caldana et al. (2004) suggested that the characteristics of type 8 organs, namely, the reduction in size of the right hepatic lobe and the compensatory increase of the left and caudate lobes, may result from pathological processes in patients with schistosomiasis.

Figure 4. Type 3 liver with total atrophy of the left lobe.

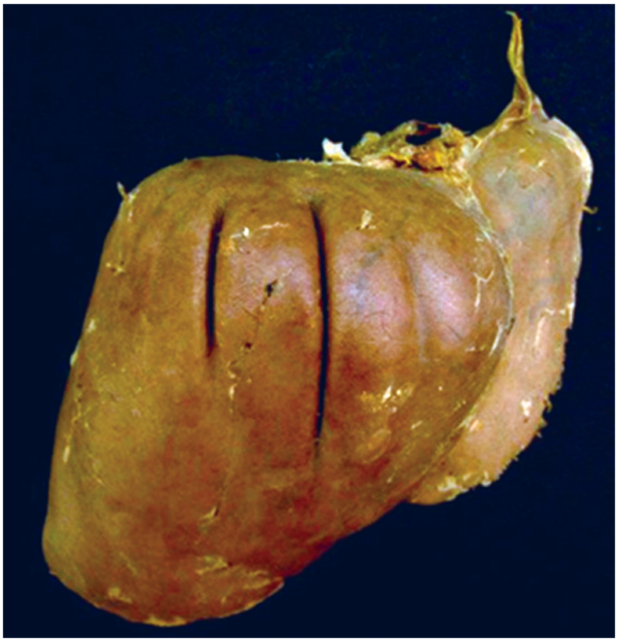

Figure 5. Type 7 liver with diaphragmatic impressions.

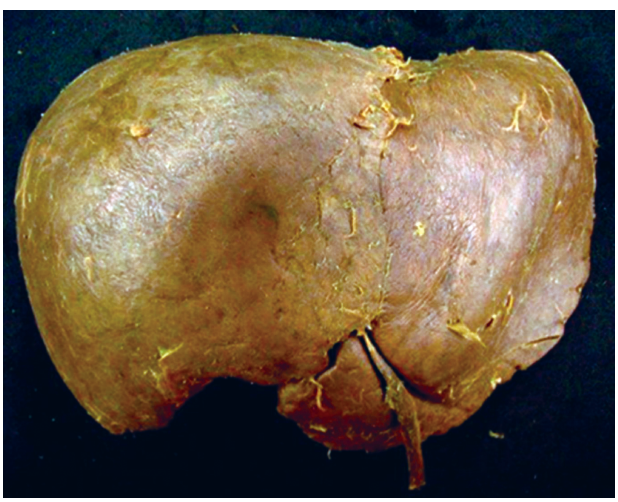

Figure 6. Type 8 liver with right lobe very much smaller than the left.

Only one example (1/35; 1.64%) of a type 9 liver was found in the present study (Figure 7). This particular organ was characterized by anatomical changes in the diaphragmatic face of the right lobe, specifically at the acute lower margin that separates the diaphragmatic from the visceral face. The organ showed deep invagination of the fossa of the gallbladder in an upward convexity, separating the right lobe of the diaphragmatic face into two further major regions.

It should be pointed out that, although distinct morphological types of human liver can be identified in the literature (ROYER, 1959; NETTER, 2000), relatively few studies are available on this topic and detailed descriptions of the different types of anatomical variations are scarce. One reason for this may be associated with a particular difficulty encountered in the present study relating to the characterisation of cadaveric sources in terms of sex, age and previous diseases, all of which may impact on liver morphology.

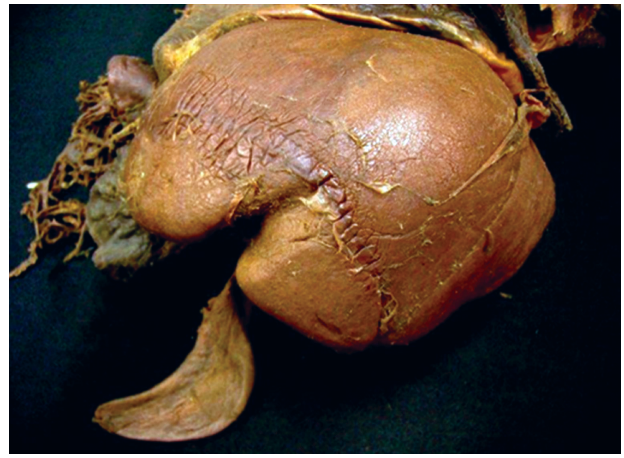

Figure 7. Type 9 liver with biliary vesicle invading the diaphragmatic face.

4 Conclusion

In conclusion, it is noted that although anatomical variations in the shape of the liver are frequently encountered, few systematic analyses have been reported in the literature. However, detailed descriptions of normal and variant liver morphologies can make a significant contribution to understanding the causes of the changes and is a prerequisite for the favourable outcome of a surgical procedure.

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