Original article

Comparative intimal-media morphology of the human splenic and common hepatic arteries

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Abstract

The splenic artery has been reported to be tortuous in adults and remains the most vulnerable to atherosclerosis among the visceral branches of the abdominal aorta. The hepatic artery on the other hand is the least affected by atherosclerosis. Studies have shown that among other factors, flow patterns, which are dependent on the vessel geometry, may influence its micro architecture and consequently susceptibility to pathology. We sought to compare the histological organization of the human common hepatic and splenic arteries. Material and methods: Following approval from KNH – Ethics and Review committee and written consent obtained from deceased's' relatives fifteen specimens were obtained during autopsies conducted at the City and Chiromo. Subjects were aged between 21 and 44 years. Sections taken within 5 mm from origin were prepared for paraffin embedding and sectioning and stained using Masson's trichrome and Weigert's elastic stains. Results and conclusion: The splenic artery had prominent intimal thickenings, multiplication and fragmentation of the internal elastic lamina in the tunica intima and lacked external elastic lamina in the tunica media. The common hepatic artery was noted to have minimal intimal thickening, single continuous internal elastic lamina and prominent external elastic lamina. The features of the splenic artery suggests an adaptive role to increased blood flow and wall tension stress attributable to its tortuosity and may be part of the explanation for the higher incidence of atherosclerosis previously reported.

Keywords: splenic artery, common hepatic artery, intimal thickening, elastic lamina.

1 Introduction

The histomorphological organization of arteries determines their physico-mechanical properties and is influenced by hemodynamic forces of the luminal blood flow including, pulse rate, arterial flow velocity and resistance to flow in vascular segments and supplied organs (YOSHIDA, YAMAGUCHI, CARO et al., 1988; LABARBERA, 1990). In an attempt to normalize flow, arteries may undergo remodeling often characterized by histomorphological reorganization of the mural components as well as alterations in arterial morphometric features. These may include formation of intimal thickenings (LANGILLE, 1996) and multiplication of the internal elastic lamina (TADA and TARBELL, 2004).

Further, vessel geometry influences flow pattern, such that mechanical stress is altered in regions with bends and curves such as branching points (ZARINS, GIDDENS, BHARADVAJ et al., 1983; SMITH, 2002). Arterial tortuosity in particular creates a turbulent helical flow that results in nonuniform distribution of shear forces on the vessel (WENN and NEWMAN, 1990). While the common hepatic (CHA) is linear, the splenic artery (SA) in adults has a tortuous course (SAHNI, JIT, GUPTA et al., 2003). This may create a different hemodynamic environment that may affect its histomorphology and ultimately influence the incidence of atherosclerosis and aneurysms (FRIEDMAN, 2002).

Clinico-pathological studies have shown that the celiac trunk and its branches are a frequent site of extra-aortic abdominal aneurysm and atherosclerosis (STONE, ABBAS, GLOVICZKI et al., 2002; CARLOS, PAULINA, ALBERTO et al., 2005). The common hepatic has been reported to be resistant (KRUS, TURJMAN and FIEJKA, 2000a,b) while the splenic artery is the most frequently affected by these pathologies (ABBAS, STONE, FOWL et al., 2002; PASHA, GLOVICZKI, STANSON et al., 2007). There is a dearth in published reports comparing the histomorphological organization of the common hepatic and splenic artery.

2 Material and methods

A total of 16 cases were obtained for this study. However, one autopsy case was excluded due to demonstrable abdominal aneurysm. Specimens for microscopic studies were all from subjects aged between 21 and 44 years. Celiac axis blocks were selected from the postmortem materials, obtained within 48 hours after death, by purposive sampling for histological studies. Five millimeter long segments were taken from the proximal segments of the common hepatic arteries and splenic artery (Figure 1).

Each of the segments harvested was fixed by immersion in 10% formal saline. These segments were then processed for paraffin embedding by dehydration in increasing grades of isopropyl alcohol (70, 80, 90, 95, and 100%) each for an hour, and cleared using trichloroethane. Paraffin wax infiltration was carried out for 13 hours followed by embedding in the same. Seven (7) µm thin transverse sections were cut by a Leitz Wetzlar® (SM2400, Germany) sledge microtome, floated in a warm water bath and mounted in albumin-coated glass slides. These were left to dry overnight in an oven at 37 °C.

Weigert's resorcin-fuchsin stain with van Gieson counterstaining was used to elaborate mature and elaunin elastic fibers in the arterial wall. Other sections were stained using Masson's Trichrome to elaborate cytoarchitecture and connective tissue of the wall. Slides were mounted and examined (at ×35, ×100, and ×400 magnification) under a Leica® (BME model, Germany) light microscope. The structure of the splenic artery (SA) was compared with the common hepatic (CHA). Observations made were recorded on a data sheet. Photographs of representative histological slides of the splenic and common hepatic arteries were also obtained using a digital camera (Fuji™ FinePix® A900, 9.0 MP) at medium and high power using photomicroscope for histomorphology.

3 Results

Both the splenic and common hepatic arteries were muscular arteries with distinct tunica intima, media and adventitia (Figure 2). Intimal thickenings were observed in some parts of the arterial wall. In the splenic artery, these thickenings were more diffuse while in the common hepatic, very minimal thickenings were noted (Figure 3a, b). These thickenings demonstrated differences in proportions of collagen and elastic fibers. The intimal thickenings were characterized by abundant collagen fibers and smooth muscle cells (SMCs). The SMCs were mainly longitudinal with a few scattered in an oblique fashion.

The common hepatic had single and continuous internal lamina (IEL) in most parts of the vessel wall (Figure 4b). The SA exhibited multiple and discontinuous IEL in most parts of the vessel. In regions of intimal thickening, the morphology of the IEL was slightly different (Figure 4a). In the common hepatic artery, the convolutions of the IEL were greatly increased in these regions. In addition to these, the internal elastic lamina in the SA was characterized by fragmentation of the lamina (Figure 4a).

The tunica media of the splenic artery demonstrated predominance of longitudinal SMCs, minimal elastic fibers and absence of an external elastic lamina (EEL) (Figure 5a). The tunica media of the CHA on the other hand, had filamentous elastic fibers between layers of circumferential SMCs and prominent thickened EEL (Figure 5b).

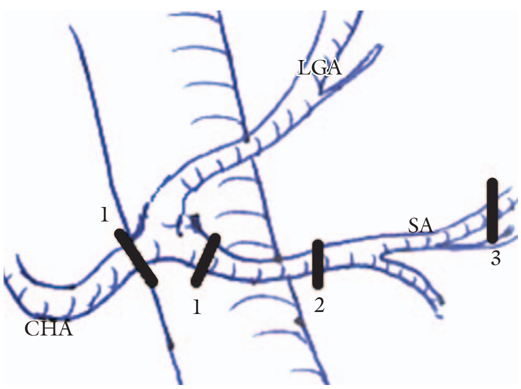

Figure 1. Illustration on sectioning (not drawn to scale).

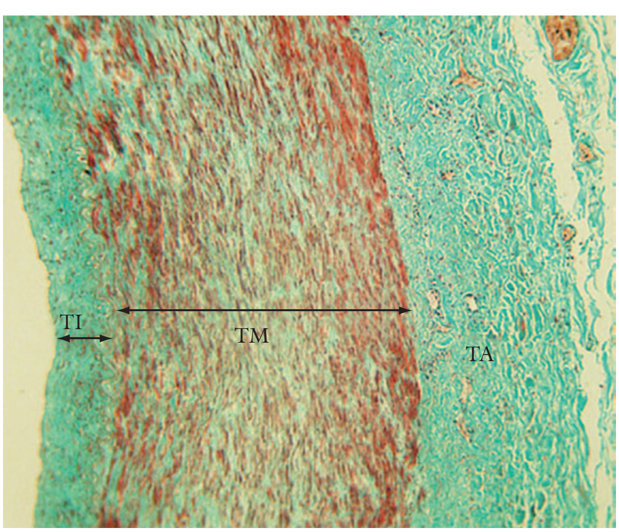

Figure 2. Photomicrograph of a transverse section of the proximal splenic artery showing the mural layers. Note the thick tunica media (TM) which occupies most of the vessel wall and the peripheral adventitia (TA). Masson Trichrome; Magnification ×100.

4 Discussion

In this study, the SA had more prominent intimal thickening compared to the common hepatic artery. Similarly prominent intimal thickening have been described in the coronary arteries (STARY, 1989), intracranial parts of vertebral arteries (CHOPARD, LUCAS and LUADANA, 1991) and the adductor portion of the superficial femoral artery (WOOD, ZHAO, ZAMBANINI et al., 2006). Interestingly, all these vessels have a tortuous course. Wood, Zhao, Zambanini et al. (2006) suggested that tortuosity in the adductor portion of the femoral artery induces a helical flow pattern which results in a highly nonuniform distribution of wall tensile stress (WTS). It is therefore possible that tortuosity in the SA creates regions of higher WTS in portions of the vessel wall that induce higher degrees of intimal thickening to homogenize the WTS. Pertinent to these observations are reports of previous studies that sites of intimal thickenings are associated with increased vulnerability of the vessel wall to atherosclerosis and related pathologies (STARY, BLANKENHORN, CHANDLER et al., 1992; PESONEN, 2004). It is also probable that the higher degree of intimal thickening in the SA is related to its increased propensity to develop atherosclerosis.

Observations of the present study have shown that the IEL was multiple and fragmented in the SA while the CHA had a single lamina. Similar observations have previously been described in the mesenteric and celiac artery (JARVINEN, SISTO, LAURIKKA et al., 1996) and coronary and hepatic arteries (KRUS, TURJMAN and FIEJKA, 2000b). Johnson, Lawler and Burns (1993) described a similar organization in the wall of cervical vertebral artery following a dissecting aneurysm. In these studies, sites of multiplication and fragmentation of the IEL were associated with increased wall tension (JARVINEN, SISTO, LAURIKKA et al., 1996; KRUS, TURJMAN and FIEJKA, 2000b). In addition, they were associated with myoelastic sphincters in cerebral vessels following experimental induction of hypertension

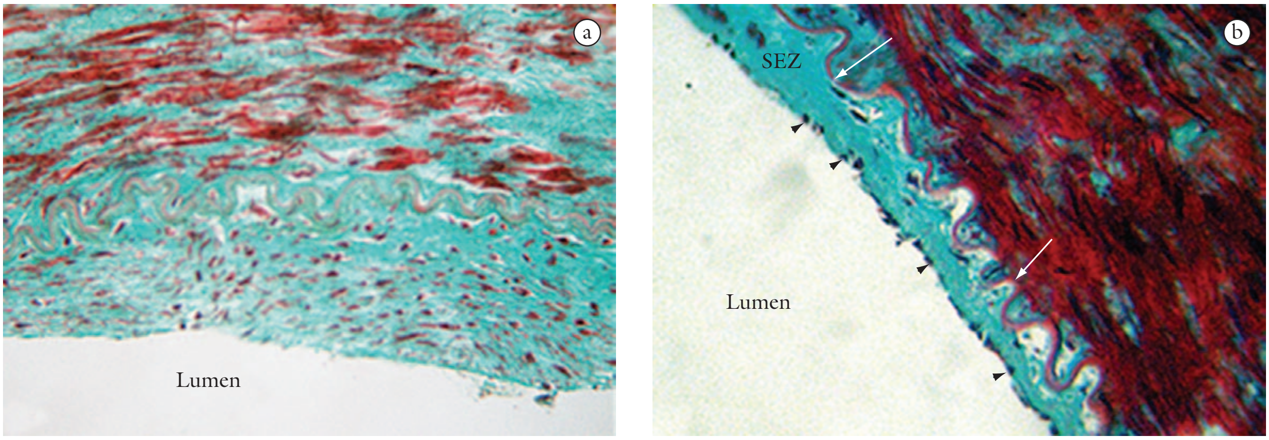

Figure 3. Photomicrographs showing the fibromuscular organization of the intimal thickening in the splenic artery (Figure 3a) and the components of the tunica intima in the common hepatic artery (Figure 3b). Notice the flattened endotheliocytes (arrowheads), subendothelial zone (SEZ) and the internal elastic lamina (arrows). Masson's Trichrome; Mag×400.

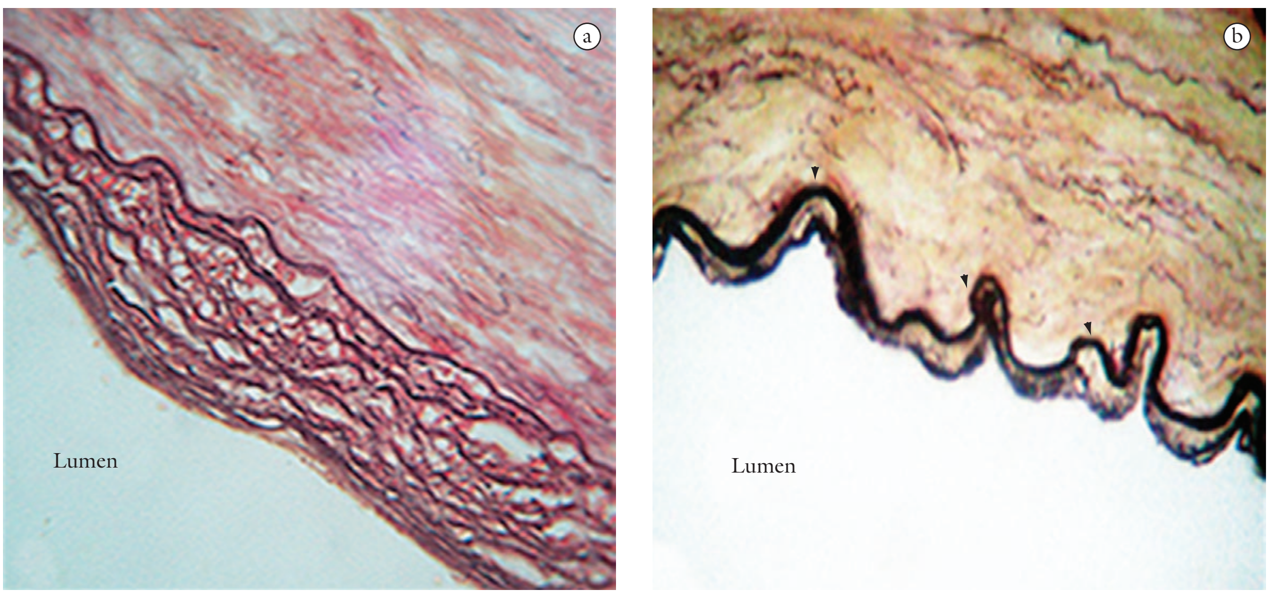

Figure 4. Photomicrographs comparing the organization of the internal elastic lamina in the splenic artery and common hepatic artery. Figure 4a shows a predominantly elastic intimal thickening with multiplication of the IEL in the SA. Figure 4b shows a single and continuous IEL with an overlying endothelium in the CHA. Weigert's elastic stain with Van Gieson's counterstain; Mag×400.

(NOVIKOV and YAL'TSEV, 2002). These features of IEL are thought to comprise an adaptive response to local hemodynamic forces (TADA and TARBELL, 2004; SLAGER, WENTZEL, GIJSEN et al., 2005). Therefore, multiplication of the IEL in the SA suggests higher WTS that may be elevated so as to cause fragmentation.

Mechanisms of multiplication may either be retrograde i.e. dissection due to increased catabolism or progressive i.e. due to synthesis of new elastin fibers (OHO and RABINOVITCH, 1994). The latter constitutes a physiological response since cyclic mechanical conditioning increases the production of elastin (KIM, NIKOLOVSKI, BONADIO et al., 1999; KIM and MOONEY, 2000). It is therefore possible that the multiplication observed in the present study may represent a progressive process that serves to reinforce the vessel wall. In this study we were unable to determine the exact process of multiplication of the IEL. Future studies may focus on the etiology of this phenomenon.

The tunica media of both the SA and CHA were all muscular and devoid of elastic lamellae except for a few filamentous fibers in the CHA. This is concordant with observations of previous studies which have reported a similar structure in the splenic and hepatic arteries (ORTIZ, DIAZ, DANIEL-LAMAZIERE et al., 1998; KRUS, TURJMAN and FIEJKA, 2000a,b). According to these workers, muscular columns in the tunica media of serve to adjust the vessel caliber and ensure adequate flow to the organs supplied (ORTIZ, DIAZ, DANIEL-LAMAZIERE et al., 1998), while elastic fibers provide a reservoir for potential energy obtained during systolic stretch (SHADWICK, 1999; KRUS, TURJMAN and FIEJKA, 2000b). These features imply that the common hepatic artery though muscular and ideally distributive, may propel blood during diastole by elastic recoil therefore ensuring laminar flow. In respect to this, cyclic variations in blood flow velocity and WTS may be abolished and thus maintain baseline levels.

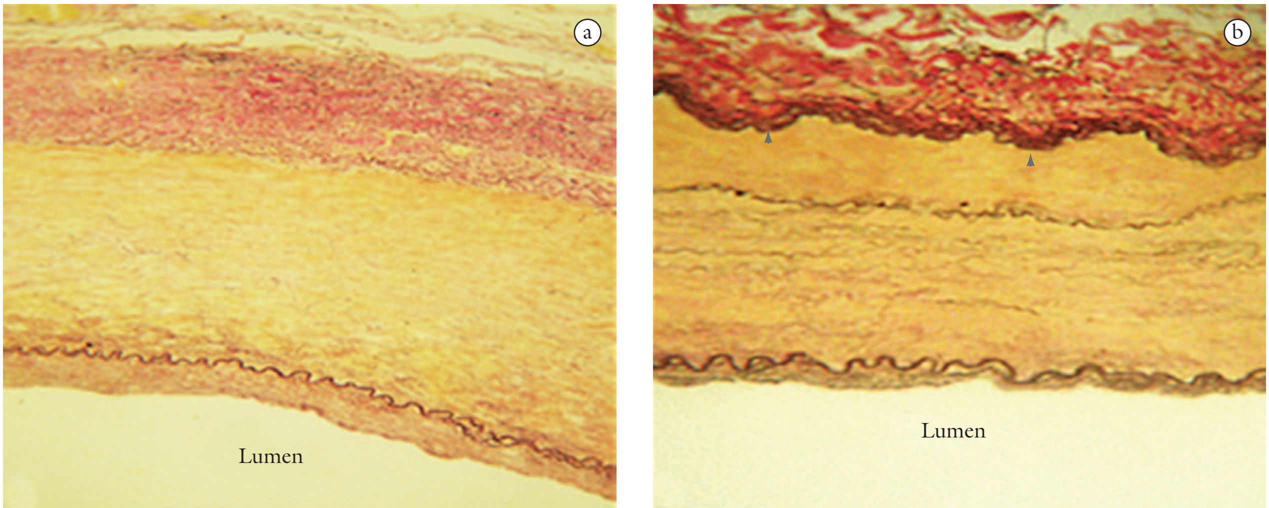

Figure 5. Photomicrographs showing a highly muscular media with a dearth in elastic fibers in the SA and absent external elastic lamina (Figure 5a).The common hepatic artery showing a muscular media with scattered filaments of elastic fibers. The EEL is present (Grey arrow heads) (Figure 5b). Weigert's elastic and Van Gieson counterstain, Mag×100.

Splenic artery though muscular does not have an external elastic lamina which is present in the common hepatic arteries does. A similar structure has been reported in the intracranial part of the vertebral artery (PELTIER, TOUSSAINT, DERAMOND et al., 2003). The external elastic lamina has been shown to confer additional reinforcement to the arterial wall (MIZUTANI and KOJIMA, 2000). These elastic fibers peripheral to IEL are thought to reduce flattening out of the IEL and therefore resist inverse stretch of the internal elastic lamina that may result in breakdown (SVENDSEN and TINDALL, 1986). The absence of such structure in the splenic artery suggests a weaker and exposed internal elastic lamina and vessel wall. This predisposes the splenic artery to higher likelihood of aneurysm formation and rupture.

5 Conclusion

The features of the SA namely multiple and fragmented IEL, prominent intimal thickening and absent EEL may constitute adaptations to the helical flow due to tortuosity and may be part of the explanation for the higher incidence of atherosclerosis and aneurysms previously reported.

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