STREAMLINE FLOW IN THE HUMAN PORTAL VEIN

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Streamline flow in the portal vein was studied in twelve patients undergoing laparotomy without liver disease. Liver scintigrams were obtained following injection of tracer doses of $^{198}$Au-colloid into a mesenteric vein and compared with repeat scintigrams obtained following i.v. injection of $^{99m}$Tc-microaggregated albumin. Particularly from subdivisions of the superior mesenteric vein, portal vein blood is directed predominantly to the right lobe. This may explain the predominance of right lobe involvement in infectious diseases which embolize to the liver via the superior mesenteric vein.

Certain intestinal infectious diseases which spread to the liver by way of the portal vein tend to localize in the right lobe. This tendency has been attributed to selective streamlining of blood coming up from the superior mesenteric vein. While streamline flow has been demonstrated in animals, human studies have produced contradictory results. This study demonstrates streamline flow in the human portal system after injection of radiogold into various mesenteric veins.

METHOD

Twelve patients without liver disease who were undergoing laparotomy were selected. An identified mesenteric vein was injected slowly with 200–300 $\mu$Ci of $^{198}$Au-colloid in a 1–5-ml volume (Fig. 1). On the earliest possible postoperative day a scintigram of the hepatic distribution of the $^{198}$Au was done. Immediately thereafter 2–5 mCi of $^{99m}$Tc-microaggregated albumin was injected into an arm vein, and a second liver scintigram was obtained. This second study provided a control for each patient's overall distribution of hepatic blood flow. All information was stored on tape for later playback.

Areas of interest of identical dimensions were set up over both lobes, and counts in the right area were expressed as a percentage of the total counts occurring in both areas (Fig. 2). With these data the hepatic distribution of blood flow to right and left lobes from a selected mesenteric vein ($^{198}$Au) could be determined and compared with the distribution following the control injection in an antecubital vein ($^{99m}$Tc).

Gold-198 was selected for mesenteric vein injection because of its longer half-life relative to $^{99m}$Tc.
RESULTS

Streamlining to the right lobe occurs but is dependent upon the mesenteric vein injected (Fig. 3). Gold-198-colloid introduced into four cecal veins (Patients 1, 2, 4, and 5) and one terminal ileal vein (Patient 6) streamlined to the right hepatic lobe. Gold-colloid injected into the midjejunal vein (Patient 7) showed no preference for either lobe. Colloid introduced into the proximal jejunal vein (Patient 8) had a tendency to flow to the left. One of four sigmoid vein injections of 198Au (Patient 11) showed streamlining to the right lobe. The remaining three and one cecal vein injection (Patients 3, 9, 10, and 12) showed no preference for either lobe.

DISCUSSION

Serege (3) originally investigated streamlining in 1901 by injecting India ink into portal vein tributaries of dogs. Flow in the splenic vein streamlined to the left lobe, flow in the large mesenteric vein was directed to the right. Glenard (4) confirmed this work, but Bauer, et al (5) described homogeneous distribution of India ink throughout the liver irrespective of the portal tributary injected.

Bartlett, et al (6) in 1914 injected fat emboli into portal vein radicles of dogs. Flow from the stomach, spleen, duodenum, proximal jejunum, and rectum went mainly to the left lobe while flow from the distal jejunum, ileum, and proximal ¾ of the colon went to the right. Copher, et al (7) after injecting trypan blue into dog portal vein tributaries in 1928, concluded that the stomach, spleen, and greater part of the colon drain predominantly to the left lobe while duodenum, head of the pancreas, and upper jejunum drain to the right. They also observed streamlining by translumination of the portal vein during injection.

Hahn, et al (8) injected 32P tagged on phosphoric acid into portal vein tributaries of the dog. Bianchi, et al (9) injected radiogold absorbed onto carbon particles. Both studies showed streamlining of splenic vein flow to the left lobe and of mesenteric vein flow to the right. Hahn speculated that tumor emboli might be affected by this flow and noted predominantly right-sided liver metastases from primary intestinal malignancy. Some investigators using radionuclide agents did not demonstrate streamlining (10–13).

Moore, et al (14) observed streamlining during human portal venography in which flow from the right gastroepiploic vein went to the right lobe. Ruzicka, et al (15) also observed such streamlining during human portography. Atkinson, et al (16) acknowledged that streamlining might occur at the beginning of the portal vein but concluded that the
channels mixed before reaching the liver. Portographic studies on animals by Daniel, et al (17) showed perfusion of both lobes although the right received a greater proportion. Others (18–21) deny any consistent streamlining during portography.

Portography involves a rapid, high-pressure injection of a large volume into the low-pressure portal system. This may increase flow and velocity, obscure streamlining, and result in extensive filling of the portal venous bed (16,19). This study circumvented that problem by injection of small volumes slowly.

Streamlining appears to influence the hepatic location of amebic abscesses and hydatid cysts. Amebic ulceration of the colon most frequently involves the cecum (22,23). The amebae are carried to the liver by the portal vein to produce abscesses. Solitary right lobe abscesses occur in approximately 90% of patients with hepatic involvement (24–35). Seventy percent of hydatid liver cysts are also in the right lobe (36,37). In both diseases the predilection for the right lobe may have resulted from streamlining of flow from the superior mesenteric vein.

Streamlining may affect the hepatic spread of other intra-abdominal infections (38–40). Kinney, et al (38) concluded that abscesses following acute appendicitis unassociated with pylephlebitis, tend to occur in the right lobe. Of 32 liver abscesses arising secondarily to intra-abdominal infections drained by the superior mesenteric vein, 27 were in the right lobe. The study of Ochsner, et al (39) has similar conclusions. Schiff (40) also refers to streamlining as a cause for selective hepatic localization of infectious processes.

CONCLUSIONS

This clinical investigation of the intrahepatic distribution of human portal blood flow was conducted during laparotomy under general anesthesia. A small mesenteric vein was catheterized, colloidal radiogold slowly injected, and postoperative scanning performed to quantitate distribution of nuclide within the liver. While laparotomy and general anesthesia affect splanchic blood flow, they are the only conditions under which human mesenteric veins can be directly visualized and injected. Direct catheterization of small mesenteric veins is commonly used to measure portal pressure (41). The conditions under which the portal system was studied in this investigation are comparable to those found in other clinical studies.

Other studies of the human portal system have used venography which can alter the normal hemodynamics. The injections in this study would not change the flow characteristics of the low-pressure portal bed. Attempts to establish "controls" in other human studies were not reported. By using nuclear medicine techniques, each patient could serve as his own control. There is only a slight difference in the absorbed fraction of energy between 99mTc and 198Au when the activity is in a small sphere or thick ellipsoid (42). Thus the relative thickness of the right and left lobes of the liver would not significantly influence the count ratio of the two nuclides nor prevent their comparison. Further confirmation of this is seen in those patients in whom streamlining did not occur; the right/left count ratios were the same regardless of the radiocolloid used.

Streamlining is influenced by a number of variables. Exertional and positional changes in active laboratory animals alter portal blood flow (43). However, in resting states portal streamlining occurs, particularly to the right lobe following superior mesenteric vein injections as shown by five of six injections into ileal-cecal veins in this study. The
individual magnitude of streamlining varies of course (Fig. 3).

It is well established that certain infectious intestinal diseases, such as amebiasis, which seed emboli into the portal vein have a high incidence of right hepatic lobe involvement. The right lobe is six times larger than the left (44); and if hepatic blood flow were homogeneous, a similar proportion of focal lesions would be expected. However, the occurrence of solitary right lobe involvement in amebiasis is nine times greater than the left. Such a ratio suggests preferential perfusion of the right lobe by vessels transporting the infectious emboli. Streaming of blood from ileal-cecal veins via the superior mesenteric vein to the right hepatic lobe as demonstrated by on August 27, 2017. For personal use only. jnm.snmjournals.org Downloaded from GATES AND DORE

SUMMARY

Streamlining of blood in the human portal vein occurs when injection of \textsuperscript{198}Au-colloid is made in mesenteric vessels particularly in subdivisions of the superior mesenteric vein. Blood from these ileal-cecal subdivisions is predominantly directed to the right lobe. This process may account for the preponderant occurrence of right lobe involvement in certain infectious diseases which embolize to the liver via the superior mesenteric vein.

ACKNOWLEDGMENTS

The authors are indebted to the following members of the Surgical and Gynecological Departments who did the injections for this study: I. Berke, P. Carney, B. Feldman, R. Feldman, J. Freeman, P. Hartley, F. Hurtubise, J. Kroyer, R. MacKenzie, E. Moore, J. Sewak, and M. Todd. The review and suggestions concerning this study by George V. Taplin are deeply appreciated. The technical support of Eileen Brief and secretarial help of Dorothy Maurer were invaluable. This project was supported by Grant No. 123-1,000 studies. Arch Intern Med (Chicago) 116: 95–110, 1965


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