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Research Article

Patient's Anthropometric Measurements are Correlated with the Liver Parenchymal Surface Area at the Hepatectomy Cross Section

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ABSTRACT

Introduction: Three major complications occur in association with surgical liver resection: hepatocellular insufficiency, haemorrhage and biliary fistula on the hepatectomy cross-section. The liver morphology plays a role in the development of postoperative hepatocellular insufficiency, as this complication occurs when the ratio of the remaining to total liver volume is insufficient. The hepatic volume correlates with anthropometric measures. This study was performed to determine whether anthropometric characteristics influence the surface area of the hepatectomy cross-section, a liver morphological parameter related to potential complications.

Materials and Methods: We measured the parenchymal surface area of the hepatic cross-section after right hepatectomy using computed tomography, and examined correlations of this area with patients' sex, age and anthropometric characteristics (body weight, height, Body Mass Index (BMI), Maximum Abdominal Perimeter (MAP) and body surface area).

Results: The study population comprised 140 patients (69 men and 71 women). The average surface area of the hepatectomy cross section was (73.23 ± 16.82) cm^2. This area correlated weakly, but significantly, with patients' height ($r=0.22$, $p<0.05$), BMI ($r=0.26$, $p<0.05$) and MAP ($r=0.23$, $p<0.05$), and more strongly with patients' body weight ($r=0.31$, $p<0.001$) and body surface area ($r=0.31$, $p<0.05$).

Conclusion: The surface area of the hepatectomy cross section correlates with anthropometric characteristics, with the strongest correlations observed with the body weight and body surface area.

Keywords: Liver surgery; Anatomy; Practical application; Liver resection

Abbreviations: BSA: Body Surface Area; BMI: Body Mass Index; MAP: Maximum Abdominal Perimeter; 18F-FDG: 18F-Fluorodeoxyglucose; PET/CT: Positron Emission Tomography/Computed Tomography

INTRODUCTION

The increasing incidence rates of primary and secondary liver tumours have led to an increase in the number of surgical liver resections, with associated increases in postoperative complications [1]. Morbidity related to hepatic resection is dominated by three major risk factors: hepatocellular insufficiency, haemorrhage and bile leakage from the hepatectomy cross section [2-4]. Hepatectomy planning includes the assessment of remaining liver volume to avoid postoperative liver failure related to insufficiency of this volume relative to the patient's requirement [5-7]. This requirement is estimated by analysing preoperative anthropometric data, particularly the body weight and Body Surface Area (BSA) [8]. Thus, direct relationships exist among patients' morphological characteristics, the hepatic volume and perioperative complications. This study was performed to examine whether patients' morphological characteristics also influenced the surface area of the hepatectomy cross section, which is the main factor related to pre and postoperative haemorrhagic and biliary complications. We sought to identify anthropometric parameters correlated with this surface area under the assumption that they may influence the occurrence of these complications.

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MATERIALS AND METHODS

This retrospective study was conducted with data from consecutive patients followed in the neoplastic pulmonary pathology unit of the University Hospital Centre of Limoges, France, for whom the results of 18F-Fluorodeoxyglucose (18F-FDG) Positron Emission Tomography/Computed Tomography (PET/CT) were available in the institutional archives. Patients aged <18 years, pregnant women, those with histories of hepatic or vesicular surgery, those with primary or secondary hepatic tumours and patients with hepatic dysmorphism were excluded.

Morphological data

Patients' body weight and height were measured on the day of 18F-FDG PET/CT. Body Mass Index (BMI) was calculated using the formula: body weight [kg]/height $[m]^2$. Body Surface Area (BSA) was determined using the formula of Shuter and Aslani [9]:

$0.00949 \times \text{height (m)}^{0.655} \times \text{body weight (kg)}^{0.441}$.

Radiological data

Axial CT slices were analysed using the TELEMIS™ PACS software. The Maximum Abdominal Perimeter (MAP; cm) was measured radiologically on an axial section at the level of the greatest anteroposterior abdominal distance in the sagittal plane passing through the midline (Figure 1).

Sagittal reconstruction was performed in the plane passing through the right edge of the inferior vena cava and the middle of the gallbladder, which approaches the plane separating the right liver from the left liver, corresponding to that followed for right lobectomy resection (Figure 2). The surface area of the hepatectomy cross section (cm^2) was defined as the surface area of the hepatic parenchyma corresponding to this plane (Figure 3).

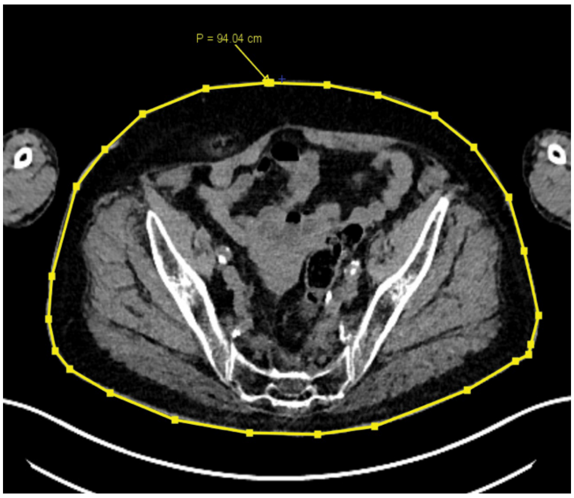

Figure 1: Maximum abdominal perimeter measurement.

Statistical analysis

Data were compared between male and female patients by Student's t-test. Correlations of anthropometric parameters with the measured surface area of the hepatectomy cross section were examined by Pearson's correlation analyses. The coefficients were taken to indicate weak (0.1-0.3), intermediate (0.31-0.5) and strong (0.51-1.0) correlations. In all analyses, $p<0.05$ was taken to indicate statistical significance.

We certify that the data were collected in accordance with the relevant governmental and institutional regulations and all human and this study have been performed in accordance with the ethical

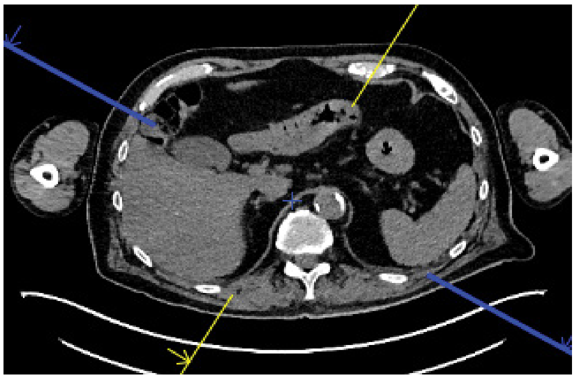

Figure 2: Right hepatectomy cross section.

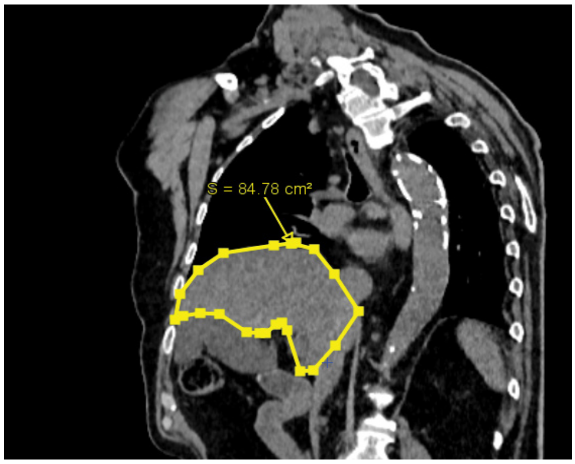

Figure 3: Measurement of the surface area of the cross section.

Table 1: Correlations between cross-sectional hepatectomy surface area and anthropometric parameters.

	All patients (n=140)	Females (n=71)	Males (n=69)
	Pearson's correlation coefficient (p-value)	Pearson's correlation coefficient (p-value)	Pearson's correlation coefficient (p-value)
Age (years)	-0.10 (0.26)	-0.11 (0.34)	-0.11 (0.37)
Height (m)	0.22 (0.008)	0.13 (0.27)	0.19 (0.12)
Body weight (kg)	0.31 (<0.001)	0.25 (0.03)	0.28 (0.02)
BMIa (kg/m^2)	0.26 (0.002)	0.22 (0.07)	0.24 (0.05)
BSAb (m^2)	0.31 (< 0.001)	0.25 (p=0.03)	0.29 (0.02)
MAPc (cm)	0.23 (0.005)	0.27 (0.03)	0.15 (0.21)

BMI: Body Mass Index; BSA: Body Surface Area; MAP: Maximal Abdominal Perimeter standards laid down in the 1964 Declaration of Helsinki and all subsequent revisions.

RESULTS

The study population comprised 140 patients (71 women and 69 men), with an average age of 65.14 ± 10.32 years. The average body weight was (70.38 ± 16.82) kg, the average BMI was 24.95 ± 4.63 and the average BSA was 1.76 ± 0.23 m^2. The mean surface area of the hepatectomy cross section was 73.23 ± 19.58 cm^2.

Relative to female patients, male patients were significantly taller (1.61 ± 0.07 *vs*. 1.73 ± 0.06 m, $p<0.001$) and heavier (61.86 ± 14.26 *vs*. 79.16 ± 14.66 kg, $p<0.001$), with a greater mean BMI (23.71 ± 4.74 *vs*. 26.23 ± 4.19) kg/m^2, $p<0.001$), MAP (92.90 ± 12.76 *vs*. 97.54 cm ± 11.47 cm, $p<0.05$) and BSA (1.63 ± 0.19 *vs*. 1.91 ± 0.18 m^2, $p<0.001$). The liver area did not differ significantly between male and female patients (78.32 ± 19.56 and 72.23 ± 19.26) cm^2, respectively; p=0.07.

In the total study population, the surface area of the hepatectomy cross section correlated significantly, but weakly, with height, BMI and MAP. Significant intermediate correlations were observed with body weight and BSA. In female patients, this area correlated weakly with body weight, BSA and MAP. In male patients, it correlated weakly with body weight and BSA (Table 1).

DISCUSSION

Among anthropometric measures, the strongest correlations with the surface area of the hepatectomy cross section were observed for the bodyweight ($r=0.31$, $p<0.001$) and BSA ($r=0.31$, $p<0.05$). These correlations were constant, regardless of patient sex.

The BSA and body weight are used for the adaptation of drug dosages because they are correlated with metabolism, particularly that in the liver. The morphology of the liver is related to the patient's anthropometric characteristics. Relationships of certain liver parameters with the body weight and BSA have been demonstrated. An early study demonstrated that the liver weight and measurements were related to the body weight, height and BSA in 24 patients [10]. In a CT study conducted with 369 patients in China, the liver volume was related to the BSA and correlated strongly with other morphological characteristics [11]. An equation for the calculation of liver weight from the BSA and body weight also has been proposed [12]. This relationship is independent of sex, as men and women with equivalent BSAs have been shown to have similar liver weights [12]. One limitation of this study was that the liver data were collected on autopsy, and thus *ex vivo* instead of in the normal anatomical position of the liver in life. As anatomical examination has shown that the inclination of the portal fissures of the liver differs between the *ex vivo* and *in vivo* conditions, the capacity for morphological analogy is unclear [13]. Formulas have been proposed for the calculation of the total hepatic volume from the BSA and body weight, based on the observation of similar correlations between the total liver volume and BSA in four centres, despite the use of different radiological equipment and reconstruction techniques [14].

Of the many correlations between hepatic morphological factors and patients' anthropometric characteristics, those with body weight and BSA are strongest. The use of such correlations between hepatic volume and morphological parameters is essential in the assessment of minimum remaining liver volume after hepatectomy and in the context of liver transplantation [8,15-17]. The minimum remaining liver volume required to avoid postoperative liver failure is >0.5% of the bodyweight [7]. Thus, patients' liver morphology and anthropometric characteristics directly influence the risk of complication occurrence after hepatic resection.

Other surgical complications that occur after hepatic resection include haemorrhage and biliary fistula on the hepatectomy cross section. We hypothesised that as these complications may be related to patients' anthropometric characteristics and liver morphology, they also may be related to the surface area of the hepatectomy cross section. We assumed that a larger surface area would be related to a greater risk of postoperative complication. Thus, we attempted to identify risk factors for complications that may be related to the surface area of the hepatectomy cross section. The relationship between the type of hepatectomy and postoperative bile leakage is unclear. However, major hepatectomy and anterior right or central hepatic resection appear to be associated with greater risks of complications, indicating that the position and size of the cross section affect complication occurrence [18]. However, the resection location appears to directly influence the complication risk, regardless of the surface area of the cross section. Resection of liver segments I, II and V seems to be associated with a greater risk of bile leakage [18]. In addition, anatomical resection reduces the risk of leakage, regardless of the surface area. A resection plan that extends beyond the portal fissures, such as extended resection of segment IVa or IVb, entails an increased risk of bile leakage [19]. Resection of segment IV is an independent risk factor for the development of bile leakage, due to the proximity of the biliary convergence and the possibility of hilar plate opening [19,20]. However, the development of biliary complications can still be related to risk factors that are dependent on patients' anthropometric characteristics, and thus to the liver morphology and surface area of the hepatectomy cross section. A history of hepatectomy, neoadjuvant chemotherapy, cholangiocarcinoma, blood transfusion, biliary reconstruction, obesity and long operation time are reported risk factors for bile leakage [18-20]. The latter two factors are potentially related to the surface area of the hepatic cross section. The effect of a long operation time, particularly a duration >5 hours, can be explained by difficulties in liver mobilisation or by portal hypertension, and possibly by the surface area of the hepatic cross section. Obesity, which is associated with metabolic syndrome, can lead to diffuse hepatomegaly and therefore an increased hepatic cross section surface area. It also prolongs the operation time due to the difficulty of mobilising the liver. With regard to the quality of the hepatic parenchyma, steatosis and cirrhosis are considered to be risk factors for postoperative complications, although some authors have suggested that cirrhosis is also a protective factor [18,19].

This study has two important limitations. First, the measurement of the selected area, although it approached the definition of right hepatectomy, was not strictly identical to that performed during actual intervention. Second, the morphology of the liver, and thus of the hepatectomy cross section, varies with the total hepatic volume and is related to the variable volumes of liver sectors and segments.

CONCLUSION

The liver morphology, and thus logically the surface area of the hepatectomy cross section, is influenced by the patient's anthropometric characteristics. This proposition was confirmed in the present study, and this surface area was also shown to increase with patients' body weight and BSA. Although these findings do not confirm a relationship between the surface area of the hepatectomy cross section and postoperative morbidity, greater surface areas were related to increased risks of complications.

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