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Haemodynamic changes associated with PEEP ventilation

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Keywords

Blood flow, cardiovascular system, liver, norepinephrine, positive end-expiratory pressure, sympathetic nervous system, ventilation

Comments

The influence of PEEP on regional organ perfusion is of obvious interest in intensive care. Although this study was primarily related to operating theatre anaesthetic practice, it has relevance to critical care medicine. The independence of mesenteric organ perfusion from sympathetic control shown in these anaesthetised patients should be evaluated in intensive care patients to determine whether these autoregulatory mechanisms are preserved in the face of severe illness.

Introduction

The percent of cardiac output delivered to the splanchnic organs is 25%, and previous studies have shown that these organs receive up to 50% of sympathetic outflow. Sympathetic outflow may be measured by the plasma spillover of norepinephrine. The effect of general anaesthesia and different ventilatory strategies on the regional blood flow and sympathetic outflow to the splanchnic organs is not well described.

Aims

To investigate the sympathetic and haemodynamic responses of the mesenteric organs and the liver to a standardised haemodynamic challenge in patients who were undergoing major upper abdominal surgery. The haemodynamic challenge was the application of positive end-expiratory pressure (PEEP). The sympathetic nerve activity was studied using a kinetic radiotracer to measure plasma spillover of norepinephrine which has been described previously by other groups.

Methods

Following ethics committee approval, eight patients gave their informed consent to participation. All the patients had non-metastatic gastric adenocarcinoma (of a similar stage) or pancreatic neoplasm. The patients were anaesthetised using the same method. Samples were taken from radial arterial, central venous and hepatic catheters. Blood flows in the portal vein and hepatic artery were measured directly using ultrasound. The measurements were repeated following the application of 10 cmH₂O of PEEP.

Results

When 10 cmH₂O was applied, there was no change in heart rate, systolic or diastolic blood pressure. There was a statistically significant decrease in portal blood flow accompanied by an increase in mesenteric vascular resistance with PEEP. At the same time there was an increase in hepatic arterial blood flow and a decrease in hepatic arterial vascular resistance. The proportion of hepatic blood flow derived from the hepatic artery increased with PEEP from 31 to 49%. Mesenteric oxygen delivery decreased and hepatic oxygen delivery was unchanged with the application of PEEP. There was no significant change in regional oxygen consumption during this time. There was no change in measured spillover norepinephrine in arterial, hepatic or venous blood flow with PEEP.

Discussion

The haemodynamic changes associated with the application of PEEP appear to occur without alterations in the regional sympathetic activity. The cardiovascular changes with PEEP may be attributed to the decrease in venous return and end-diastolic filling. However, regional blood flow variations are not well described. Hepatic blood flow changes with PEEP occurred independently of any change in sympathetic activity. Total hepatic blood flow was maintained due to reciprocal changes in portal and hepatic blood flow. This response is independent of sympathetic control and other authors have suggested it can be influenced by adenosine. The same response is also seen in transplanted livers, confirming independence from sympathetic control. Despite the reduction in portal oxygen delivery, total hepatic oxygen delivery was constant due to the increase in arterial hepatic oxygen delivery. The authors admitted that surgery and anaesthesia may both have an effect on mesenteric organ blood flow but their baseline levels were similar to those found in previous studies in awake, healthy humans. In conclusion, PEEP ventilation altered mesenteric and hepatic perfusion, independent of any change in corresponding sympathetic nerve activity. Regulation of hepatic blood supply maintained liver oxygenation during PEEP despite a simultaneous decrease in mesenteric perfusion.

References

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