

**Morphology and Morphometry of Fetal Liver at 16–26 Weeks of Gestation by
Magnetic Resonance Imaging – Comparison with Embryonic Liver at Carnegie
Stage 23**

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Running title: **The morphology and morphometry of fetal liver**

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Abstract

Aim: Normal liver growth was described morphologically and morphometrically using Magnetic Resonance Imaging (MRI) data of human fetus, and compared with embryonic liver to establish a normal reference chart for clinical use.

Methods: MRI images from twenty-one fetuses at 16–26 weeks of gestation and eight embryos at Carnegie stage (CS) 23 were investigated in the present study. Using the image data, the morphology of the liver as well as its adjacent organs was extracted and reconstructed three-dimensionally. Morphometry of fetal liver growth was performed using simple regression analysis.

Results: The fundamental morphology was similar in all cases of the fetal livers examined. The liver preferably grew along the transversal axis. The four lobes were clearly recognizable in the fetal liver but not in the embryonic liver. The length of the liver along the three axes, liver volume and four lobes correlated with the body weight (BW). The morphogenesis of the fetal liver on the dorsal and caudal sides was affected by the growth of the abdominal organs, such as the stomach, duodenum and spleen, and retroperitoneal organs, such as the right adrenal gland and right kidney. The main blood vessels such as inferior vena cava, portal vein and umbilical vein made a groove on the surface of the liver. Morphology of the fetal liver was different from that of the embryonic liver at CS23.

Conclusion: The present data will be useful for evaluating the development of the fetal liver and the adjacent organs that affect its morphology.

Keywords

Fetal liver morphology, morphometry, magnetic resonance imaging, prenatal period, three-dimensional reconstruction

Introduction

The liver occupies a large part of the abdominal cavity during most of the prenatal period and plays an important role in the development as functional organs.^{1,2} It develops into a hematopoietic organ after 6 weeks and at around 8 weeks, it begins to produce biochemical molecules such as albumin, bile, glycogen, and fetal-specific proteins that play an important role in development. The liver is involved in numerous metabolic processes as well as in endocrine cycles with the placenta. The evaluation of the growth of the fetal liver is very significant in not only understanding fetal liver growth but also assessing fetal physiology and well-being.³⁻⁸ The estimated liver volume and liver length are usually used as parameters for evaluating liver growth.³⁻⁸

Congenital anomalies of the liver are unexpectedly frequent (occurring in 19.3% of the patients) during laparoscopy.⁹ Anomalies in hepatic morphology are most often discovered during surgical interventions in adults. These facts imply that morphological anomalies tend to be neglected and overlooked, in spite of the progression in prenatal diagnosis.^{10,11} The advent of ultrasound (US) and Magnetic Resonance Imaging (MRI) enabled a more detailed study of the morphology of liver, which is potentially useful for prenatal diagnosis. It is essential to be aware of the morphological changes occurring during the fetal period and to define the normal limits of hepatic measurements. The present study was thus aimed at acquiring clinical references concerning the three-dimensional (3D) morphology and morphometry of the liver, as an addition to the previously used parameters – liver length and volume.

Materials and Methods

Human embryo specimens

Approximately 44,000 human embryos and fetuses, comprising the

“Kyoto collection” and considered historical specimens, are collected and stored at the Congenital Anomaly Research Center of Kyoto University.¹²⁻¹⁵ In most cases, pregnancy was terminated for socioeconomic reasons, under the Maternity Protection Law of Japan. Twenty-one fetuses at 16–26 weeks of gestation that were diagnosed as externally normal and eight embryos at CS23 (approximately 9–10 weeks of gestation) were studied.¹⁶ MRI images from embryos at CS23 were acquired as has been described elsewhere.¹⁷ MRI images from fetuses were acquired from the Kyoto University Hospital (Kyoto, Japan). All scans were conducted using a 1.5T MRI system (Excelart Vantage, powered by Atlas; Toshiba Medical Systems, Otawara, Japan) with knee or head coils. After getting the localizers, T1-weighted and T2-weighted images were acquired. For T1-weighted images, a 3D gradient-echo sequence was used with the following parameters: time-of-repetition (TR)/time-of-echo (TE), 30/7 milliseconds (ms); flip angle (FA), 50°; field-of-view (FOV), 180 × 135 mm; matrix, 256 × 192; and slices, 70–150 of 0.70 mm thickness, resulting in isotropic 0.70 mm resolution. T2-weighted images were acquired using a two-dimensional fast spin-echo sequence with the following parameters: TR/TE, 6000/108 ms; FOV, 180 × 135 mm; matrix, 256 × 192; and slices, 30–50 of 0.70 mm thickness, resulting in isotropic 2 mm resolution without inter-slice gap.

MR image processing and 3D reconstruction of the liver and adjacent organs

3D MRI image datasets for each fetus were obtained as DICOM formatted files. MRI image processing of the embryonic liver was performed as has been described elsewhere.¹⁸ Sequential two-dimensional (2D) images were resectioned digitally and 3D images were reconstructed using the software OsiriX™ (version 3.9, Pixmeo SARL, Geneva, Switzerland). Targeted

organs and regions of interest were segmented in a series of coronal-section images using the region of interest (ROI) module in OsiriX. 3D objects were computationally reconstructed with DeltaViewer™ [<http://delta.math.sci.osaka-u.ac.jp/DeltaViewer/index-j.html>].¹⁹ Morphogenesis of the liver and its adjacent organs was analyzed in detail using the 3D images.

Morphometry

An orthogonal coordinate system was defined using cranio-caudal (Z) axis, left/right (X) axis and dorsoventral (Y) axis. Lengths of the liver along the 3D orthogonal axes were defined as the transverse length (L_{TR}), dorsoventral length (L_{DV}) and cranio-caudal length (L_{CC}) (Fig. 1a).

The liver image was extracted from a series of coronal-section images, as described above. The volume of the whole liver (V_{Li}) and its four lobes, including the right lobe (R_L), left lobe (L_L), caudate lobe (C_L) and quadrate lobe (Q_L), was calculated by stacking the extracted liver image in a series of coronal-section images using the ROI module of OsiriX. The volume of the fetus and embryo was calculated using the Region Growing module in OsiriX.

Coronal section of the fetal abdomen, including the umbilical portion (UP), was selected for the measurement of sectional area of the abdomen (S_{Ab}) and the liver (S_{Li}) (Fig. 1b). The anatomical landmarks – inferior vena cava (IVC), UP, umbilical vein (UV) and fossa of the gall bladder (fGB) were used for subdividing the liver into the four lobes mentioned above.

The crown-rump length (L_{CR}) and trunk height (L_{TH}) were measured as the reference for the fetal growth and as the change in the cranio-caudal growth of the abdominal cavity, respectively. In the present paper, the humeral head was marked instead of the acromion used by Otani et al. (2008),²⁰ because the humeral head was more evident in our 3D images.

Simple regression analysis was performed between fetal body weight (BW) and morphometric data, i.e. L_{CR} , L_{TH} , S_{Ab} , S_{Li} , L_{TR} , L_{DV} , L_{CC} , V_{Li} , and the volumes of the four lobes of the liver.

This study was approved by the Committee of Medical Ethics of Kyoto University Graduate School of Medicine, Kyoto, Japan (E986).

Results

Fetal body weight and fetal growth

BW ranged between 80.6 g and 790.0 g. Both L_{CR} and L_{TH} , used as indicators of fetal growth, were found to correlate with BW ($R^2= 0.78$ for L_{CR} and 0.81 for L_{TH}) in the present study (Fig. 2a). S_{Ab} ranged between 5.18 cm² and 24.73 cm² and was also found to correlate with BW ($R^2= 0.96$ for S_{Ab}) (Fig. 2b).

Fetal body weight and morphometry of the liver

The length of the liver along the three axes correlated with the BW ($R^2= 0.82$ for L_{TR} , 0.89 for L_{DV} and 0.94 for L_{CC}) (Fig. 3a). The slope of increase was 0.048 for L_{TR} , 0.040 for L_{DV} and 0.028 for L_{CC} , suggesting that the rate of growth is firstly in the transverse direction, then in the dorso-lateral direction, and finally in the cranio-caudal direction. The ratios of L_{CC} to L_{TH} and of L_{CC} to L_{CR} were $36.0\pm7.7\%$ and $17.3\pm3.8\%$ respectively, which were almost constant irrespective of the BW (Fig. 3b).

S_{Li} ranged between 2.62 cm² and 148.89 cm² and correlated with the BW ($R^2=0.95$ for S_{Li}) (Fig. 3c). The ratio of S_{Li} to S_{Ab} was $55.0\pm8.6\%$, which was almost constant irrespective of the BW (data not shown).

The V_{Li} was also significantly correlated with BW ($R^2=0.90$) (Fig. 3d). The V_{Li} of an 80.6 g fetus was 2.98 cm³, while that of a 790.0 g fetus was

higher by approximately 13.3 times (39.65 cm^3).

The four lobes, R_L , L_L , Q_L and C_L , were divided and their volumes were calculated. All lobes were found to linearly correlate with BW ($R^2 = 0.92$ for R_L , 0.82 for L_L , 0.79 for Q_L and 0.94 for C_L) (Fig. 3e). The volume ratio of each lobe to total liver was almost constant irrespective of BW, i.e., $42.4 \pm 6.8\%$ for R_L , $32.4 \pm 5.3\%$ for L_L , $17.3 \pm 2.9\%$ for Q_L and $8.0 \pm 2.9\%$ for C_L , respectively (Fig. 3f).

The median and distribution of the morphometry data for the present study is summarized in Table 1.

Morphology of the liver

A 3D image of the liver was then reconstructed from all twenty-one fetuses (Fig. 4a). As anticipated based on the morphometrical study, the morphology was similar in all cases of the liver examined. The four lobes were clearly recognizable in the fetal liver. The liver grew preferably along the transversal axis and to the dorsoventral axis rather than the cranio-caudal axis (Fig. 4b).

Anatomical relationships with the liver and adjacent organs

3D reconstructions with the adjacent organs revealed that the morphology of the liver was affected by the adjacent structures. The cranial, lateral and abdominal surfaces of the liver curved smoothly because they were in contact with the abdominal wall and the diaphragm (Fig. 4a). The cranial surface of the liver was dome-shaped in 16–19 week old fetuses, while it was rather flat in the fetuses that were more than 20 weeks old. The thoracic organs, including the lungs and heart, and the liver were clearly separated by the developing diaphragm. Thus, the thoracic organs had no effect on the

morphogenesis of the liver during the fetal period.

The morphogenesis of the fetal liver on the dorsal and caudal sides was affected by the growth of the abdominal organs, such as the stomach, duodenum and spleen, and the retroperitoneal organs, such as the right adrenal gland and the right kidney (Figs. 5a, b).

The spleen formed hollows on the left-lateral regions of the dorsal surface of the liver (Figs. 5a-a, 4b). The stomach and duodenum ran around the C_L. The left lateral side of the C_L in contact with the lesser curvature of the stomach was smooth, while the side of C_L in contact with the duodenum was sharp edged; this became the hepatic portal region (Figs. 5a-b, 5c). The bile duct with gall bladder and portal vein (PV) contributed to the formation.

Retroperitoneal organs were located close to the dorsal-caudal side of the liver. The adrenal gland developed remarkably in the fetal period, with the right adrenal gland forming an indentation on the right lateral region of the dorsal surface of the liver (Fig. 5a-c), while the right kidney formed a soft hollow (Fig. 4a-d).

The small and large intestines were located close to the dorsal-caudal side of the liver, forming a wide and shallow hollow respectively in the caudal side of the dorsal surface of the liver (Fig. 5a-e, b).

The main blood vessels such as IVC, PV and UV made a groove on the surface of the liver. An apparent arch was made at the abdominal caudal edge of the liver for the umbilicus, including UV (Fig. 5c).

Comparison with the embryonic liver at CS23

Livers from 16-week-old fetuses (80.6–91.7 g, n=3) were selected and compared with those from CS23 stage embryos (approximately 9 and 10 gestational weeks) according to the liver volume, direction of growth, and surfaces and lobulations of the liver.

Liver volume: The fetal liver was $3.19 \pm 0.25 \text{ cm}^3$ in volume, more than 40 times larger than the embryonic liver ($0.08 \pm 0.03 \text{ cm}^3$) (Table 2).

Direction of growth: The liver grows preferentially in the dorsoventral direction (fetal/embryonic liver ratio; 4.10 times) than in the cranio-caudal and the transverse directions (3.38 times and 3.60 times respectively). The L_{DV}/L_{CC} , L_{TR}/L_{CC} increased slightly (1.20 times and 1.07 times respectively), while L_{CC}/L_{TH} decreased apparently (0.53 times).

Surfaces: The cranial, lateral and abdominal surfaces of the embryonic liver, which are in contact with the abdominal wall and the diaphragm, curved smoothly (Fig. 6a). Cranially, the embryonic liver formed a prominence at the right medial region, which may be influenced by organs in the thoracic region, especially the heart via the diaphragm (Figs. 6a, 6b). The cranial side smoothly continued to the dorsal abdominal wall without an edge. The caudal dorsal surface had remarkable hollows due to adjacent organs, such as the “imprint of the stomach”, and horizontal plane of the pyloric antrum on the caudal surface (Fig. 6a, 6b-*ii*). The right adrenal gland developed remarkably, forming a dent in the liver. The spleen, right kidney and bowel may also affect the morphology of the fetal liver, while they may not affect the embryonic liver at CS23.

Lobulations: The lobulations such as C_L and Q_L were not apparent in CS23 from outside, while they were present in the fetal liver.

Discussion

The evaluation of the growth and function of fetal liver is of utmost importance for understanding fetal physiology and evaluating fetal well-being. Up to now, liver volume and liver length have been used as valuable parameters for the determination of the status of fetal growth and nutrition.³⁻⁸ Recent advances in US and MRI have enabled a precise evaluation of 3D

structures, providing comprehensible and useful information for prenatal diagnosis.^{10,11,21} The larger field of view of MRI enables the investigator to better understand the morphology of the liver itself, as well as the relationship between the liver and its adjacent structures. The morphometric and morphological data provided in the present study will enable a better understanding of the morphogenesis of the liver and its relationship with the adjacent organs during the fetal period. Furthermore, it will prove to be useful for defining the normal limits of hepatic measurements other than the liver length and volume, which will be applicable for the clinical referencing of the 3D morphology and morphometry of the liver.

In the present study, the BW of the fetuses ranged from about 80 g to 800 g; in other words, the BWs varied by ten times. The liver volume correlated with the BW and the external morphology changed almost proportionally. Unlike the previous paper in which morphology was found to vary among the individuals,²² it did not vary in the present study. The main vascular system within the liver and other adjacent organs was almost complete by the end of the embryonic periods, which may have resulted in stability of the external morphology.²³ This conservative feature may be advantageous for fetal diagnosis because deviation from normal morphology can be easily detected.

The fetal liver was affected along with many organs on the dorso-caudal surfaces, not only in case of organs which were already affected by CS23 (i.e. the stomach, the pyloric antrum, the right adrenal gland), but also the spleen, right kidney, bile duct, gall bladder, bowel, and main blood vessels. The formation of C_L is apparent in the fetal liver. C_L results from several growing structures such as portal vein and bile duct with gall bladder, stomach and duodenum. The formation of C_L is one of the most remarkable features distinguishing fetal liver from embryonic liver.¹⁸ Precise morphological

observations may lead to the diagnoses of the conditions not only specific to the liver itself but also to the adjacent organs.

The fetal liver was not affected by the thoracic organs on the cranial surfaces. The cranial surface was smooth and dome-shaped in the 16 and 19 week-old fetuses, while it was rather flat in the fetuses that were more than 20 weeks old. The development of the diaphragm may have resulted in a clear separation between the chest and the abdomen. Conversely, the irregularity of the cranial surface of the liver may indicate abnormal development of the diaphragm. Congenital diaphragmatic hernia has an incidence of one in 2,500–3,000 live births and continues to be associated with significant perinatal mortality rates of around 30–55%.^{24,25} Decrease in the lung volume and abnormal positioning of the abdominal organs serve as clues for finding the disease. The present data suggest the possibility that the precise observation of the liver surface may also assist in the early diagnosis of the disease.

Morphological variations between the embryonic liver at CS23 and fetal liver at 16 weeks gestation were evident, though, due to technical reasons, the transitions were not fully analyzed in the present study. An MRI apparatus with 1.5T was used for studying the fetuses, while MRI microscope was used for the embryos, as described in the Materials and Methods section.¹⁷ Further development of the MRI apparatus may be needed for the acquisition of data for fetuses between 11 and 15 gestational weeks.

The present study provides data for better understanding of the morphogenesis of the liver and its relationship with adjacent organs. This can be used as a clinical reference for the 3D morphology and morphometry of the liver and its adjacent organs, in addition to pre-existing parameters such as liver length and volume.

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This study was approved by the Committee of Medical Ethics of Kyoto University Graduate School of Medicine, Kyoto, Japan (E986).

Figure legends

Fig 1 Morphometry of the liver

(a) An orthogonal coordinate system is defined using the cranio-caudal (Z) axis, left/right (X) axis and dorsoventral (Y) axis. Length of the liver along each axis is defined as cranio-caudal length (L_{CC}) and transverse length (L_{TR}) and dorsoventral length (L_{DV}) respectively. Li: Liver.

(b) Coronal section of the fetal abdomen including the umbilical portion (UP) was selected for the measurement of sectional area of the abdomen (S_{Ab} ; dashed line) and the liver (S_{Li} ; bold line). The anatomical landmarks used for subdividing the liver into four lobes are indicated. Fossa of gall bladder (fGB) and umbilical vein (UV) are located at the caudal region and not present in this plane. RL: right lobe, CL: caudate lobe, LL: left lobe, QL: quadrate lobe, IVC: inferior vena cava.

Fig 2 Simple regression diagram between fetal body weight and fetal growth

(a) Trunk height (L_{TH}) and crown-rump length (L_{CR}) by BW of the fetus.

(b) Abdominal area (S_{Ab}) by BW of the fetus.

Fig 3 Simple regression diagram between fetal body weight and morphometry of the liver

(a) Change in liver length measured along three axes. L_{CC} : cranio-caudal length, L_{TR} : transverse length, L_{DV} : dorsoventral length.

(b) Ratio of liver length and fetal growth (L_{TR}/L_{CC} , L_{DV}/L_{CC} , L_{CC}/L_{CRL} , and L_{CC}/L_{TH})

(c) Liver area (S_{Li}) by BW of the fetus.

(d) Calculated liver volume by BW of the fetus.

(e) Calculated volume of four lobes by BW of the fetus. RL: right lobe, CL: caudate lobe, LL: left lobe, QL: quadrate lobe.

(f) Schematic drawing indicating the proportion of each lobe to the total liver volume. RL: the right lobe, CL: caudate lobe, LL: left lobe, QL: quadrate lobe, IVC: inferior vena cava, UV: umbilical vein, fGB: fossa of the gall bladder, PV: portal vein.

The definition of each morphometric parameter is described in the Materials and Methods section (see also Fig 1).

Fig 4 Representative 3D images of the fetal liver

(a) Six-side view of the representative 3D reconstructed fetal liver.

(b) 3D images of the liver from three fetuses of different BWs. BW and calculated liver volume are indicated. Inferior vena cava (brown), portal vein (blue) and umbilical vein (yellow) are indicated.

Fig 5 Anatomic relationship between the liver and adjacent organs

(a) Dorso-caudal view of the liver. The symbols (i.e. *a-f*) indicated in the figure are mentioned in the text.

(b) Dorso-caudal view of the liver with adjacent organs. The liver (green), lung (blue), heart (red), adrenal gland and spleen (purple), pancreas (blue), stomach (orange), kidney (yellow) and bowel (brown) are reconstructed in the picture.

(c) Dorso-caudal view of the liver with inferior vena cava (IVC), portal vein (PV) and umbilical vein (UV).

(d) Dorso-caudal view of the liver with spleen (purple), pancreas (blue) and stomach (orange).

(e) Dorso-caudal view of the liver with adrenal gland (purple) and kidney (yellow).

Fig 6 Representative 3D images of embryonic liver

(a) Six-side view of the representative 3D reconstructed liver

(b) 3D images of the embryonic liver with adjacent organs.

i) Lateral view with thoracic (lung: blue, heart: red) and retroperitoneal organs (adrenal glands: purple, kidney: yellow).

ii) Dorso-caudal view with abdominal (stomach: orange) and retroperitoneal organs (adrenal glands: purple and kidney: yellow).

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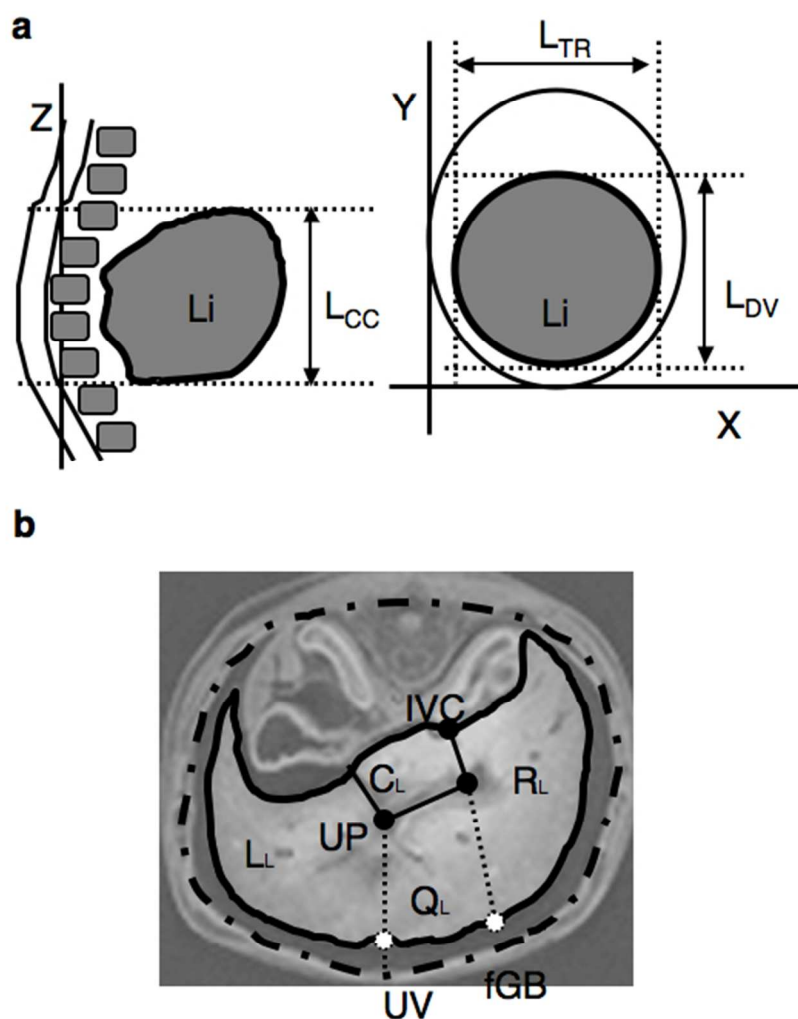


Fig1 Morphometry of the liver

- (a) An orthogonal coordinate system is defined using the cranio-caudal (Z) axis, left/right (X) axis and dorsoventral (Y) axis.
- (b) Coronal section of the fetal abdomen including the umbilical portion (UP) was selected for the measurement of sectional area of the abdomen (SAb; dashed line) and the liver (SLI; bold line).

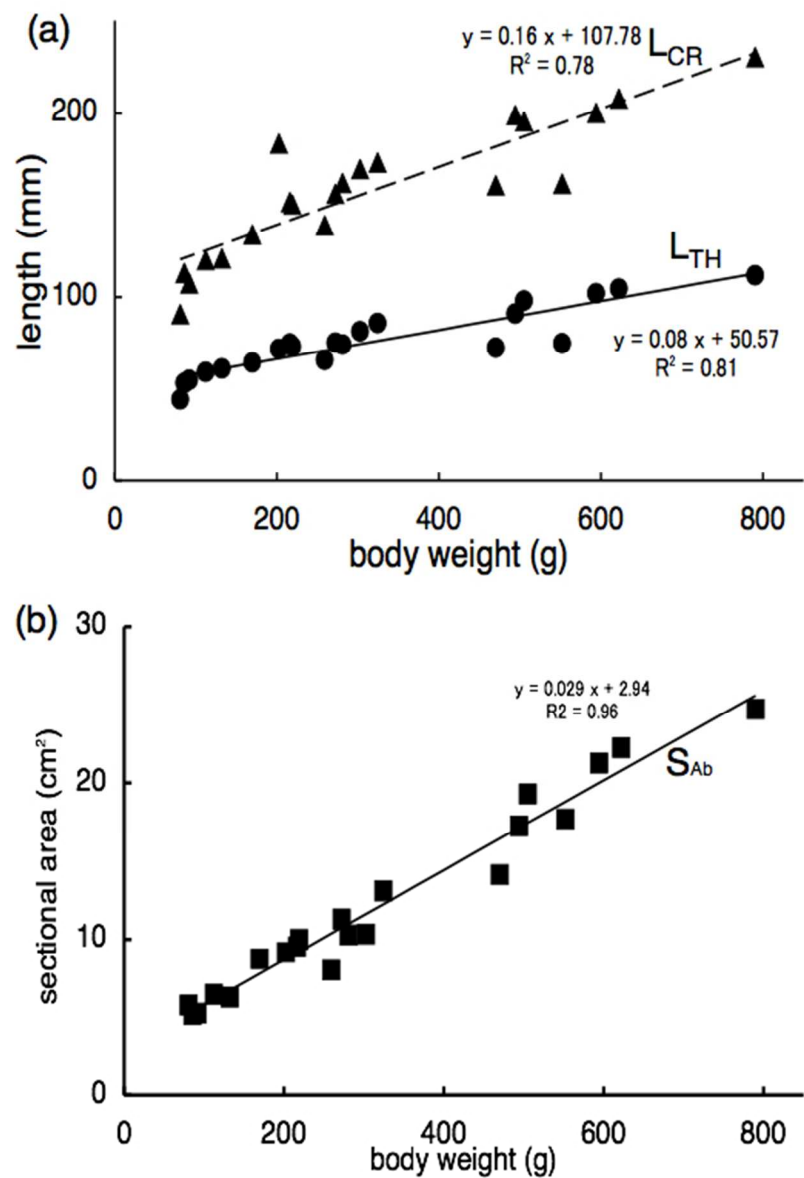


Fig2 Simple regression diagram between fetal body weight and fetal growth
(a) Trunk height (LTH) and crown-rump length (LCR) by BW of the fetus.
(b) Abdominal area (SAb) by BW of the fetus.

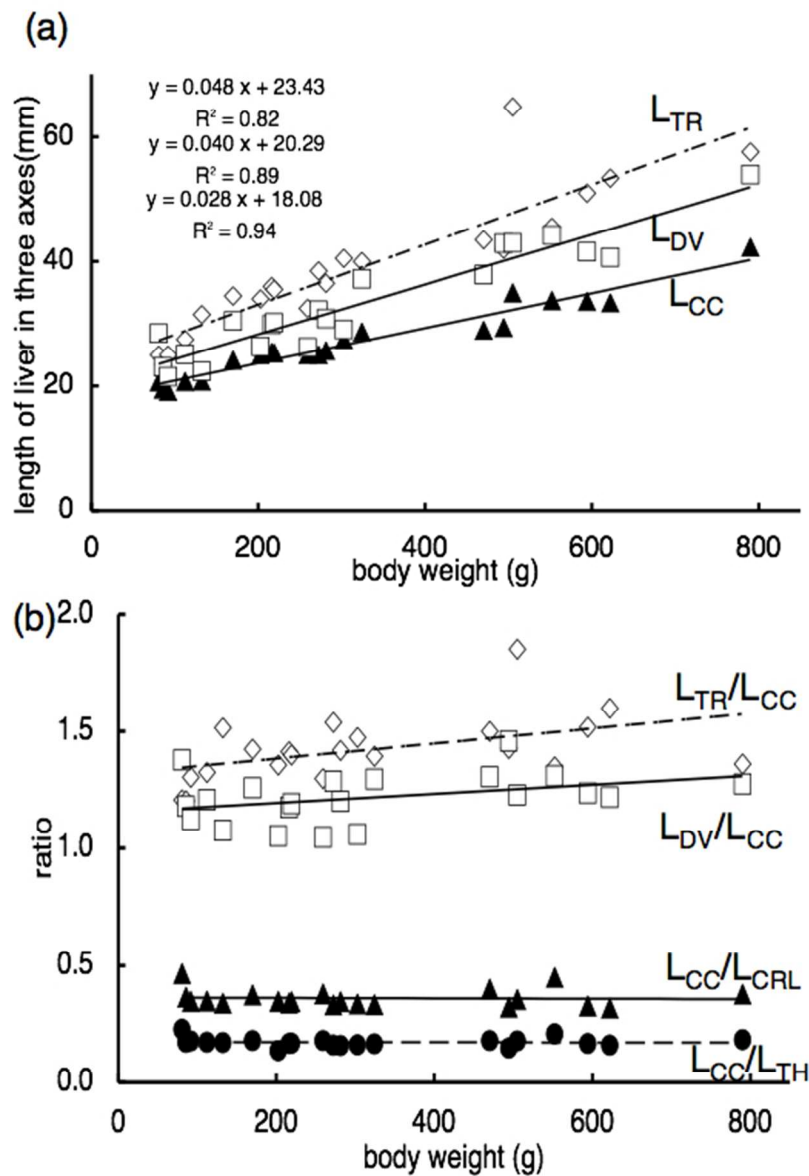


Fig.3 Simple regression diagram between fetal body weight and morphometry of the liver
 (a) Change in liver length measured along three axes. LCC: cranio-caudal length, LTR: transverse length, LDV: dorsoventral length.
 (b) Ratio of liver length and fetal growth (LTR/LCC, LDV/LCC, LCC/LCRL, and LCC/LTH)

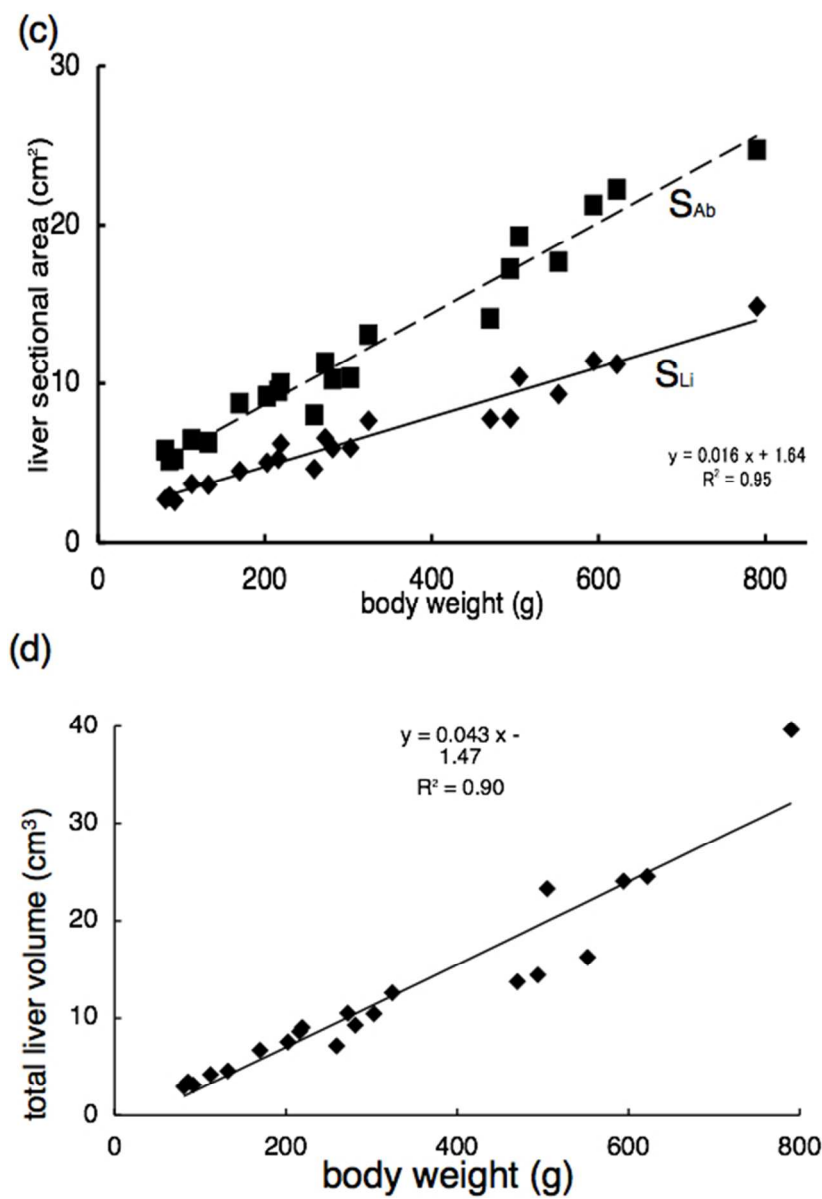


Fig3(c) Liver area (SLi) by BW of the fetus.
(d) Calculated liver volume by BW of the fetus.

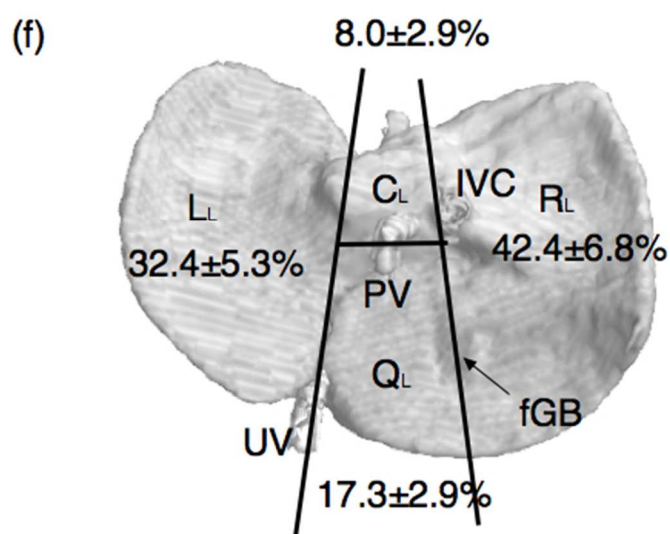
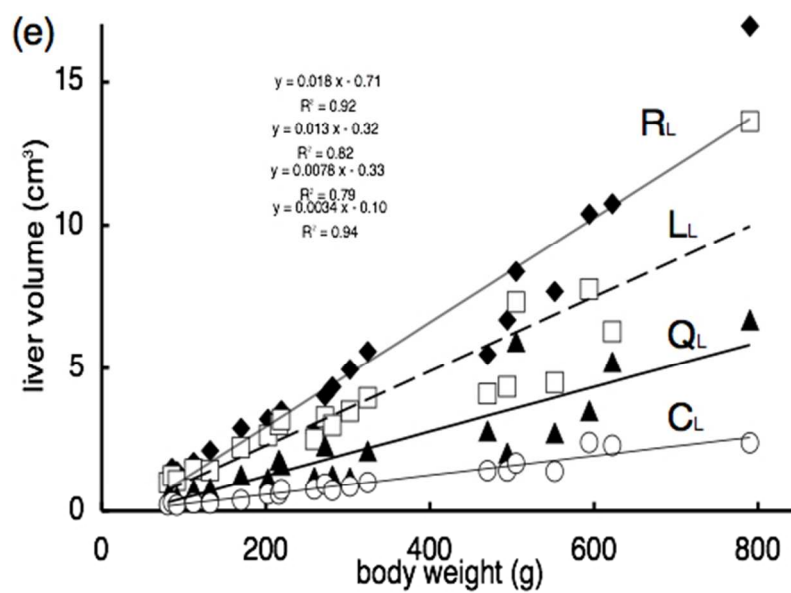
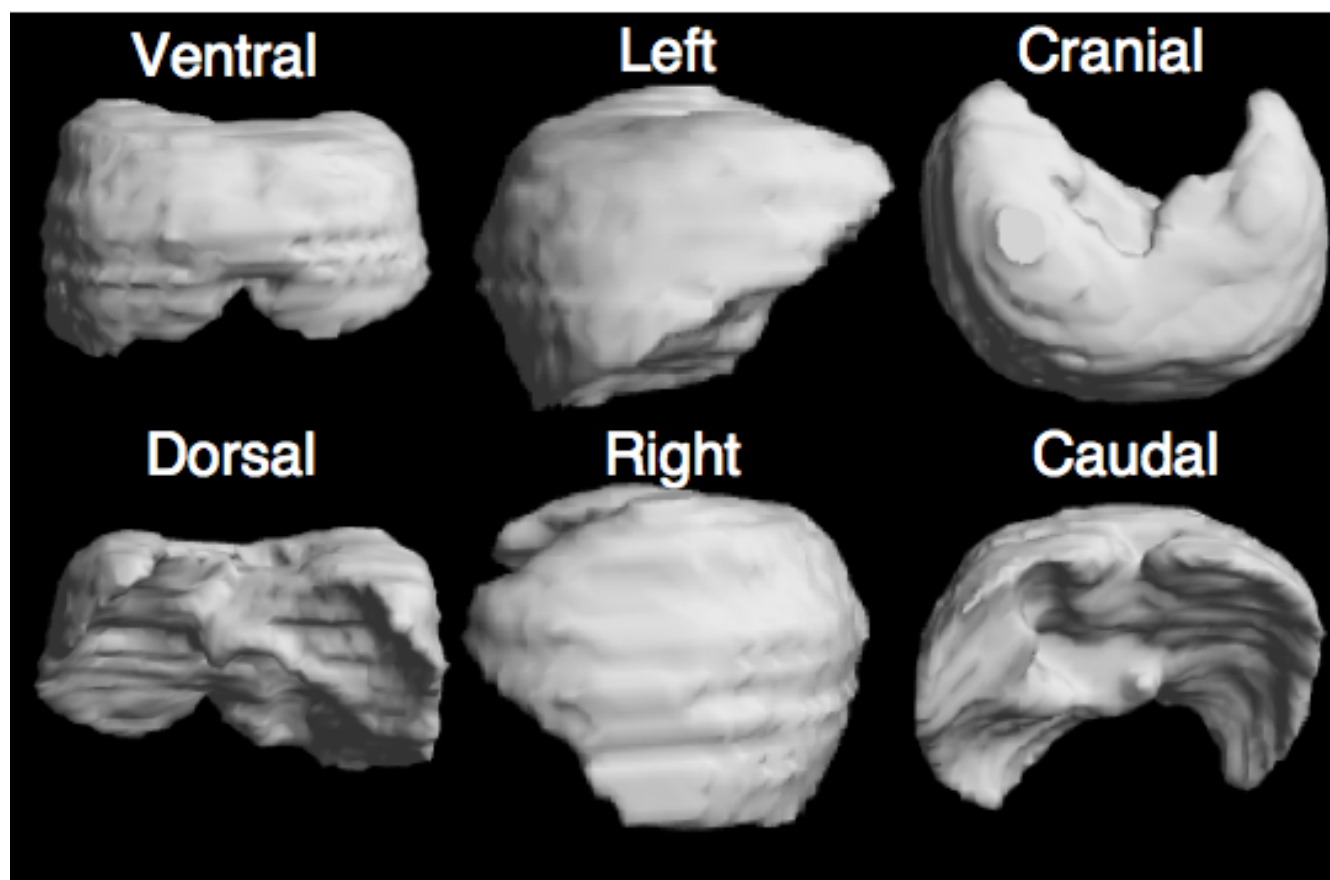


Fig3(e) Calculated volume of four lobes by BW of the fetus.
 (f) Schematic drawing indicating the proportion of each lobe to the total liver volume.

(a)



(b)



85.5 g
3.46 cm³

324.0 g
12.64 cm³

622.0 g
24.56 cm³

Figure 4

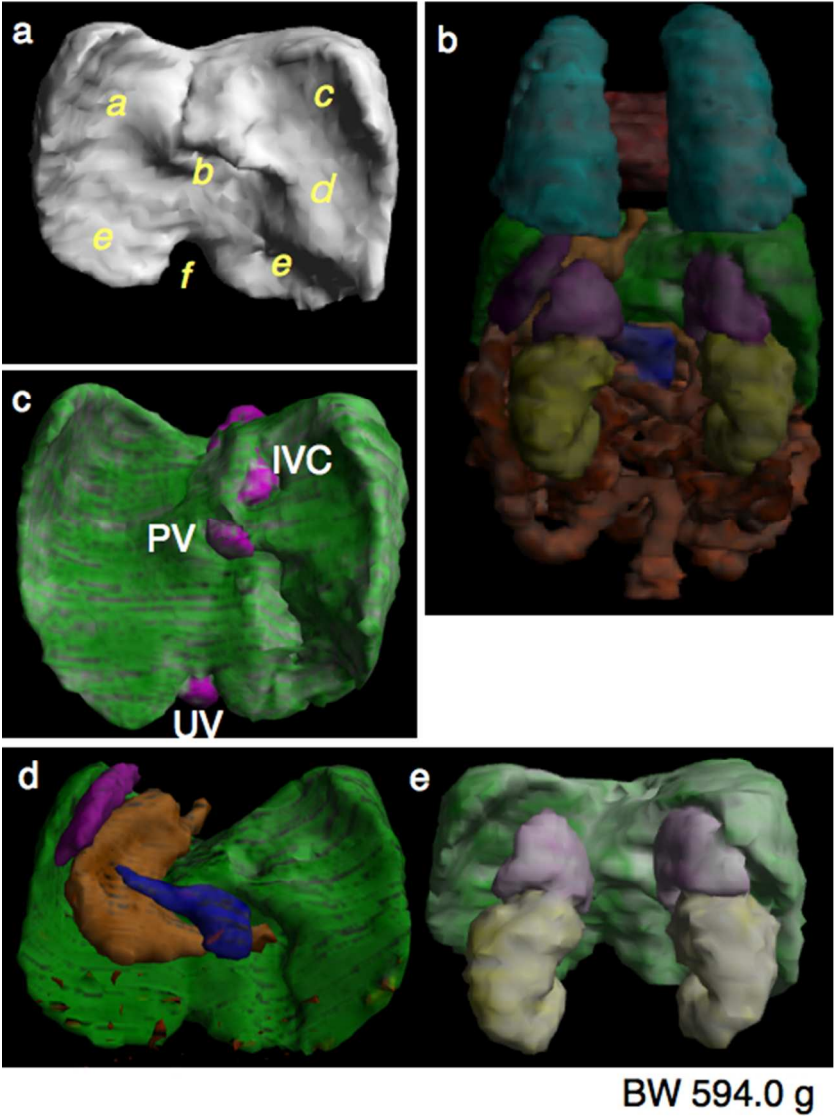


Fig5. Anatomic relationship between the liver and adjacent organs
(a) Dorso-caudal view of the liver. The symbols (i.e. a-f) indicated in the figure are mentioned in the text.
(b) Dorso-caudal view of the liver with adjacent organs. The liver (green), lung (blue), heart (red), adrenal gland and spleen (purple), pancreas (blue), stomach (orange), kidney (yellow) and bowel (brown) are reconstructed in the picture.
(c) Dorso-caudal view of the liver with inferior vena cava (IVC), portal vein (PV) and umbilical vein (UV).
(d) Dorso-caudal view of the liver with spleen (purple), pancreas (blue) and stomach (orange).
(e) Dorso-caudal view of the liver with adrenal gland (purple) and kidney (yellow).

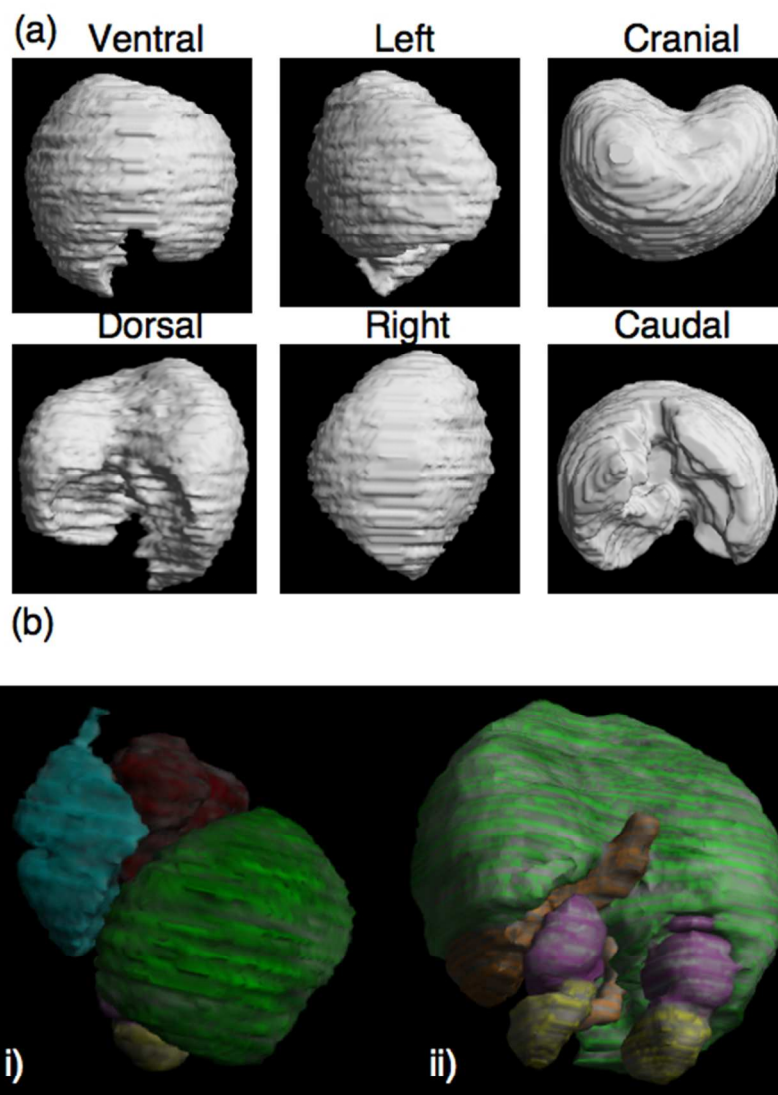


Fig.6

Representative 3D images of embryonic liver

(a) Six-side view of the representative 3D reconstructed liver

(b) 3D images of the embryonic liver with adjacent organs.

i) Lateral view with thoracic (lung: blue, heart: red) and retroperitoneal organs (adrenal glands: purple, kidney: yellow).

ii) Dorso-caudal view with abdominal (stomach: orange) and retroperitoneal organs (adrenal glands: purple and kidney: yellow).

Table 1 Summary of the fetal liver morphometry

Symbol	Description	Median	Distribution
Weight (g)			
BW	Body weight	272.0	80.6-790.0
Length (mm)			
L _{CC}	Cranio-caudal length	25.5	19.2-42.3
L _{DV}	Dorsoventral length	30.5	21.5-54.0
L _{TR}	Transverse length	36.5	23.5-57.6
L _{TH}	Trunk height	74.2	44.3-111.9
L _{CR}	Crown-rump length	161.1	91.0-230.6
Area (cm ²)			
S _{Ab}	Sectional area of the abdomen	10.29	5.18-24.73
S _{Li}	Sectional area of the liver	5.96	2.62-14.89
Volume (cm ³)			
V _{Li}	Liver volume	9.30	2.98-39.65
R _L	Right lobe	6.31	1.98-26.02
L _L	Left lobe	3.20	1.00-13.63
Q _L	Quadrangle lobe	1.62	0.49-6.70
C _L	Caudate lobe	0.76	0.20-2.38

Table 2 Comparison between fetus at 16 weeks of gestation and embryo at Carnegie Stage 23

	Embryo at Carnegie	Fetus at 16 weeks	fetal/embryonic
Morphometry	Stage 23 (n=8)	gestation (n=3)	liver ratio
	(mean $\pm$ SD)	(mean $\pm$ SD)	(times)
Body weight (g)	not weighed	85.9 $\pm$ 5.6	
Whole body (cm ³)	1.46 $\pm$ 0.43	79.4 $\pm$ 10.2	54.4
V _{Li} (cm ³)	0.08 $\pm$ 0.03	3.19 $\pm$ 0.25	41.2
Liver/whole body (%)	5.3 $\pm$ 1.1	4.1 $\pm$ 0.6	0.77
L _{CC} (mm)	5.9 $\pm$ 0.7	19.8 $\pm$ 0.8	3.38
L _{DV} (mm)	5.9 $\pm$ 0.7	24.4 $\pm$ 3.7	4.10
L _{TR} (mm)	6.8 $\pm$ 1.0	24.6 $\pm$ 0.9	3.60
L _{TH} (mm)	8.7 $\pm$ 1.4	50.9 $\pm$ 5.7	5.86
L _{DV} /L _{CC}	1.02 $\pm$ 0.06	1.23 $\pm$ 0.14	1.20
L _{TR} /L _{CC}	1.16 $\pm$ 0.04	1.24 $\pm$ 0.06	1.07
L _{CC} /L _{TH}	0.73 $\pm$ 0.06	0.39 $\pm$ 0.06	0.53
V _{Li} /(L _{CC} X L _{DV} X L _{TR})	0.31 $\pm$ 0.03	0.28 $\pm$ 0.07	0.89

L_{TR}; transverse length, L_{DV}; dorsoventral length, L_{CC}; craniocaudal length, L_{TH}; trunk height; V_{Li}; volume of the liver, SD; standard deviation