BJA Education Advance Access published June 8, 2015

OXFORD

Revalidation FOR ANAESTHETISTS RCA Revalidation matrix Matrix reference 1A01, 1A02, 1A03

BJA Education, 2015, 1–6

doi: 10.1093/bjaceaccp/mkv017
Advance Access Publication Date: 0 2015

Splanchnic circulation

D Harper MBChB BMSc FRCA[1] and B Chandler MBChB FRCA FFICM[2,*]

[1]Research Fellow, Scarborough Hospital, Scarborough, North Yorkshire, UK, and [2]Consultant Anaesthetist, Department of Anaesthesia, Scarborough Hospital, Woodlands Drive, Scarborough, North Yorkshire, UK

*To whom correspondence should be addressed. Tel: +44-1723-368111; Fax: +44-1723-342581; E-mail: ben.chandler@nhs.net

Key points

- The arterial supply to the splanchnic bed comprises three divisions of the abdominal aorta; the coeliac artery; and the superior and inferior mesenteric arteries.
- Under physiological conditions, blood flow in the splanchnic circulation is controlled via intrinsic (myogenic and metabolic) and extrinsic (autonomic and humoral) mechanisms.
- The splanchnic bed forms an important circulatory reservoir, which can be mobilized during periods of physiological stress.
- Disorders of the splanchnic circulation may contribute to the multi-organ dysfunction syndrome and vice versa.
- A number of techniques used in anaesthesia and critical care influence the distribution of blood flow in the splanchnic circulation.

The splanchnic circulation is a complex system. A number of important functions depend on its normal operation, including digestion and absorption within the gut, maintenance of the mucosal barrier, and successful healing of surgical anastomoses, but we have little quantitative information about its physiology because routine measurement in humans is so difficult. This article outlines some basic science and describes how influential the splanchnic circulation might be in our clinical practice.

Anatomy

The term 'splanchnic circulation' describes the blood flow to the abdominal gastrointestinal organs including the stomach, liver, spleen, pancreas, small intestine, and large intestine. It comprises three major branches of the abdominal aorta; the coeliac artery; superior mesenteric artery (SMA); and inferior mesenteric artery (IMA) (Fig. 1). The hepatic portal circulation delivers the majority of the blood flow to the liver.

Coeliac artery

The coeliac artery is the first major division of the abdominal aorta, branching at T12 in a horizontal direction ~1.25 cm in length. It shows three main divisions such as the left gastric artery, common hepatic artery, and splenic artery and is the primary blood supply to the stomach, upper duodenum, spleen, and pancreas.

Superior mesenteric artery

The SMA arises from the abdominal aorta anteriorly at L1, usually 1 cm inferior to the coeliac artery. The five major divisions of the SMA are the inferior pancreaticoduodenal artery, intestinal arteries, ileocolic, right colic, and middle colic arteries. The SMA supplies the lower part of the duodenum, jejunum, ileum, caecum, appendix, ascending colon, and two-thirds of the transverse colon. It is the largest of the splanchnic arterial vessels delivering >10% of the cardiac output and therefore has significant implications for embolic mesenteric ischaemia.

Inferior mesenteric artery

The IMA branches anteriorly from the abdominal aorta at L3, midway between the renal arteries and the iliac bifurcation. The main branches of the IMA are the left colic artery, the sigmoid branches, and the superior rectal artery. It forms a watershed with the middle colic artery and supplies blood to the final third of the transverse colon, descending colon, and upper rectum.

Physiology

Resting splanchnic blood flow (SBF) is typically 30 ml min^{-1} 100 g^{-1} of tissue, which equates to 25–30% of the cardiac output.

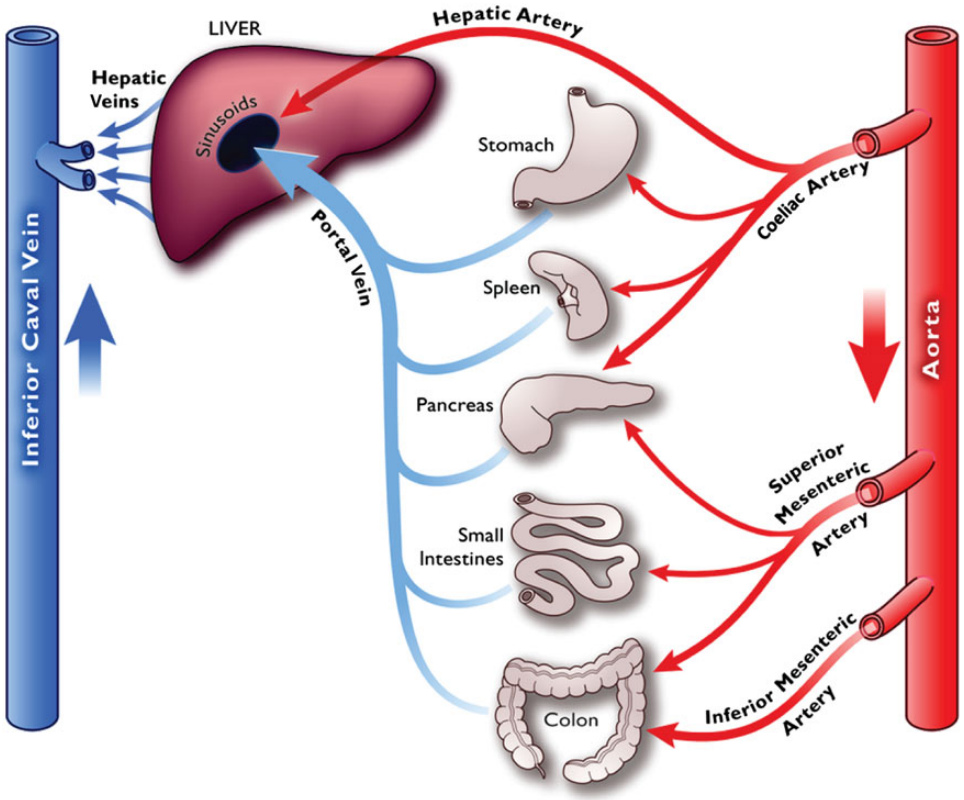

Fig 1 Schematic representation of the splanchnic circulation.[1]

This may decrease to <10 ml min^{-1} 100 g^{-1} in low cardiac output states or peak locally at 250 ml min^{-1} 100 g^{-1} after a meal. The splanchnic circulation must therefore be highly adaptive. The mechanisms of physiological regulation of SBF are complex but the academic debate focuses primarily on three circulatory determinants: intrinsic (local metabolic *vs* myogenic), extrinsic (autonomic nervous system), and humoral (local or circulating vasoactive substances).

Intrinsic control

The splanchnic vascular bed demonstrates an autoregulatory capacity similar to that seen in other vascular beds such as the renal and cerebral circulations. This ensures that a constant blood flow can be maintained across a wide variety of perfusion pressures. There are two proposed mechanisms: metabolic and myogenic control.

The metabolic hypothesis focuses on the balance between oxygen supply and demand rather than blood flow. Accumulation of metabolites such as H^+, K^+, adenosine or CO_2, during periods of poor supply and tissue hypoxia serve to produce vasodilation, thereby restoring blood flow. Alternatively increased delivery of oxygen to the tissues will result in vasoconstriction.

The myogenic hypothesis describes the mechanism by which vessels respond to an increase in transmural pressure or stretch by constricting, thereby restoring blood flow to baseline levels. This is mediated through opening of mechano-sensitive cation channels, principally sodium (Na^+). The resulting depolarization activates voltage-gated calcium (Ca^{2+}) channels elevating intracellular Ca^{2+} concentrations, thereby inducing smooth muscle contraction. Conversely the vessels relax and reduce their tone in response to a reduction in transmural pressure.

Extrinsic control

All of the splanchnic vasculature with the exclusion of the capillaries receive sympathetic innervation. The postganglionic fibres from the coeliac, superior mesenteric, and inferior mesenteric ganglia follow the path of the corresponding arteries. Sympathetic stimulation exerts a direct effect through the release of noradrenaline mediating α-adrenergic vasoconstriction. Alterations of blood flow in response to sympathetic stimulation follow a triphasic pattern. Initial reductions in flow return to near normal within minutes of stimulation followed by a reactive hyperaemia on cessation of activity. Sympathetic vasoconstriction plays an important role in the distribution of blood volume throughout periods of both physiological and pathological stresses such as exercise and major haemorrhage.

Parasympathetic innervations from the vagal and pelvic nerves synapse with postganglionic fibres in the gut wall. Parasympathetic stimulation increases intestinal motility and secretions, which indirectly increase blood flow. Release of nitric oxide (NO) upon activation of muscarinic receptors (M1) by acetylcholine in the endothelial layer leads to vascular smooth muscle relaxation and an increase in mucosal blood flow.

Humoral control

Circulating vasoactive mediators of the splanchnic circulation are legion and may be exogenous or endogenously produced (Table 1). The complex interplay of factors is evident during postprandial hyperaemia. Local production of vasodilator metabolites such as adenosine and CO_2 secondary to increased mucosal metabolic activity and consumption of O_2 lead to increased blood flow. In addition, the hyperosmolar conditions