Title: THE EFFECTS OF INCREASED INTRA-ABDOMINAL PRESSURE ON HEPATIC AND SPLANCHNIC BLOOD FLOW DURING ISOFLURANE ANESTHESIA IN NEWBORN PIGLETS

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Introduction: In normovolemic animals, an acute increase in intra-abdominal pressure (IAP) obstructs blood flow in the inferior vena cava (reduces preload) and compresses the abdominal aorta and its branches (increases afterload). Decreases in cardiac output and changes in distribution of blood flow occur; hepatic blood flow may be compromised (1). These hemodynamic changes are exaggerated in animals anesthetized with halothane (2). Isoflurane may preserve hepatic and splanchnic blood flow in spite of increased IAP because it decreases mesenteric vascular resistance and causes minimal depression of cardiac output. We have characterized the hemodynamic phenomena and redistribution of flow that occur when an acute increase in IAP is superimposed on the effects of isoflurane anesthesia in newborn piglets.

Methods: After obtaining institutional approval of this protocol, six piglets (age: 3-14 days) were anesthetized with intravenous thiopental (10 mg/kg) and metocurine (0.2 mg/kg) to facilitate endotracheal intubation. Anesthesia was maintained with 0.5% isoflurane in 100% oxygen. Controlled ventilation was adjusted to maintain normocarbia. All animals received isotonic IV fluids at 4 ml/kg/h.

Both femoral arteries, the left external jugular vein, and the left internal carotid artery were isolated and cannulated. Two intraperitoneal catheters were inserted percutaneously. A thoracotomy was performed; the left atrial appendage was cannulated for microsphere injection. Arterial pressure (MAP) and heart rate (HR) were continuously recorded. Left ventricular (LV) contractility was estimated by peak LV dP/dt, obtained by processing the signal of a micromanometer-tipped catheter; LV end-diastolic pressure (LVEDP) was measured at end-expiration. Organ blood flows and cardiac index (CI) were determined using radioactive microspheres; calibrated withdrawal into an artificial organ was selected as the reference for flow. The individually processed tissues were combined into four compartments: hepatic (liver, gallbladder); splanchnic (stomach, spleen, intestines, pancreas); other viscera (heart, lungs, brain, kidneys, adrenal glands); and carcass (remainder). Total peripheral resistance index (TPRI) was calculated as the quotient of MAP over CI. The stroke volume index (SVI) was calculated by dividing CI by HR.

The abdomen was insufflated with nitrogen to maintain an intraperitoneal pressure of 20 mmHg for 30 min. Hemodynamic recordings and microsphere injections were performed before inflation, after 30 min of inflation, and 30 min after deflation. Changes in cardiovascular variables and compartmental blood flows were assessed by repeated-measures analysis of variance with post-hoc Newman-Keuls tests of the factor means. Significance was accepted at the level of $p<0.05$. Values are reported as the mean +/- SEM.

Results: During inflation, LVEDP decreased and TPRI increased, which resulted in significant reductions in SVI and CI (see Table I). No change in dP/dt was observed. MAP and HR were significantly increased; this change was sustained 30 min after deflation. Following deflation CI, SVI, and TPRI returned to baseline values; LVEDP remained significantly reduced. No significant change was noted in the profile of blood flow distribution during or after inflation (see Figure 1). Hepatic and splanchnic blood flow was preserved during inflation even though cardiac output decreased and vascular resistance increased significantly.

Discussion: Acutely increased IAP is a clinically relevant problem in pediatric anesthesia. It affects neonates after repair of gastroschisis, omphalocele, and diaphragmatic hernia, as well as older children who have undergone liver transplantation. It is essential that anesthesiologists tailor their management to optimize hepatic and splanchnic blood flow. The results of this study suggest that isoflurane preserves hepatic and splanchnic blood flow during acute increases in IAP even though cardiac output decreases and peripheral resistance increases.

References:
1. Lynch FP, et al: Cardiovascular effects of increased intra-abdominal pressure in newborn piglets. J Pediatr Surg 9:621-626, 1974.
2. Diamant M, et al: Hemodynamics of increased intra-abdominal pressure: interaction with hypovolemia and halothane anesthesia. Anesthesiology 48:23-27, 1978.

Table 1. Summary of Hemodynamic Changes

	PRE-INFLATION	INFLATION	POST-DEFLATION
MAP	73.3 +/- 18.0	82.8 +/- 17.4*	86.7 +/- 19.5*
HR	166.0 +/- 31.0	218.0 +/- 18.0*	214.0 +/- 10.0*
CI	164.0 +/- 24.0	115.0 +/- 27.0*	147.0 +/- 24.0
LVEDP	6.4 +/- 3.8	3.8 +/- 1.9*	3.4 +/- 1.8*
dP/dt	10980.0 +/- 49.0	11712.0 +/- 45.0	12444.0 +/- 60.0
TPRI	457.0 +/- 149.0	726.0 +/- 72.0*	500.0 +/- 272.0
SVI	1.0 +/- 0.2	0.5 +/- 0.1*	0.7 +/- 0.1

* $p < 0.05$

Figure 1. Summary of Changes in Distribution of Blood Flow