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Variant anatomy of the hepatic artery in adult Kenyans

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SUMMARY

Knowledge of the variant vascular anatomy of the subhepatic region is valuable to hepatobiliary surgeons to limit operative complications due to unexpected bleeding. One hundred and two subhepatic regions were studied by gross dissection for the pattern of arterial blood supply. Measurements were made for the distance of hepatic bifurcation from the liver. The common hepatic artery (CHA) originated from the celiac trunk in 95.1% and from the superior mesenteric artery (SMA) in 4.9% of cases. The mean distance of bifurcation from the liver was 2.6cm and the CHA gave rise to 2 hepatic branches in 93.1% of cases. The right hepatic artery (RHA) passed anterior to the CHD in 48%, posterior in 41.2% and in 7.8% was related to the common bile duct (CBD). Accessory RHA and left hepatic arteries (LHA) were observed in 10.8% and 9.8% of the cases.

There is wide variation in the pattern of arterial supply to the liver and biliary apparatus in adult Kenyans. A comprehensive understanding and application of this aspect of surgical anatomy is essential for good results to be maintained and even improved when carrying out surgical procedures in this area.

Key words: Hepatic arteries – Variations – Kenyans

INTRODUCTION

Variable accounts of the origin and branching patterns of the hepatic arteries exist (Michells, 1966; Nowak, 1977; Gruttadauria et al., 2001; Molmenti et al., 2003), including an origin from the superior mesenteric artery, total absence (Nowak, 1977; Gruttadauria et al., 2001), or early bifurcation (Niederhuber and Ensminger, 1983; Ger, 1989; Kenny et al., 1986; Deshpande et al., 2002; Molmenti et al., 2003). Accessory and aberrant arteries originating from different vessels exist, the left gastric and the superior mesenteric arteries being those most frequently involved (Stapleton et al., 1998).

Knowledge of the variant anatomy of the subhepatic region is valuable to hepatobiliary surgeons, since bleeding from aberrant vessels may increase the risk of intra-operative complications (Hugh et al., 1992; Scott-Connor and Hall, 1992). The literature suggests that these variations can be explained, at least in part, in terms of ethnic and methodological differences (Gruttadauria et al., 2001; Molmenti et al., 2003; Deshpande et al., 2002).

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The existing literature from Africa is scarce. The purpose of this study was to observe the pattern of the hepatic arteries in Kenyans and to document their relationship with the biliary duct system.

Materials and Methods

One hundred and two consecutive cases were obtained from the Department of Human Anatomy and the Nairobi City Mortuary. The Department of Human Anatomy runs a funeral service where autopsies are performed. All cases with gross hepatic and subhepatic pathologies were excluded. After entry to the peritoneal cavity, the stomach and intestines were displaced to expose the celiac trunk and its branches. The hepatoduodenal ligament was further dissected to expose the hepatic arteries**.**

The distance of bifurcation of the CHA from the liver was measured with calipers and the mean distance was noted. The study recorded the presence of RHA and whether it passed anterior or posterior to the common hepatic duct (CHD) and CBD.

An accessory artery within this study was defined as any artery supplying the liver with an abnormal origin but with the normal artery still present. An aberrant artery was described as any artery supplying the liver with an abnormal origin with the normal artery being absent.

Results

One hundred and ten cases were available for study. Eight were excluded due to liver pathology and disrupted subhepatic anatomy. A total of 61 males and 41 females were examined.

The common hepatic artery originated from the celiac trunk in 97 cases (95.1%). The rest (4.9%, n=5) were aberrant and originated from the superior mesenteric artery (Fig. 1).

The bifurcation point of CHA from the liver averaged 2.63 cm (SD 1.09, range 0.5-5 cm). The majority of cases bifurcated at a point 3 cm from the liver (16.7) (Fig. 2). In 95 (93.1%) cases, the CHA gave rise to 2 hepatic arteries. However, in three cases (2.9%) there were 3 hepatic arteries (Fig. 3). Two of the latter cases had the third artery as an accessory RHA while in the other case it was an accessory LHA. One case had four hepatic branches (Fig. 4) the extra two vessels being accessory right hepatic and cystic arteries. In three cases (2.9%), there was no bifurcation with the vessel forming either the right or left hepatic artery.

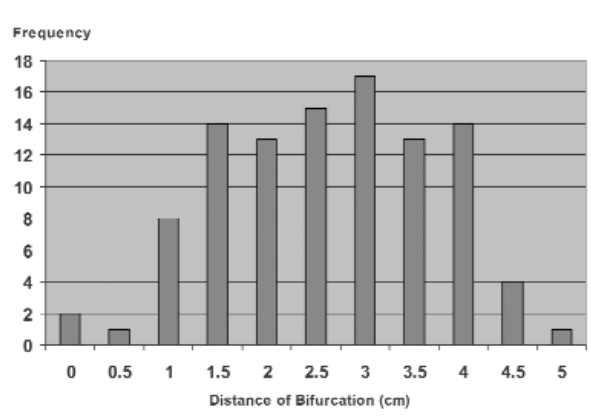
In 91 (89.2%) cases the RHA was related to the common hepatic duct while in the other 11 (10.8%) cases, it was related either to the common bile duct or to the independent right and left hepatic ducts. Of the 91 cases, 49 (48%) had the RHA coursing anterior to the common hepatic duct (Table 1, Figs. 3, 4) while 41.2% had their RHA coursing posterior to the CHD. In the remaining 11 cases, two cases (2.0%) had the RHA anterior to the CBD whereas 6 cases (5.9%) had the same vessel posterior to the CBD. The other three cases all had their RHA related to the independent right and left hepatic ducts.

Table 1. Relationship of right hepatic artery to common hepatic duct (CHD) and common bile duct (CBD).

	Relation to CHD		Relation to CBD	
	Number	Percentage	Number	Percentage
Anterior	49	48.0%	2	2.0%
Posterior	42	41.2%	6	5.9%
Total	91	89.2%	8	7.9%

An accessory RHA was found in eleven cases (10.8%). The accessory RHA had its origin from the common hepatic artery in 4 cases, the cystic artery in 6 cases, while one case originated from the left hepatic artery. Of all the cases studied, only two did not have a normal left hepatic artery originating from the CHA. These two cases had aberrant left hepatic arteries originating from the left gastric artery (Fig. 5). Accessory Left hepatic arteries were demonstrable in ten cases (9.8%). These originated from the left gastric artery in five cases, the CHA in three cases, while in the other two they originated from the LHA and RHA. There was one case in which the LHA divided into two before entering the liver.

Fig. 2. Point of bifurcation of proper hepatic artery.



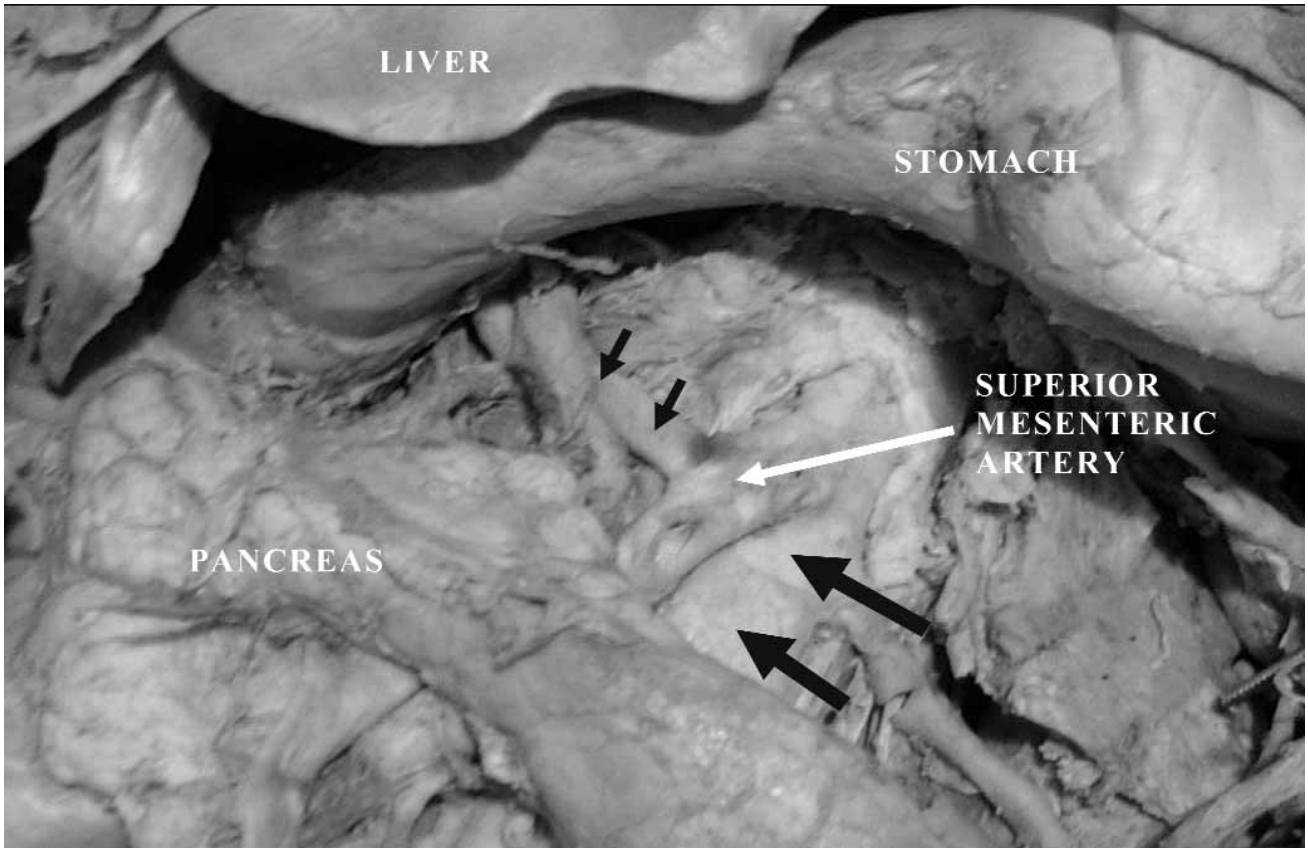


Fig. 1. Common hepatic artery (small arrows) arising from the superior mesenteric artery. The aorta is labeled with the thicker and longer arrows.

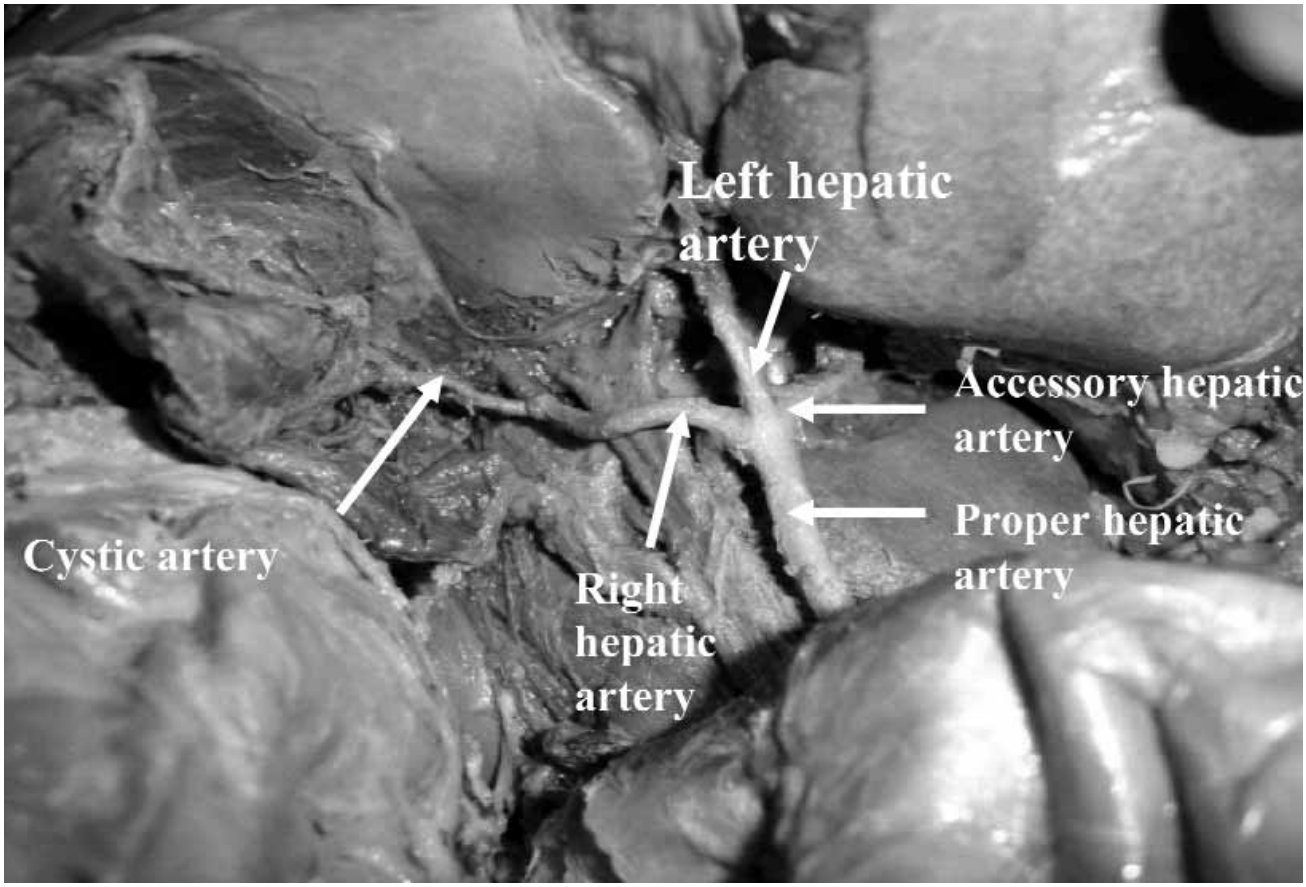


Fig. 3. The proper hepatic artery has trifurcated. The right hepatic artery runs anterior to the common right hepatic duct and gives off a cystic artery within Calot's triangle.

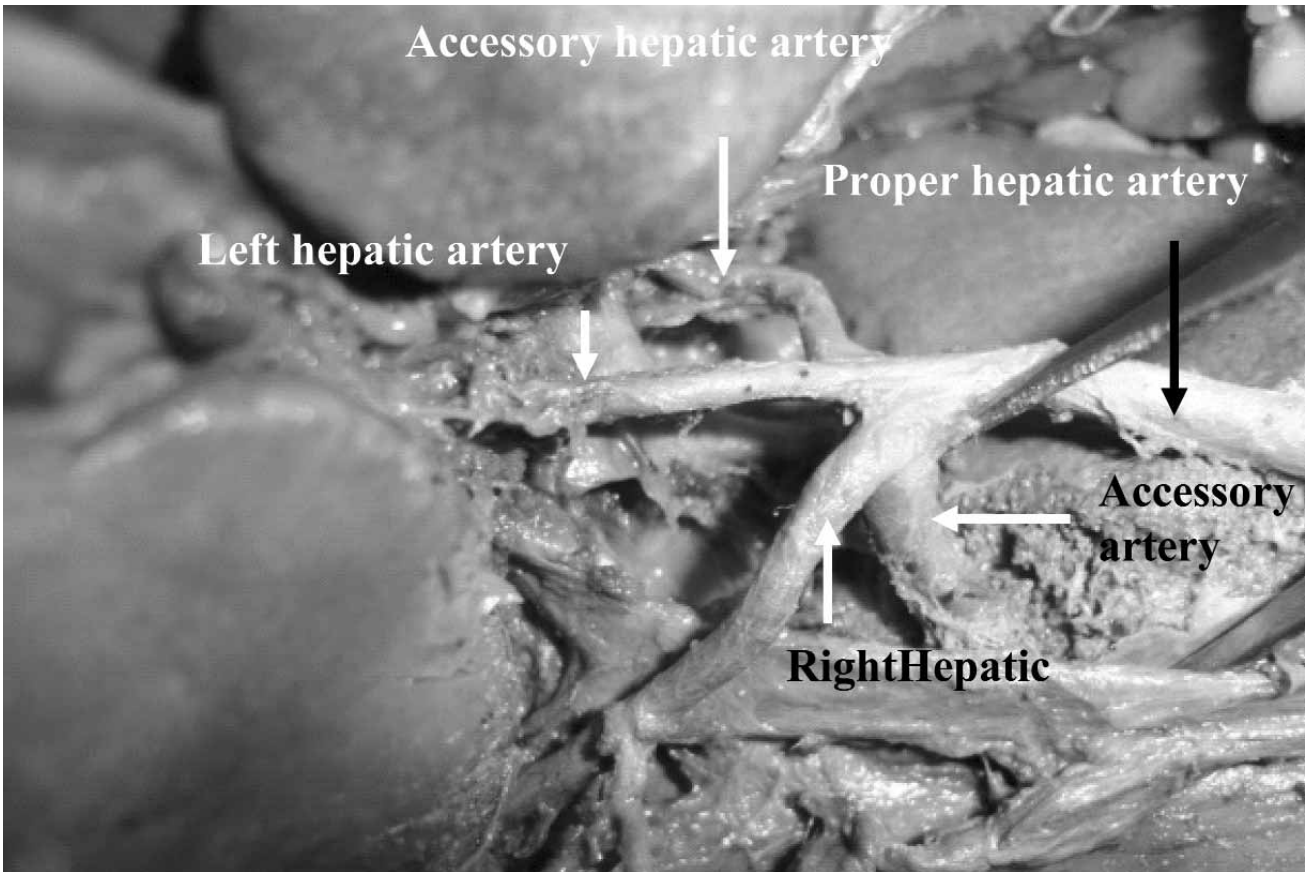


Fig. 4. Quadrifurcation of the proper hepatic artery into the right, left hepatic and two accessory hepatic arteries.

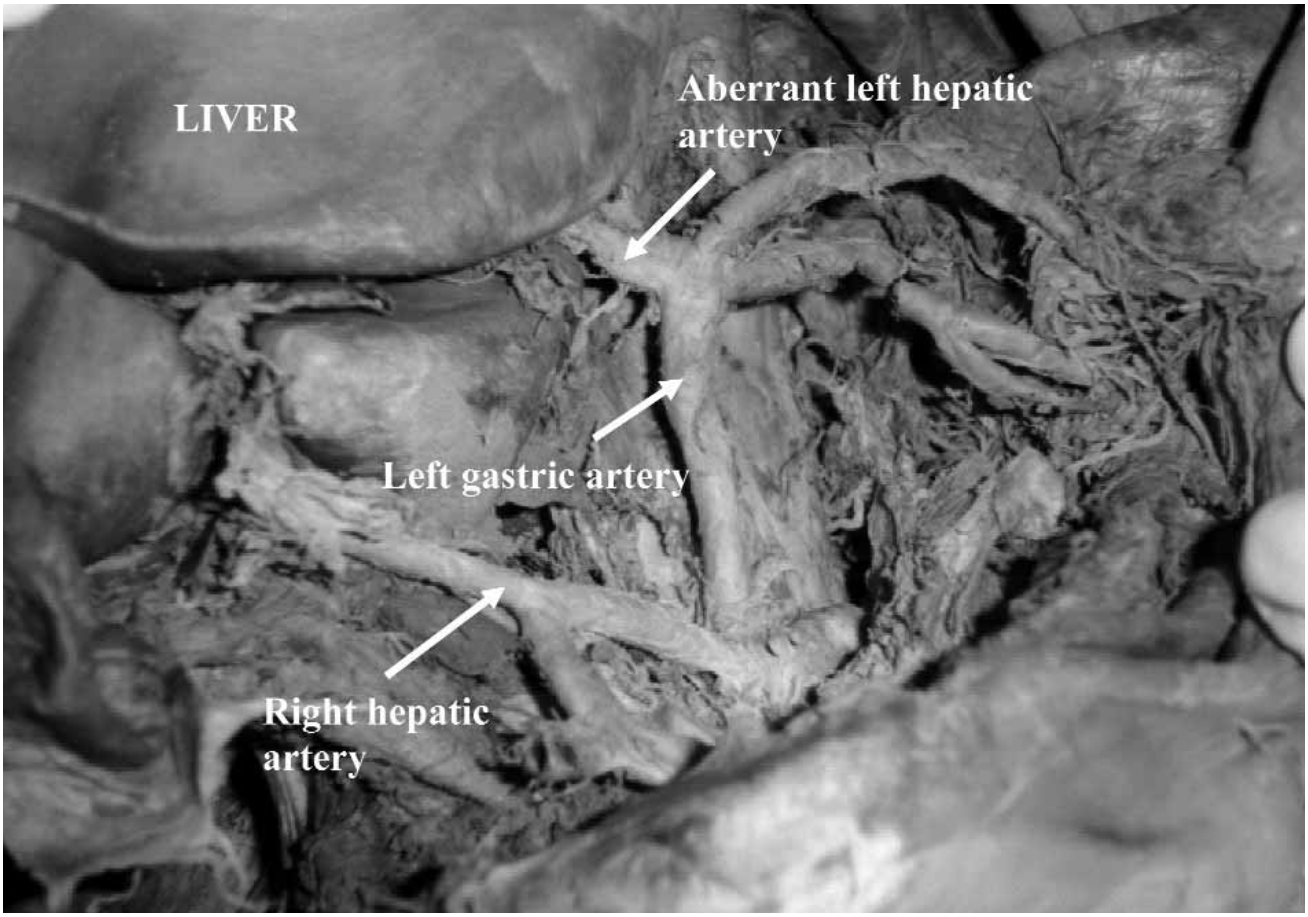


Fig. 5. An aberrant left hepatic artery originating from left gastric artery.

Discussion

The observations of the present study revealed that the common hepatic artery originated from the celiac in 95.1% of cases. In the other 4.9% (five cases), it originated from the superior mesenteric artery. Previous reports have documented a celiac trunk origin in 6.7-35% of Germans (Noah et al., 1995; Freund et al., 1995), 70.8-98% of Americans (Gruttadauria et al., 2001; Molmenti et al., 2003; Varotti et al., 2004) and 93% of Russians. An Australian study showed this normal origin in only 9% of cases. Such a highly contrasting result may not necessarily be due to methodological differences but is likely be due to the definitions. Most authors have reported that, when aberrant, the CHA originates from the SMA, as was found in this study. We found an aberrant CHD in 4.9% of the population, a figure that compares well with American rates of 0.86-5% of the population (Gruttadauria et al., 2001; Molmenti et al., 2003; Varotti et al., 2004). In Britons, this aberrant origin was recorded in 2.5% of cases whereas in Brazilians, it was found in 1.6% of the population (Deshpande et al., 2005; Bertevello and Chaib et al., 2002) (Table 2).

Table 2. Comparison of the origin of CHA in different populations.

	Germans	Americans	Russians	British	Brazilians	Kenyans
Origin of CHA	Coeliac (65-93.3%)	Coeliac (70.8-98%)	Coeliac (93%)	Coeliac (97.5%)	Coeliac (98.4%)	(95.1%)
		SMA (0.86-5%)		SMA (2.5%)	SMA (1.6%)	SMA (4.9%)

Although not observed in the present study, independent right and left hepatic arteries originating from the aorta have been found in Swiss and Romanian (Bordei and Antohe, 2002; Fasel et al., 1996) subjects and from the left gastric artery among Russians (Iul 'chiev, 1984; Thayer et al., 2001). However, surgeons and radiologists should still be aware of the possibility of these differences since they are potential sources of confusion at angiography and may lead to troublesome bleeding during surgery. Bifurcation of the CHA has been reported to occur within 4cm of the liver with early bifurcation occurring in 2-20% (Gruttadauria et al., 2001; Molmenti et al., 2003). The present study revealed that the artery bifurcated approximately 2.63 cm from the liver. Early bifurcation was rarely found, the maximum distances being 4.5 and 5 cm found in four and one cases respectively. In Americans, different studies have provided contrasting results, ranking from as low as 2.14% to as high as 20%. The discrepancies may represent either true population differences or merely the end results of measurements under different conditions with different impacts on the measurement.

We observed trifurcation of the CHA in 2.9% of cases, with the third vessel being an accessory RHA in two cases and an accessory LHA in the other. The accessory vessel followed the pattern of the RHA in those cases. In Brazilians, trifurcation was reported in 15% of cases, whereas in Taiwanese, it was found in only 4.4% of cases. These accessory vessels may be the only source of hepatic arterial supply to specific segments of the liver. Pertinent to this observation is that even with the vascular variations, the accessory vessels are still end arteries and there is no significant anastomosis between them and the other arteries (Gruttadauria et al., 2001). A rare variation observed in the current study was the finding of a CHA giving rise to 4 branches (LHA, RHA, a cystic artery and an accessory RHA).

All the cases studied had a normal RHA originating from the CHD. In Ethiopians and Americans, this origin was found in 83% whereas in Brazilians it is 75% (Molmenti et al., 2003; Iul 'chiev, 1984; Futara et al., 2001; Chaib et al., 2005).

The present study also reveals a rate of 10.8% for accessory RHA. In 3.9% of cases, the vessel originated from the CHA, whereas in 5.9% and 1% of cases it originated from the cystic and left hepatic arteries, respectively. Our findings are similar to the rates found in Americans (7%) and Ethiopians (9%) but differ from Brazilian (18.3%) and Japanese data (18.4%) (Molmenti et al., 2003; Futara et al., 2001; Chaib et al., 2005; Matsumara, 1998). In contrast to our findings, however, these studies did not document accessory RHA originating from the common hepatic artery or the cystic arteries.

The accessory vessel arose from the SMA, gastroduodenal and the LHA in Ethiopians and from the SMA, celiac axis, renal, gastroduodenal and left gastric arteries in Japanese and Americans (Michells, 1966; Gruttadauria et al., 2001; Molmenti et al., 2003; Deshpande et al., 2002). Such differences may have been due to definition, especially as regards to the common hepatic artery. Other studies may define the CHA to have trifurcated, instead of giving off an accessory artery, but this does not

account for the vessel originating from the cystic artery. Our unique finding has implications during laparoscopic cholecystectomy, where the cystic artery must be identified and ligated. The risk of compromising the blood supply to the liver exists and surgeons should thus be careful and clamp the cystic artery distal to the accessory artery. In addition the presence of such a vessel presents problems in the metastasis of bile duct carcinoma, allowing faster access to the liver (Tamada et al., 1996).

The course of the RHA in the present study also differed from other classical textbook descriptions and those of other studies. When related to the CHD (89.2%), it was found to be anterior and posterior to it in 48% and 41.2% of cases respectively. In classical descriptions and other studies, the RHA courses posterior to the CHD in most cases. In Americans, the RHA was posterior to the CHD in 65% and anterior to it in 12% of cases (Molmenti et al., 2003). In Australians, the vessel is anterior to the CHD in 29% of cases. The vessel was related to the CBD in the remaining 7.8% of the population. When related to the CBD, in 2.0% of cases the vessel was anterior to the duct. This compares with 1% in the study by Hiatt et al. (Gruttadauria et al., 2001). In our study we found the vessel to be posterior to the CBD in 5.9%, a figure which concurs with the American study, which recorded 12% (Molmenti et al., 2003). The position of this vessel is also important during cholecystectomies, where surgeons should be aware of the possibility of finding a RHA anterior to the CHD or CBD especially during laparoscopic procedures.

No aberrant arteries were recorded in any of our cases, unlike in Ethiopians (8.2%), Americans (13.5%), Brazilians (25%), Italians (18%) and Germans (10-12%) (Molmenti et al., 2001; Noah et al., 1995; Freund et al., 1995; Futara et al., 2001). These aberrant arteries have been reported to originate from the celiac axis in 1% of Americans and 7.3% of Ethiopians. Possible explanations for the variable results include a smaller sample size and different definitions of an aberrant artery. In addition, the type of study and the area of liver supplied by the aberrant artery should be considered. This is because the intrahepatic supply may differ from what is seen outside the liver, such that what is described as RHA in fact divides in the liver to form a right and left hepatic artery. This therefore renders the other vessel an accessory and not an aberrant artery.

There was a normal LHA originating from the CHA in100 cases. This contrast with the Ethiopian study, where it originated from the CHA in 71.8%, while in Americans it was in 82% (Molmenti et al., 2001; Futara et al., 2001). Two cases had an aberrant artery originating from the left gastric artery. An accessory LHA was present in 9.8% of cases (10 cases). These originated from the CHA (3), left gastric (5), RHA (1) and LHA (1).

The figures for the left gastric artery (4.9%) do not correspond to the range found by Molmenti et al. and Chaib et al. but are closer to those found by Varotti et al. and Jones and Hardy (Molmenti et al., 2003; Chaib et al., 2005; Varotti et al., 2004; Jones and Hardy, 2001). The Italians were reported to have an origin from the left gastric artery in 18% of cases, whereas in Ethiopians it was reported to be about 16.4%. These figures suggest that the anatomy with regards to the LHA is the same as that found in other populations and ethnicities. However, angiographic studies have described prevalences as high as 40% (Hollinshead, 1971). Incidence levels may thus be higher than demonstrated, the observed differences being due to the different methodologies used. The importance of the accessory vessel from the left gastric artery is based on its susceptibility to damage during gastrectomy (Hollinshead, 1971). The vessel originating from the CHA was found in 2.9% of cases. This compares with Ethiopians, where it was found in 4.5% of the population. The other origins demonstrated for the RHA and LHA, each accounting for 1.0%, are close to what was reported for Ethiopians and Australians (2.7% and 2% respectively). The role of the accessory arteries and the segments of the liver supplied should be considered during planning for liver surgery since these vessels are end arteries in most cases and injury would compromise liver supply, resulting in necrosis of the entire left hemiliver or some segments, commonly two and three.

In conclusion, this study shows that there are variations in the arterial anatomy of the hepatobiliary apparatus. Surgeons should thus be aware of the possibility of these variations when undertaking any operation in that area.

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