Scientific Works. Series C. Veterinary Medicine. Vol. LXIII (2)
ISSN 2065-1295; ISSN 2343-9394 (CD-ROM); ISSN 2067-3663 (Online); ISSN-L 2065-1295

MACROSCOPIC ANATOMY OF THE GALLBLADDER AND EXTRAHEPATIC BILIARY TRACT IN THE GUINEA PIG (*CAVIA PORCELLUS*)

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Abstract

In mammals the variations of the anatomy of the extrahepatic biliary tree have long been recognized. The aim of this study was the macromorphological description of the gallbladder and extrahepatic biliary tract in guinea pigs (Cavia porcellus).Using dissection techniques the gallbladder topography, anatomic particularities regarding the shape and the connecting elements were assessed. Also, the macroscopic appearance of extrahepatic biliary tract and its path was described. The round and well developed gallbladder, exceeds the ventral border of the liver being visible on both, the visceral and the diaphragmatic surfaces of the liver. The gallbladder was connected with the right medial lobe and with the quadrate lobe of the liver by two tiny ligaments. Proximal, the unique cystic duct shows an obvious constriction and a conspicuous swelling. On its path on the hepatoduodenal ligament, the cystic duct joined the left hepatic duct to form the common bile duct. The right hepatic duct drained the right territory of the liver and joined the common bile duct itself. The left territory of the liver and in some cases the quadrate lobe was drained by the left hepatic duct. Distally, the common bile duct shows a unique ampullary dilatation from which a small duct drains into the first segment of duodenum. The major duodenal papilla was located at 1.5 cm distal to the pylorus.

Key words: *gallbladder, extrahepatic biliary tract, macroscopic anatomy, guinea pigs*

INTRODUCTION

The anatomy of the biliary tree involves complex relationship between the liver, intrahepatic biliary canaliculi, bile ductules, gallbladder and extrahepatic biliary tract (Barone 2009; Ellis, 2011). In animals, the obstruction of the extrahepatic tract is frequently present more than it is reported (Bacon et al., 2003; Amsellem et al., 2006; Miwa and Sladky 2016). Considering the many anatomical variations of biliary tract in mammals (Oldham-Ott and Gilloteaux 1997) a proper knowledge of the normal anatomy of the extrahepatic biliary tract is essential in order to prevent its injury during the surgery. Most liver anatomical descriptions contain descriptions of biliary tract too. Due to the extensive use of rats as experimental model in liver transplantation, the most studied is the rat liver (Higgins 1931; Madrahimov et al., 2006). With the exception regarding the absence of the gallbladder in rats, the macroscopic anatomy and connecting elements of the liver resemble the human anatomy of the liver. From the caviomorphs order, the chinchilla's liver was described having four lobes and a well developed gallbladder (Spotorno et al., 2004). The gallbladder is located between the right and medial lobes, having more than one cystic duct and a complex hepatic ducts system (Nowak et al., 2014). In guinea pigs the liver was described having six lobes (Cooper and Schiller, 1975; Breazile and Brown 1976; Stan 2014) and a well developed gallbladder attached to a fossa which delineates the quadrate lobe, drained by a cystic duct which receives several hepatic ducts to form the common bile duct (Higgins 1927; Quesenberry et al., 2004). In guinea pigs, the angioarhitecture, the inervation and the musculature of gallbladder and and bile ducts was assessed by scanning electron microscopy of vascular corrosion casts, histochemical methods and light electron microscopy (Aharinejad and Lametschwandtner 1992; Cai and Gabela 1983). In rabbit, the absence of the common hepatic duct was reported (Brewer

2006). Also, in humans, the biliary tract and its vascular anatomy show numerous anatomical variations (Lamah et al., 2001; Horiguchi and Kamisawa 2010). The aim of this study is to perform a detailed morphological description of gallbladder and extrahepatic biliary tract in guinea pigs.

MATERIALS AND METHODS

Ten adult guinea pigs, four male and six female (mean body weight 420±50g) were used. The Institutional Bioethics Committee of University of Agricultural Science and Veterinary Medicine in accordance to Directive 2010/63 /EU of the European Parliament and of the Council on the protection of animals used for scientific purposes approved the study. Euthanasia was performed by administration of an overdose of isoflurane. The abdominal cavity was opened and the wall of it was carefully removed. The gallbladder topography, its connecting elements and the extrahepatic biliary tract was recorded after the displacement on right and left side of the liver lobes, without altering hilum topography and its components.

RESULTS AND DISCUSSIONS

Gallbladder topography

The rounded shape of gall bladder (*Vesica fellea*) exceeded the ventral border of the liver, being visible both on diaphragmatic and visceral surface of the liver, in all examined specimens (Figure 1).

Its diameter was 9 mm ± 0.3 mm and the total length was 11 mm ± 0.1mm. The gall bladder was attached to a fossa (*Fossa vesicae felleae*) situated at the delineation of the right medial lobe and the quadrate lobe (Figure 1), showing an obvious transition zone at the neck and a small swelling on the beginning of the cystic duct (Figure 2).

Ventral edge of right medial lobe embraces the gallbladder fundus (*Fundus vesicae felleae*) being attached to the later by a small but conspicuous ligament. Also, on the left side, the gallbladder fundus was attached to the quadrate lobe by a second small ligament (Figure 3).

Figure 1 The rounded shape of the gallbladder in guinea pigs. The gallbladder exceeds the ventral border of the liver being visible on both visceral and diaphragmatic surfaces of the liver.

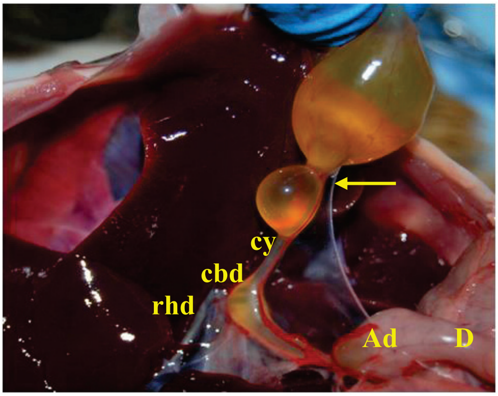

Figure 2 An obvious constriction and a small swelling found at the beginning of the cystic duct - arrow. Rhd –right hepatic duct join the common bile duct –cbd. Ad – ampularry dilatation.

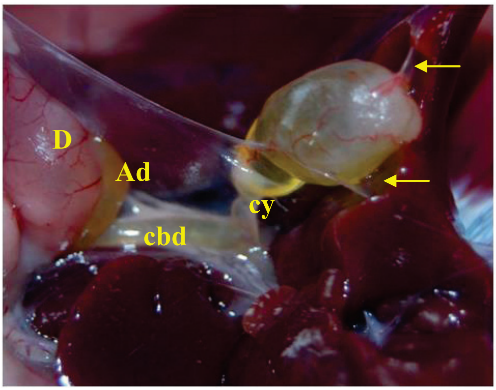

Figure 3 The gallbladder ligaments – arrows. The cystic duct – cy, join the common bile duct – cbd. Ampullary dilatation – Ad, of distal segment of common bile duct. D - duodenum

The extrahepatic biliary tract

The cystic duct (*Ductus cysticus*) diameter was 2 mm ± 0.2 mm making an acute angle with the common bile duct. (Figure 4).

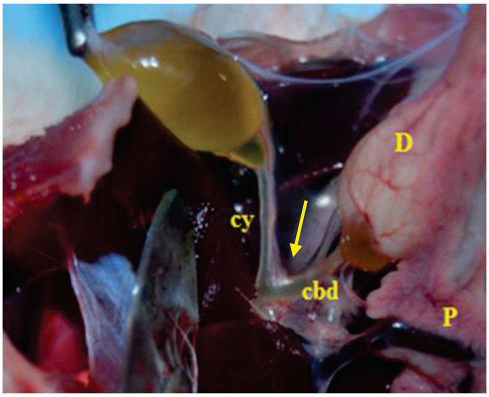

Figure 4 The cystic duct made an acute angle with the common bile duct - arrow

First, the cystic duct joins the left hepatic duct to form the common bile duct, the right hepatic duct draining at short distance after the mentioned union, on the right side of the common bile duct (Figure 5).

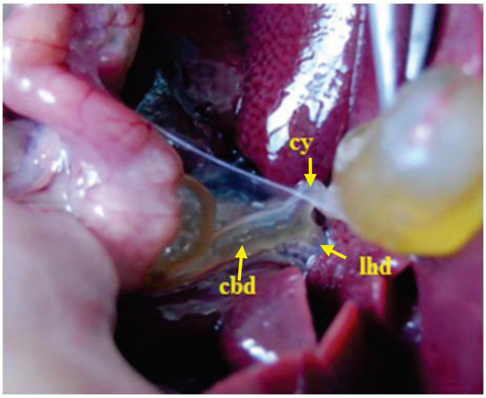

Figure 5 The union of cystic duct – cy, with the left hepatic duct – lhd, to form the common bile duct – cbd.

The right hepatic duct was formed by the union of the hepatic duct that drains the caudate process of the caudate lobe with the channel that drains the right lateral and right medial lobes. The left medial and lateral lobes and the quadrate lobe were drained by the biliary channels which merged to form the left hepatic duct. In three cases the quadrate lobe was drained by a separate channel that joined the cystic duct itself. Distally, above and attached of duodenal wall, the common bile duct shows a unique ampullary dilatation from which a small duct drains into the first segment of duodenum. Proximal of this dilatation the common bile duct showed a small contraction. The opening of the common bile duct observed through the duodenal lumen appeared like a slight elevation of the duodenal mucosa. The major duodenal papilla was located about 1.5 cm distal to the pylorus inside of the first segment of the duodenum (Figure 6).

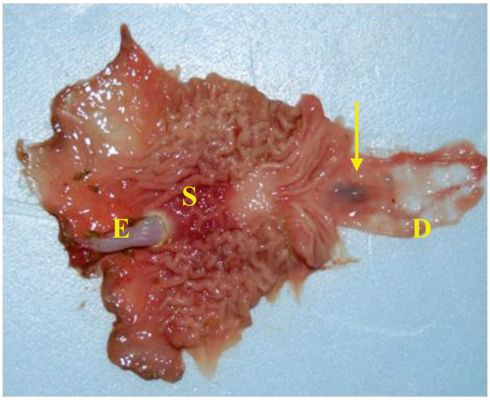

Figure 6 The major duodenal papilla (arrow) located about 1.5cm distal to the pylorus inside of the first segment of the duodenum – D. E – esophagus; S – stomach.

Like most of the mammals, excepting horse, deer, rat, European hamster which have no gall bladder, (Higgins 1931; Shiojiri 1997; Martin and Neuhaus 2007; Barone 2009; Hunyh and Pignon 2013) the guinea pigs show a well developed gall bladder. Different from humans, rabbit, chinchilla and hamster, the guinea pig gall bladder have a rounded shape. However, in contrast with many other species in which the gall bladder is firmly attached and covered by the liver lobes, the guinea pigs gall bladder, exceed the ventral edge of the liver. It was stated that the guinea pigs gall bladder is suspended by a single membrane from the liver with the reminder of the gall bladder hanging freely. Our result pointed out the presence of two small ligaments which connect the medial margin of the right middle lobe on the right side of the gall bladder and a second one between the gallbladder and the ventral edge of the quadrate lobe. Also, the obvious neck zone constriction is typical for the guinea pigs. This feature and the acute angle formed by the cystic duct with the gall bladder is the morphological explanation of bile stasis. Based on this feature and on the fact that guinea pigs form cholesterol gallstone when given 1% cholestyramine and a weight loosing pellet diet, using guinea pigs as experimental models in gallstone disease in human, is common. The bile stasis, abnormal bile composition, or infections are involved in gallstone formation both in human and guinea pigs (Wagner and Manning 1976). Both in normal or pathological conditions in humans has been found the presence, just below the gall bladder neck, of a dilated pouch at the cystic beginning, named Hartmans pouch (van Eijck et al. 2007; Ellis 2011). In six cases we found an equivalent dilatation, issue that has not been mentioned so far in guinea pigs. As in humans, this is a morphological aspect rather than an anatomic and constant feature.

The gallbladder and the extrahepatic ducts are subject to numerous variations, both in humans and animals, which are best understood by considering their embryological development (Shiojiri, 1997; Uemura et al., 2015). In some animals, including the rat, the deer, the horse and the pigeon, the gallbladder do not develop in embryonic state (Shiojiri 1997; Hisami, 2010; Uemura et al., 2015; Hill, 2017). On the other hand, it was stated that the variability of gallbladder anatomy in mammals is mainly dependent upon diet. Frequent eating of pigeons, rat and deer, which eat almost continuously, imply a continuous secretion and a constant flow of bile from the liver to the intestine, the presence of a gallbladder is not required. In other mammals, like human, cattle, dog or hamster which eats at times the bile is storage and concentrated in the gallbladder, being concentrated one to two times in cattle, four to ten times in dogs and eight to ten times in human and hamster . The anatomical variants of extrahepatic biliary tract include differences in terms of number of ducts, their length, and the manner of union and how the drainage in duodenum is made (Mahandevan 2014). In humans it is clearly stated formation of the common bile duct by joining the common hepatic duct (resulting from the union of the right and left hepatic ducts corresponding to the left and right territories of the liver) with cystic duct (Ellis 2011; Mahadevan, 2014). In rabbit Barone (2009) describe the presence of two hepatic ducts, the left one which drain the left lobes and the quadrate lobe too, joins the cystic duct to form the common bile duct, which receive the right hepatic duct, made by the union of the ducts which drain the right lobe and the caudate lobes. This description is in compliance with the description of Aharinejad and Lametschwandtner (1992) and Jackowiak and Lametschwandtner, (2005), regarding the absence of a common hepatic duct, but the latter authors, studying the angioarchitecture of the rabbit extrahepatic bile ducts and gallbladder, by scanning electron microscopy of vascular corrosion casts, have shown that, there is four or five hepatic ducts which individual join the cystic duct to form the common hepatic ducts. Also, in chinchillas, Novak et al, 2014 state the presence of a complex system of extrabiliary tract by description of multiple cystic ducts which drain the gallbladder together with a multiple anastomosing hepatic ducts running in the hepatoduodenal ligament.

The same pattern was found by Martin and Neuhaus,(2007) who noted that the extrahepatic biliary ducts of the rats are more superficial and also has intercommunicating branches, which implies the existence of a biliary network. Due to the absence of the gallbladder in rats, the common bile duct is made by the junction of the main hepatic ducts. Compare to all mentioned, in guinea pigs the extrahepatic biliary tract is simpler, the absence of a common hepatic duct is obvious and the variability consist of the presence of a different pattern of union of hepatic ducts with the cystic ducts to form the common bile duct, which make the guinea pigs a suitable model to gall stones pathogenesis.

Our results concerning the presence of the distal ampullary dilatation of common bile duct in guinea pigs, are in accordance with those of Higgins (1927) and Cai and Gabela (1983), who also described the common bile duct ampulla and its attachment to the duodenal wall. This is a unique feature of guinea pigs common bile duct and has not been described in other species.

CONCLUSIONS

The rounded gallbladder of guinea pigs exceeds the ventral margin of the liver. It presents a small constriction and an obvious swelling at the beginning of the cystic duct. The common bile duct is formed by the union of the cystic duct with the left hepatic duct. The common hepatic duct is missing in guinea pig. Distally and attached of duodenal wall, the common bile duct shows a unique ampullary dilatation from which a small duct drains into the first segment of duodenum. The major duodenal papilla opens at 1.5 cm distal to the pylorus.

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