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Observation of Intrahepatic Branching Pattern of the Portal Vein in Water Buffaloes of Iran

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ABSTRACT

The aim of study was to evaluate of intrahepatic ramifications of portal vein in water buffalo of Iran. Apparently 12 healthy and fresh livers of were selected from slaughterhouse and transferred to anatomy and radiology labs. To remove and discharge of blood clots, the portal vein of livers was perfused with normal saline. Then the livers divided in 3 groups and portal veins were studied by using corrosion cast, gross dissection and radiological examination. The results revealed that the portal vein divided at porta in to right and left interlobar branches. The right interlobar branch was short and large and the left branch was long and narrow. Right and left interlobar branch gave dorsal, intermediate and ventral interlobular veins and transverse and umbilical parts, respectively. Dorsal interlobular vein supplied dorsal part of right lobe, papillary and caudate processes of caudate lobe. Ventral interlobular vein divided in 3 branches that distributed in ventral parts of right and quadrate lobes. The intermediate interlobubar vein distributed in the diaphragmatic parts of right lobe and papillary process. The transverse part of left branch gave off several branches to papillary process of caudate lobe and few branches to quadrate lobe. The umbilical part of left gave off 3 branches, the dorsal, intermediate and ventral interlobular branches that radiated in to the left and quadrate lobes. Therefore, the pattern of intrahepatic branches of portal vein in water buffaloes of Iran is similar to other reports about water buffaloes, cattle and dog, less or more.

Key words: Portal vein, intrahepatic branches, gross dissection, corrosion cast, radiography, water buffalo

INTRODUCTION

Blood flow in the liver is regulated by 2 separate circuits the portal vein and hepatic artery, having different physiological controls. The portal vein is formed by union of tributaries draining the digestive tract, pancreas and spleen. It is connected to systemic veins in the cardioesophageal and rectoanal regions at the extremities of its territory. These connections provide alternative outlets for portal blood when the flow through the liver is obstructed or impaired. The effects of obstruction vary between species and reflect the varying effectiveness of the hepatic artery in supplying oxygen. In dog complete obstruction is rapidly fatal. After entering the liver, the portal vein divides into right and left branches that supply the liver chiefly (Dyce *et al*., 2002). The hepatic artery divides similar to the portal vein, both send their blood within the hepatic lobule

through the hepatic capillaries, which as liver sinusoid are specially permeable. The venous blood from the liver sinusoids reaches the center of the liver hepatic veins, which at the dorsal border of the liver, open into the embedded caudal vena cava (Dyce *et al.*, 2002). There are several reports about intrahepatic branches of the portal vein in man (Gupta *et al.*, 1977; Yamane *et al.*, 1988) and some domestic animals such as cow bovine fetuses (Zanco *et al.*, 1994), sheep (Heath, 1968), goat (Xu *et al.*, 1997) cat, rabbit (Heath and House, 1970), dog (Kalt and Stump, 1993; Carlisle *et al.*, 1995), camel (Tadjalli and Akhavan, 2003) and horse (Tadjalli and Moslemy, 2007). Anuredha Roy *et al.* (2002) and Anuradha and Singh (2004) stated that Like other animals and men, the portal vein tributaries are in general satellites of the corresponding arteries in water buffalo. They studied portal vein branching of water buffalo by Venography and gross dissection. Anuradha and Singh (2004) reported that the portal vein divided into right and left interlobar vein. Then each right and left branch divides in 3 and 2 interlobular branches, respectively and each interlobular branches gave off two or more intralobular veins that supplied liver paranchyma. However, there is no other information on the intrahepatic branches of hepatic portal vein in water buffalo and specially about water buffaloes of Khuzestan province of Iran, so this study was conducted to determine the branching pattern of portal vein in livers of these animals.

MATERIALS AND METHODS

During 2008/11/1 to 2009/11/1 apparently 12 healthy and fresh livers of adult water buffaloes of either sex (6 female and 6 male) were selected from slaughterhouse of Ahvaz city of khouzestan province of Iran. The age of animals and the weight of their livers was between 5-8 years and 2-2.5 kg, respectively. The specimens' transfered to anatomy and radiology Departments of Faculty of Veterinary Medicine of Shahid Chamran University of Ahvaz, Iran. To remove and discharge of blood clots, the portal vein of each liver was perfused with normal saline and the livers divided in 3 groups. Then, to recognizing intrahepatic branches of portal vein, three different methods of anatomical and radiological techniques were employed:

Corrosion casting: Four livers were selected and the portal vein of each liver was cannulated and injected with 100 mL resin which was prepared from Rodopas with a suitable amount of blue microlite. After hardening of resin in the 4°C for 48 h, the specimen was macerated in a 2% potassium hydroxide solution to produce vascular casts of the portal vein and its ramifications.

Gross dissection: The portal vein of four livers dissected by use of routine dissection and the courses and branches of portal vein were studied.

Radiography: By use a cannula into the portal vein of the remaining four livers, the radio-opaque suspension (urographin 25%) was injected and the livers were radiographed in different profiles to obtain the venographs depicting the pattern of portal vein ramifications. Finally the results of three methods were compared and studied carefully and noted.

RESULTS

The results revealed that in the water buffalo, the portal vein enters into the porta hepatis on the visceral surface of the liver (Fig. 1, 2). The portal vein divided at porta in to right and left interlobar branches (Fig. 1, 3, 4). The right interlobar branch was short and large and the left branch was long and narrows (Fig. 3, 4). Right interlobar branch gave dorsal, ventral and

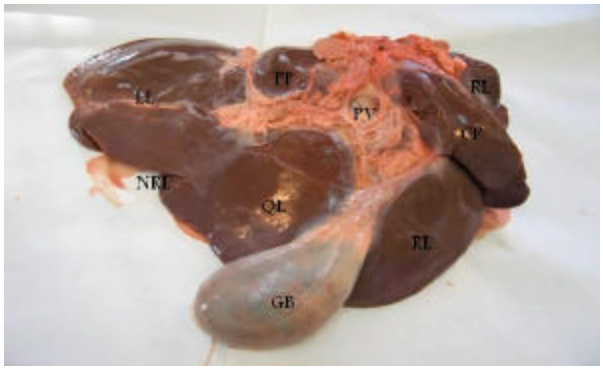

Fig. 1: Visceral surface of liver in water buffalo indicating Left Lobe (LL), papillary process of caudate lobe (PP), Quadrate Lobe (QL), Portal Vein (PV), Gall Bladder (GB), Right Lobe (RL), caudate process of Caudate Lobe (CP) and Notch of Round Ligament (NRL)

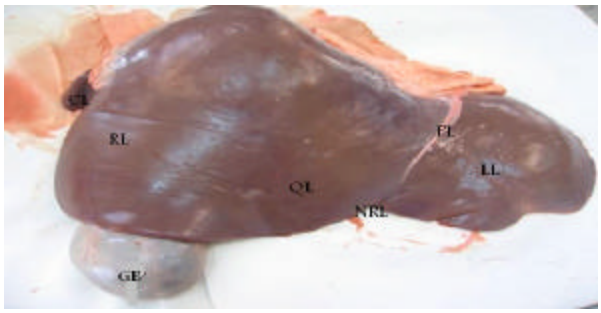

Fig. 2: Parietal surface of liver in water buffalo indicating Left Lobe (LL), Falciform Ligament (FL), Notch of Round Ligament (NRL), Quadrate Lobe (QL), Gall Bladder (GB), Right Lobe (RL) and quadrate lobe (CL)

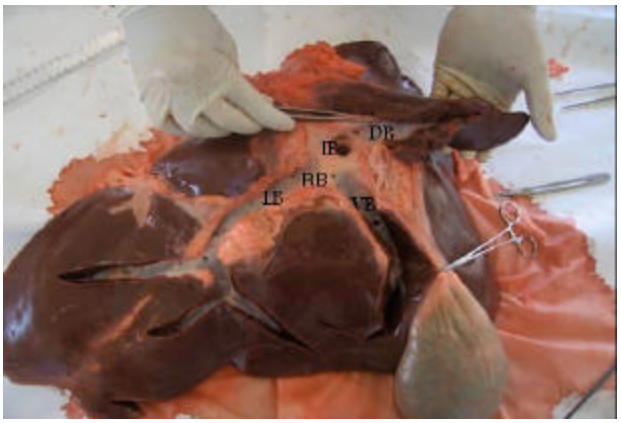

Fig. 3: Gross dissection of right branch of portal vein: Left Branch (LB), Right Branch (RB), Intermediate Branch (IB), Dorsal Branch (DB) and Ventral Branch (VB)

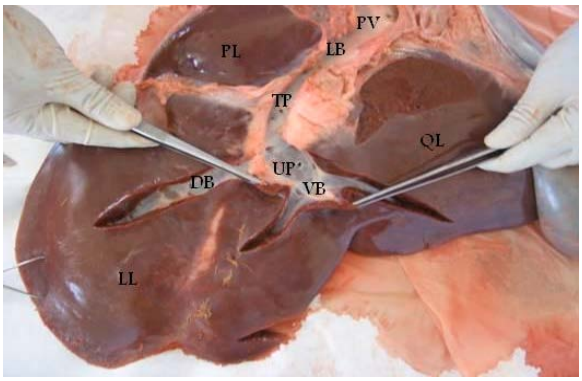

Fig. 4: Gross dissection of left branch of portal vein: Portal Vein (PV), Left Branch (LB), Transverse Part (TP), Umbilical Part (UP), Dorsal Branch (DB) Ventral Branch (VB), Left Lobe (LL), Quadrate Lobe (QL) and Papillary Lobe (PL)

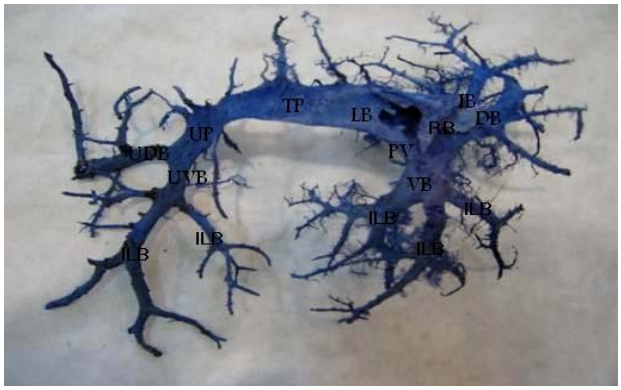

Fig. 5: Branches of the portal vein and their tributaries in liver of water buffalo, visceral surface (corrosion-cast): Portal Vein (PV), Right Branch (RB), Intermediate Branch (IB), Dorsal Branch (DB), Ventral Branch (VB), intralobular branch (ILB), Left Branch (LB), Transverse Part (TP), Umbilical Part (UP), dorsal branch of umbilical part (UDB) and ventral branch of umbilical part (UVB)

intermediate interlobular veins (Fig. 3, 5, 6). Dorsal interlobular vein supplied dorsal part of right lobe, papillary and caudate processes of caudate lobe. Ventral interlobular vein divided in 3 branches that distributed in ventral parts of right and quadrate lobes. The intermediate interlobubar vein had horizontal course and distributed in the diaphragmatic parts of right lobe and papillary process. The left interlobar branch runs at first in the long axis of the liver from porta toward the left lobe and at the boundary between the quadrate and left lobes it bends nearly sharply 80 degree toward the notch for round ligament (Fig. 4, 5, 6). So, it had transverse and umbilical parts. Transverse part that extends from the porta to flexure was nearly 11-12 centimeters length and gives off several branches to papillary process of caudate lobe and few branches to quadrate lobe (Fig. 4, 5, 6). The umbilical part of the left interlobar branch gives off 3 branches; the dorsal, intermediate and ventral interlobular branches that radiated in

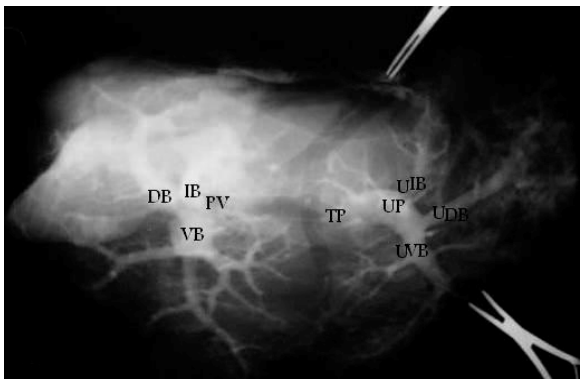

Fig. 6: Radiography of portal vein in liver of water buffalo, diaphragmatic surface: Portal Vein (PV), Intermediate Branch (IB), Dorsal Branch (DB), Ventral Branch (VB), Left Branch (LB), transverse part of left branch (TP), Umbilical Part (UP), intermediate branch of umbilical part (UIB), dorsal branch of umbilical part (UDB) and ventral branch of umbilical part (UVB)

to the left and quadrate lobes (Fig. 4, 5, 6). There was no difference between male and female of buffaloes in relation to ramification pattern of portal vein.

DISCUSSION

The main purpose of this study was to convey a more precise explanation of the intrahepatic branches of the portal vein within liver of water buffalo of Iran. The results of three methods used for investigation of ramification of portal vein revealed that liver of buffalo received functional supply through portal vein as in dog (Dyce *et al.*, 2002). The portal vein carry blood which has already passed through the capillary beds of alimentary tract, spleen and pancreas bring approximately 75% of the afferent blood volume to the liver (Ghoshal *et al.*, 1981; Nickel *et al.*, 1979). This blood is rich in nutrient and other absorbed substances but is relatively poor in oxygen (Frandson *et al.*, 2003). This investigation revealed that portal vein divided in porta into 2 main (right and left) interlobar branches. The right interlobar branch was short and stout vein and immediately divided in 3 main braches. However, the left branch of was longer, prominent and the main continuation of portal vein. On the basis of literatures, the portal vein in cow (Zanco *et al.*, 1994) and dog (Kalt and Stump, 1993; Schmidt *et al.*, 1980) also divides immediately upon entering the liver into a very short right branch and a long left branch. Carlisle *et al.* (1995), however, stated distinct branches for each liver lobe in dog. The major branches were the left lateral, left medial, quadrate, right medial, right lateral and caudate with branch to the papillary process. Then, the right interlobar vein divided into 3 interlobular veins; dorsal, ventral and intermediate branches. Getty (1975), however, stated that in cow right branch divided immediately into 4 to 5 secondary branches; the branch to the caudate process, right dorsal branch, 1 or more right intermediate branches and the right ventral branch.

In sheep (Heath, 1968), the portal vein enters the liver porta and immediately receives a small vein from the gallbladder and the cystic duct and then divides into the left and right branches.

In human (Gupta *et al.*, 1977), the division of the portal vein was always extrahepatic and in 88% of cases it is divided into the right and left branches; in 12% of cases, it is divided into three

branches out of which two branches; the anterior and posterior segmental veins, supply the right lobe and one branch, corresponding to the left branch, supplied the left lobe.

In rabbit (Heath and House, 1970), the caudate branch emerges from the portal vein that extends dorsally to the right to supply the caudate lobe. The portal vein then continues in a cranioventral direction and divides into a right branch which passes ventrally and a left branch which curves ventrally and to the left. Heath and House (1970) reported that in cat, three main branches of the portal vein, the so-called caudate, right and left branches, can be identified. The caudate branch emerges from the dorsal border of the portal vein and passes dorsally and to the right to supply the partly bifurcated caudate lobe. Tadjalli and Akhavan (2003) reported that in camel four main branches of the portal vein namely the left, right, dorsal and caudal branches, can be identified; the caudal branch ramifies around the renal fossa in the right lobe and to the eschpigle lobe, while the dorsal branch supplies the eschpigle lobe, caudal area of the portal lobe and area near caudal vena caval groove.

The portal vein of horse (Tadjalli and Moslemy, 2007) is different from other mammals. In horse, six main branches; namely the caudate, dorsal diaphragmatic, right caudodorsal, right intermediate, right common and left branches can be identified. Anuradha and Singh (2004), studied the origin, course and final ramifications of portal vein in Indian water buffaloes by use of venograms and routine dissection. They stated that the portal vein divided at porta into right (dorsal) and left (ventral) interlobar veins. Right interlobar vein was smaller and left interlobar vein was larger of the two. Anuredha Roy *et al.* (2002) reported similar finding in hepatic artery in buffalo too. The results of present study is in agreement to reports in cow (Zanco *et al.*, 1994) and dog (Kalt and Stump, 1993; Schmidt *et al.*, 1980) and Indian water buffalo (Anuradha and Singh, 2004). The results showed that the right interlobar branch gave dorsal, ventral and intermediate interlobular veins. Dorsal interlobular vein supplied dorsal part of right lobe, papillary and caudate processes of caudate lobe. Ventral interlobular vein divided in 3 smaller branches that distributed in ventral parts of right and quadrate lobes. The intermediate interlobubar vein had horizontal course and distributed in the diaphragmatic parts of right lobe and papillary process. In cow (Zanco *et al.*, 1994), stated that the right branch divides immediately into four or five secondary branches that supply the right and caudate lobes. However, Getty (1975) stated that in cow the right ventral branch runs along the right side of gall bladder fossa, supplying the ventral part of right lobe and gives central branch to the middle of diaphragmatic surface of the liver, supplying adjoining parts of quadrate, caudate and right lobes. On the basis of present results, each interlobular vein is further subdivided into 3 to 5 small (intralobular) branches to the liver parenchyma which is in agreement with the reports of Anuradha and Singh (2004) in water buffalo and Sengar and Singh (1971) in ruminants.

In dog (Kalt and Stump, 1993), the right branch was a short wide trunk that ramifies in the caudate process of the caudate lobe and in the right lateral lobe of the liver. Carlisle *et al.* (1995), however, stated that the right medial portal vein was a single vessel but the quadrate hepatic vein branched from right medial vein. Dorsal interlobular vein supplied the dorsal part of right lobe of liver, ventral interlobular supplied the ventral part of right lobe and intermediate interlobular supplied quadrate and caudate lobes. Heath and House (1970) stated that in cat the right branch supplies that part of the right lobe to the right of the fossa for the gallbladder. In sheep (Heath, 1968), the right dorsal branches that supply blood to the caudate lobe and the dorsal part of the dorsal lobe emerge from the dorsal surface of either the portal vein at the point of bifurcation, or from the proximal part of the right branch. The right branch proceeds ventrally and gives rise

to three or four major branches and a variable number of minor branches which supply a wedge-shaped segment of liver tissue. The apex of the wedge is at the depression for the gallbladder and the base along the line of the left branch of the portal vein. In camel Tadjalli and Akhavan (2003) stated that the right branch of portal vein is short and runs towards the ventral border of the right lobe. Its secondary branches lie for the most part close to the visceral surface and ramified in different parts of right lobe. The right branch of the portal vein (Gupta *et al*., 1977) in the human is a stout short trunk. It divides into the anterior and posterior segmental veins in 88% of cases. In 12% of cases, there are no right branch of the portal vein and the anterior and posterior segmental veins arise directly from the portal vein. However, the right portion of the caudate lobe in 14% of cases and caudate process in 72% of cases receive portal branches from the right branch of the portal vein. It seem present results about distribution of right interlobar branch is in agreement with reports in cow and dog.

On the basis of present results the left interlobar branch run at first in the long axis of the liver from porta toward the left lobe and at the boundary between the quadrate and left lobes it bends nearly sharply 80 degree toward the notch for round ligament. So, it showed transverse and umbilical parts. The transverse part that extends from the porta to flexure was nearly 11-12 centimeters length and gives off several branches to papillary process of caudate lobe and few branches to quadrate lobe. The umbilical part of the left interlobar branch gave off 3 branches; the dorsal, intermediate and ventral interlobular branches that radiated in to the left and quadrate lobes. The left branch of the portal vein in camel (Tadjalli and Akhavan, 2003), cow (Zanco *et al*., 1994) and human (Gupta *et al*., 1977) also divided into the umbilical part and the transverse part.

In cow (Zanco *et al*., 1994), the transverse part gives off many branches to the caudate lobe and a few to the quadrate lobe and the umbilical part gives off branches to the left lobe and quadrate lobe. In camel Tadjalli and Akhavan (2003), stated that the quadrate lobe, right lobe and portal lobe received portal blood from secondary branches of the umbilical part and the secondary branches of transverse part supply the left lobe, quadrate lobe and a part of portal lobe. In sheep (Heath, 1968), the left branch curves ventrally and to the left within a deep depression on the liver surface with a number of small branches leave the cranial surface of the left branch that supply the portion of the liver in the region of the caudal vena cava. At the level of the umbilical fissure, the left branch divides into dorsal, intermediate and ventral rami that supply the left lobe and a part of the quadrate lobe.

Kalt and Stump (1993) reported that in dog the left lobe branch was essentially the continuation of the portal vein from which successive branches passed to each of remaining lobes of liver and papillary process. Transverse interlobar vein supplied caudate lobe. Umblical interlobar vein gave dorsal, intermediate and ventral interlobular veins. As the name indicates the dorsal interlobular vein supplied the dorsal part, ventral interlobular vein supplied the ventral part of the left lobe of liver. In addition, umbilical part gave off several branches to quadrate lobe which lay close to visceral surface. Each interlobular vein gave 2 intralobular veins which further gave 3 to 5 small branches to liver parenchyma.

In cat Osman (1989) stated that the left interlobar vein; ran along the long axis of liver from porta. At the junction of quadrate and left lobe it bent sharply at 45 to 90 degree towards the round ligament and ended abruptly. It gives off about five large rami to the left lateral and left medial lobes and two or three smaller branches to the right lobe to the left of the fossa for the gallbladder. In human (Gupta *et al*., 1977), the right portion of the caudate lobe receives portal branches from

the transverse portion of the left trunk in 68% of cases. The branches to the caudate process occasionally arise from the transverse portion in 12% of cases. However, the lateral inferior vein arises from the left side and medial segmental vein originated from the right side of the umbilical part that ramifies to area of the right lobe. In rabbit and cat (Heath and House, 1970), the left branch curves ventrally and to the left. In rabbit, it bifurcates into the left medial and left lateral rami to supply the left medial lobe and the region of the right lobe to the left of the relatively deep fossa for the gallbladder.

Anuradha and Singh (2004) and Blagojev *et al.* (1994) reported similar finding in buffalo and monkey, respectively. In water buffalo the left lobar vein divides into transverse and umbilical part, transverse part from porta to flexure and umbilical part from flexure to the end. Therefore, the results showed that the main intrahepatic branches pattern of portal vein in liver of water buffaloes of Iran is similar to other reports about intrahepatic branches of portal vein in Indian water buffalo, cattle and dog.

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