Veterinary Bioscience 1: Metabolism

Lecture 1.2 – The gross structure and anatomical relationships of the liver

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Keywords
Liver; gall bladder; diaphragm; hepatic ligaments; liver lobes; bile duct system; common bile duct; hepatic artery; portal vein; duodenum; caudal vena cava

Intended learning outcomes
At the end of this lecture you should be able to:

- Describe the gross anatomy of the liver and its attachments to other structures and organs
- Compare the position and orientation of the liver, relative to the midline and the other cranial abdominal organs, in the main domestic species
- Relate the passage of the caudal vena cava and oesophagus to the dorsal part of the liver
- List the structures entering and exiting the liver at the portal region
- Describe the relationship of the gall bladder and bile duct system to the gross structure of the liver.
- Describe the development of the liver in the embryo

THE LIVER –

Functions of the liver
The largest gland in the body and plays a key role in digestion. It is a haemopoietic organ during embryonic/foetal life
Metabolic conversions - After absorption from the gastrointestinal system, all the products of digestion are transported in the portal system to the hepatic cells, where they may be stored or further processed before entering the general circulation.
Other post-natal functions of the liver include:

Secretory function - Produces bile which is usually stored in the gall bladder
Excretory function - Converts end products of protein catabolism to urea and uric acid for disposal in the kidneys
Synthetic function - Produces globulin, albumin, prothrombin and most other clotting factors, acute phase proteins and carrier proteins etc.
Storage function - Serves to store starch and glycogen, fat and some protein
Detoxifies - Extracts harmful substances from the blood
Filters blood - Removes foreign particulate matter including the breakdown products of red blood cells which come from the spleen

Position/location
The adult liver is positioned **between** the **diaphragm cranially and** the **stomach and intestinal mass caudally**
It extends across the median plane, but the **bulk lies to the right in all species**
It is held in position largely by the pressure of the viscera and by its close attachment to the diaphragm.

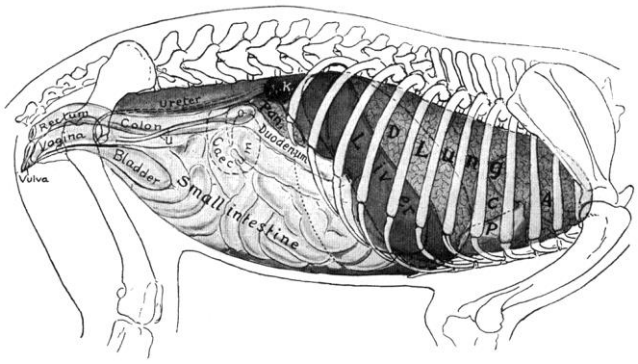


FIGURE 51–23. Projection of viscera of dog (female) on body wall; right side.

A, C, D, Apical, middle and diaphragmatic lobes of right lung; K, right kidney; O, ovary; P, pericardium; Pan., right lobe of pancreas; U, horn of uterus. Costal attachment and median line of diaphragm are dotted; also caudal contour of stomach.

Getty, 1975

External features

The **size and weight varies** within and between species, but generally:
3-5% of body weight in carnivores; 2-3% in omnivores and 1-1.5% in herbivores.
Well-fed animals have heavier livers, and weight decreases with age.

The liver is **reddish brown** in colour, firm in consistency but **friable**. It is **covered by peritoneum/serosa except for small areas** at the porta/hilus, in the fossa for the gall bladder and at the origins of various ligaments/peritoneal reflections.

A **tunica fibrosa encloses the parenchyma beneath the serosa.** It enters the parenchyma of the liver at the porta and distributes a branching trabecular network that conveys the blood vessels inwards. The finest trabeculae divide the liver into innumerable small polygonal units - the **classic hepatic lobule** - ~1 mm in diameter.

The liver has **two surfaces:**

Cranial (parietal) or diaphragmatic surface – **convex** and fits into the concavity of the diaphragm

Caudal or visceral surface - **concave** and in contact with the visceral organs.

The most indented region is the **porta of the liver** which contains:
the hepatic artery;
nerves and lymphatic vessels;
the portal vein
and the common bile duct.

also the **Fossa of the gall bladder,**
containing the gall bladder, which lies
between the quadrate and right medial lobes (dog).

(NB. The horse has no gall bladder).

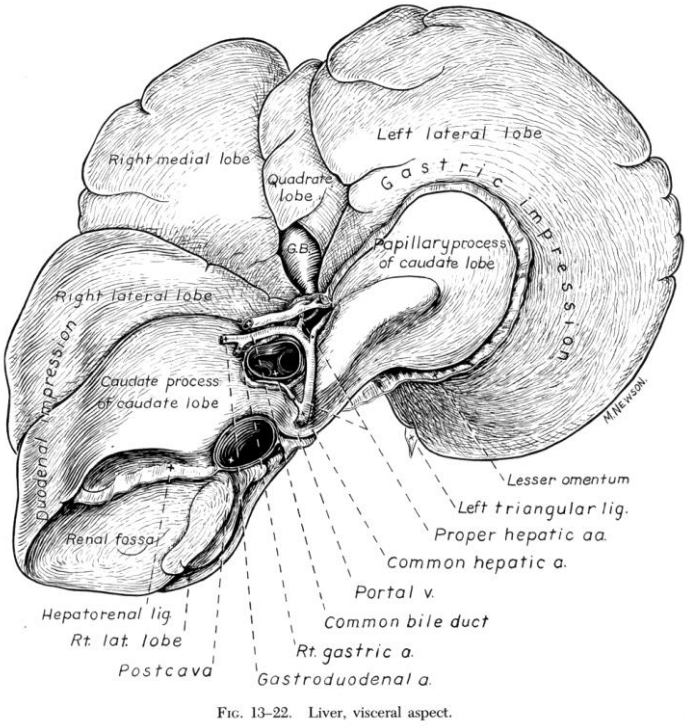


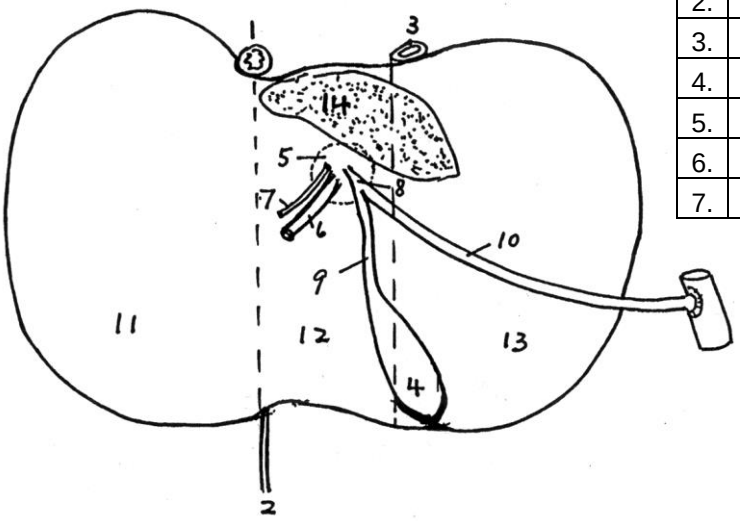
FIG. 13–22. Liver, visceral aspect.

The liver also has t**wo borders:**
Dorsal border - Is extended further caudally and dorsally on the right side by the caudate process which carries a deep impression for the cranial pole of the right kidney. Towards the median plane, the dorsal border carries a groove for the passage of the caudal vena cava and to the left of this a notch for the oesophagus

Ventral border - sharp edged and continuous around the periphery of the organ, except dorsally.

Lobes of the liver

The liver is grossly **divided into lobes** by a series of deep fissures that extend inward from the ventral margin.



1.	Oesophagus	8.	Common hepatic duct
2.	Round ligament	9.	Cystic duct
3.	Caudal vena cava	10.	Common bile duct
4.	Gall bladder	11.	Left lobe
5.	Portal area	12.	Quadrate lobe
6.	Portal vein	13.	Right lobe
7.	Hepatic artery	14.	Caudate process

Draw two imaginary lines on the visceral surface -
one from the **oesophageal notch to the ligamentum teres (round ligament)**
the other from the **caudal vena cava to the left border of the fossa of the gall bladder**
gives rise to the following lobes (in the dog) -

The **left lateral, left medial -** forms 1/3-1/2 the liver mass
The **quadrate -** deep wedge shape that lies essentially in the median plane
The **right medial, the right lateral**
The **caudate (caudate/papillary processes)** is usually the most caudal portion of the liver and is associated with the cranial half of the right kidney. The **papillary process** tends to **lie in the lesser curvatur**e of the **stomach.**

The **basic anatomical unit of the liver parenchyma is the hepatic lobule** (the **classical lobule).** It is 1.5-2mm long and 1mm in diameter**.** It is **well defined in the pig - giving the porcine liver a speckled appearance**

Ligaments

The ligaments that hold the liver in position are parts of the peritoneum, as such they were all more or less continuous with each other during embryonic development.

Ligaments - that pass from the **parietal surface of the liver to the diaphragm are:**

Coronary ligaments - as the falciform ligament passes up the diaphragmatic surface of the liver, the two layers of peritoneum that compose it separate when the caudal vena cava is reached. The layers diverge to right and left to become the right and left laminae of the coronary ligaments, which **form a connection between the liver and the immediately adjoining part of the diaphragm.**

Falciform ligament **-** forms a fat-filled fold in the dog, but it starts out as a narrow sickle shaped band with a free edge that begins on the **ventral wall of the abdomen near the umbilicus**. It passes forward from the abdominal wall **to** the diaphragm, gradually increasing in width until it reaches the **liver**, where its free border disappears into the **umbilical fissure**.

Right and left triangular ligaments **-** laterally the coronary ligaments are continuous with the right and left triangular ligaments and **attach the liver firmly to the left and right tendinous regions of the diaphragm**.

Miller et al, 1964

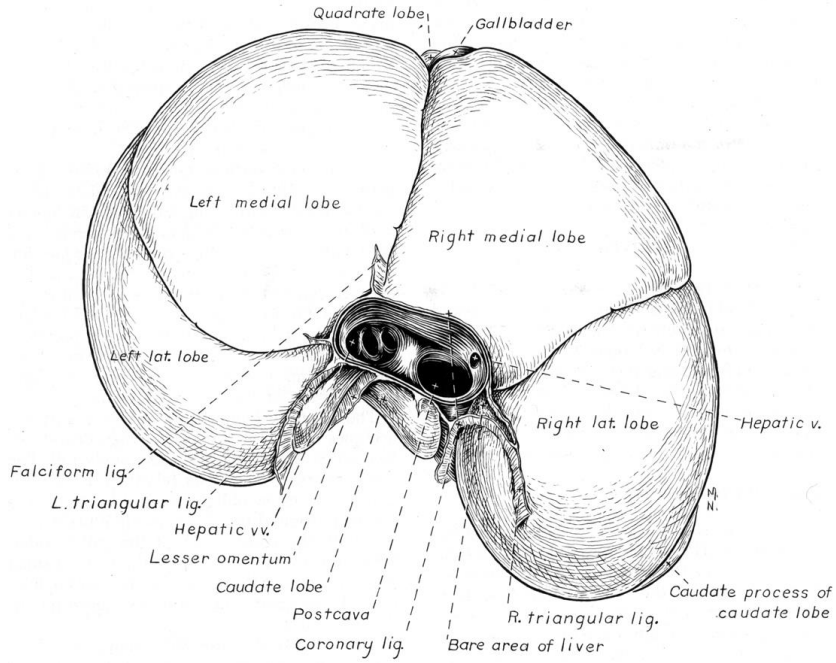


FIG. 13–21. Liver, diaphragmatic aspect.

Other ligaments:

Hepatorenal ligament - passes from the **caudate process to the ventral surface of the right kidney** (and the caecum). It develops as an offshoot from the right triangular ligament.

Round (ligamentum teres) of the liver is a slight **thickening of the caudal free edge of the falciform ligament**. It is the vestige of the umbilical vein.

Lesser omentum - Passes from the **visceral surface of the liver to the stomach (hepato-gastric) and duodenum (hepato-duodenal)**.

BILE DUCT AND GALL BLADDER

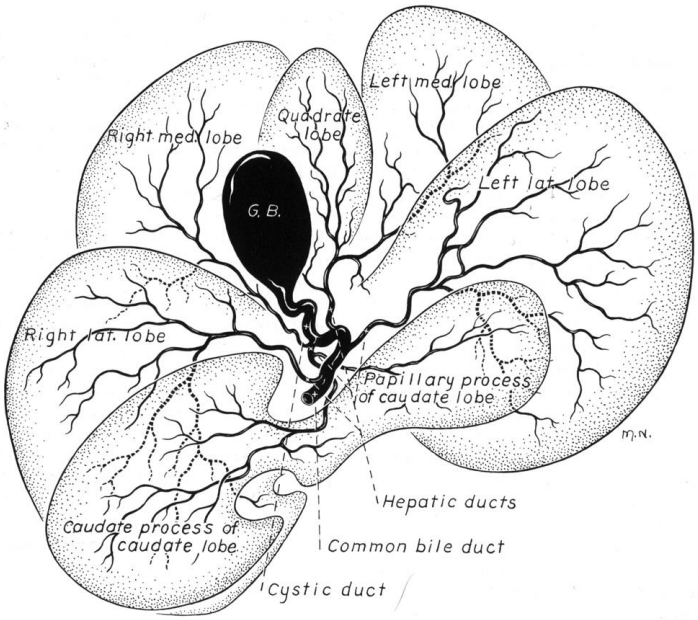
Bile Duct System

Begins with microscopic **canaliculi** within the lobules of the liver parenchyma. These open into larger ductules that, by successive unions within the connective tissue between the lobules, ultimately form **a few large hepatic ducts**.

Before or shortly after leaving the liver at the porta these combine in a single trunk **- the common hepatic duct**.

A tortuous side branch - the **cystic duct** - arises from the common trunk and leads to the pear-shaped gall bladder. The part of the **common trunk** that is **distal to the origin of the cystic duct is** known as **the bile duct or common bile duct**. It eventually runs to the duodenum, entering the dorsal or mesenteric border on the **major duodenal papilla**.

Variation in the duct system is frequent - Some hepatic ducts may enter the gall bladder directly; others may join the main outlet distal to the cystic duct



Miller et al, 1964

FIG. 13–23. Scheme of the gall bladder and hepatic ducts, visceral aspect.

Gall Bladder

Pear shaped organ
One side of the neck and part of the body are **tightly fused with the liver** (in the fossa of the gall bladder).
Where it is not fused with the liver, it has a peritoneal covering.
Generally **lies between the quadrate lobe medially and the right medial lobe laterally.**
May be regarded as a **diverticulum of the bile duct, enlarged to form a reservoir** for the storage of bile, with its neck continued by the cystic duct. **It stores bile during periods of digestive rest.**
It receives bile via the cystic duct - thus **bile can flow through the cystic duct in both directions.**

BLOOD SUPPLY TO THE LIVER

Receives blood from the **hepatic artery (branch of the celiac artery)** and the **portal vein**. The **relative importance of the two supplies varies among species**. The hepatic artery supplies 20-30% of the total blood supply, but provides around 60% of the gland's oxygen requirements.
The intrahepatic arteries run in company with the branches of the portal vein and the hepatic duct and supply the connective tissue structures before opening into the hepatic sinusoids along with the branches of the portal vein.
The portal vein is formed by the union of tributaries draining the digestive tract, pancreas and spleen.

All blood delivered to the liver is collected by a single set of veins - The central veins of the hepatic lobules form a few large hepatic veins that **drain into the caudal vena cava** as it tunnels through the liver substance.

DEVELOPMENT OF THE LIVER

The **hepatic diverticulum** - forms from the **ventral surface of the foregut** at the junction of the stomach and the duodenum. It g**rows** through the mesenteric mesenchymal cells **into** the mesoderm of **the septum transversum.**
The **endodermal cells of the hepatic diverticulum** differentiate into:

- Hepatocytes (**liver cells**) and the bile duct system and gall bladder
- **Mesodermal cells** of the **septum transversum** contribute to **blood vessels.**
- Blood stem cells from the yolk sac migrate into the liver to form blood islands, which form blood cells. (Thus at an **early stage of development the liver is haemopoietic).**

COMPARATIVE ASPECTS OF LIVER AND GALL BLADDER

<u>Dog</u>

The liver is **relatively large** in the dog - averages about 3-4% of body weight. Is **almost entirely "intrathoracic"**and the parietal surface is extremely convex. The ventral border extends across the costal arches and would be palpable except for the presence of fat in the falciform ligament. It is **deeply divided into five chief lobes** by fissures extending from the ventral margin. The centrally located papillary process, which protrudes from its dorsal part, is the most prominent feature of the visceral surface.

The **gall bladder -** is **sunk deeply between the quadrate and right medial lobes**, just to the right of the median plane opposite to the 8th intercostal space. Usually makes contact with the diaphragm, especially when distended.
Always appears at the visceral surface, but is too short to reach the ventral border.
The **common bile duct opens into the duodenum**, about **5-8cm distal to the pylorus**, usually in conjunction **with or** at least **near** the smaller **pancreatic duct on** the **major duodenal papilla**.
The discharge of bile depends on the activity of the duodenum. The sphincter of Oddi is a smooth muscle sphincter at the termination of the bile duct with the duodenum.

Horse

In the horse, the liver occupies a much **smaller proportion than in carnivore** - usually 1.5% body weight.
The **long axis runs obliquely**. Its highest point is at the **level of the right kidney** and its lowest point on the left side, usually **about 8-10cm from the abdominal floor, about the level of the costochondral junctions of the 7/8th rib**.
It is markedly asymmetrical - about **2/3 lies to the right of the median plane**.
The **visceral surface lies against the stomach, the duodenum, dorsal diaphragmatic flexure of the colon and the caecal base.**
The dorsal fixed border of the liver extends between the left and right triangular ligaments and is very irregular:
The long free margin (left, ventral and right borders) is sharper and is indented by a number of fissures:
Usually talk of **left, quadrate, right and caudate lobes in the horse** –
Right lobe is the largest-irregularly quadrilateral in form on its dorsal part is the caudate lobe and process.
Quadrate lobe is located between the right lobe and the falciform ligament which separates it from the left lobe.
The left lobe consists of a medial and lateral portion-lateral part is oval in outline and thickest centrally.

Duct system - NO GALL BLADDER, but duct system is wider to compensate.

> **Bile duct opens** into the cranial duodenum **on the papilla shared with the major pancreatic duct, about 13-15 cm distal to the pylorus** - known as the **hepatopancreatic ampulla**.

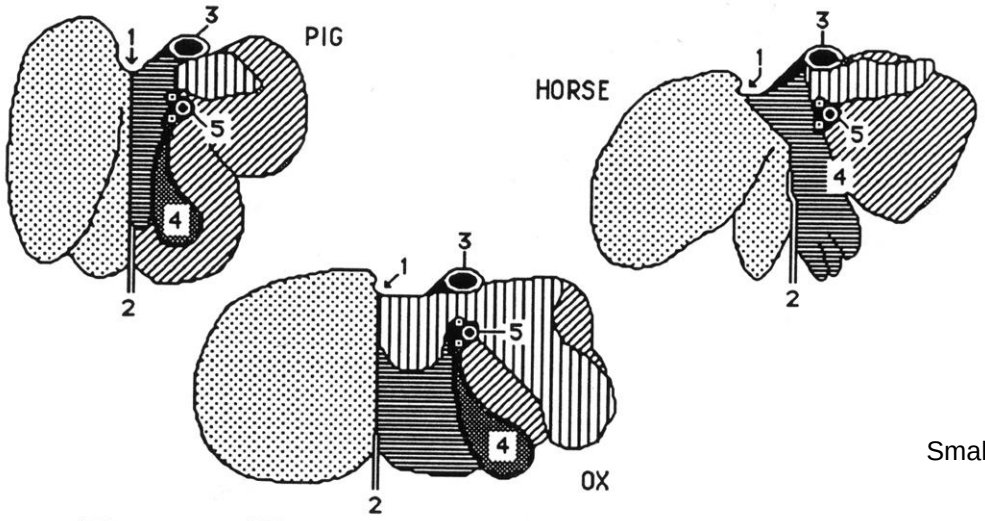
Cow

In the cow, the liver lies **in contact with the right abdominal wall, from the ventral end of the 7th rib to the last rib**. It lies **almost entirely to right of median plane** - rotated almost 90° from its position in the embryo and most other mammals - the **right lobe is dorsal** and the **left lobe is ventral** - this displacement is due to the development of the compound stomach on the left side of the abdomen.

The diaphragmatic surface faces dorsally cranially and to the right and the falciform ligament is attached along a line from the oesophageal impression to the notch for the round ligament. A long triangular area on the dorsal part of the surface is devoid of serous covering because it is attached to the diaphragm.

The **Visceral surface** is related to the reticulum, ruminal atrium, omasum, duodenum, gall bladder and pancreas.
Thick **dorsal (originally right) border** extends farthest caudally.
The **medial (originally dorsal) border** follows the midline rather closely. Towards its **lower end it is marked by an impression** that gives passage to the **oesophagus**. The **caudal vena cava tunnels through this edge** of the liver.
The **thin lateral (originally ventral) border is marked by the fissure** that marks the entrance of the **round ligament.**
The **piriform gallbladder projects beyond the lateral margin of the right lobe.**
There is no distinct pattern of liver lobulation.
The **bile (common bile) duct terminates in the second bend of the sigmoid flexure of the duodenum about 60 cm from the pylorus** in the adult cow.

The liver in the **sheep and goat** generally resemble that of cattle, though they are of course much smaller. The lobes are more distinct than in the ox. They are distinguishable from the calf liver by having a much deeper fissure for the round ligament; narrower and less bluntly shaped caudate process, and a more elongated gall bladder - the gall bladder fossa is more distinct. The pancreatic duct joins the bile duct before it reaches the duodenum and no dilatation (ampulla) is present in the duodenal wall.



Smallwood 1992

FIGURE 4–5. Livers of pig, horse, and ox, visceral surfaces.

1. Esophageal notch
2. Round ligament of liver
3. Caudal vena cava
4. Gallbladder, or point where gallbladder would have been in horse
5. Hepatic porta

Pig

In the pig, the liver is relatively large and **resembles that of the dog in lobation and position**.
It has three deep fissures that divide it into **four principle lobes - Left lateral and medial; right lateral and medial.**
The left lateral lobe is usually the largest. On the dorsal part of the right lateral lobe is the caudate lobe which is clearly marked off by a fissure. The caudate process generally does not make contact with the right kidney, therefore no renal impression. There is **no papillary process**. The short quadrate lobe is present centrally and lies ventral to the portal fissure.

The **high content of interlobular fibrous tissue outlines minute liver lobules** on the surface. These surface markings make isolated pig liver tissue readily identifiable- "Morocco leather" appearance.

The fundus of the gall bladder does not reach the ventral border of the liver and the **common bile duct opens at the duodenal papilla about 2.5-5 cm from the pylorus**.

Birds

The liver Is dark brown in the adult. It has right and left lobes, connected cranially by a bridge dorsal to the heart. Since birds lack a diaphragm, the lobes of the liver rather than the lungs embrace the caudal portion of the heart.
The larger right lobe carries the gall bladder in its visceral surface and is perforated by the caudal vena cava.
The left lobe is divided by a deep fissure into caudoventral and caudodorsal parts. Most of the parietal surface is convex and lies against the sternal ribs and sternum and is in contact with the thoracic air sacs. The cranioventral part of the parietal surface is concave where the lobes make contact with the apex of the heart.
The visceral surface is concave and makes contact with the spleen, proventriculus, gizzard, duodenum, jejunum and ovary.
Two bile ducts one from each lobe enter the distal end of the duodenum close to the pancreatic ducts. Only the duct from the right liver lobe is connected to the gall bladder. The pigeon, budgerigar and some parrots lack a gall bladder.

Further reading

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