THE EFFECT OF SPLENECTOMY ON CIRCULATORY ADJUSTMENTS TO HYPOXAEMIA IN THE ANAESTHETIZED DOG

D. J. O. FFOULKES-CRABBE, R. E. CREIGHTON, G. A. VOLGYESI, D. J. STEWARD AND H. I. A. NISBET

SUMMARY

Six intact and seven splenectomized dogs were subjected to a similar degree of hypoxaemia while under light anaesthesia and artificial ventilation. In the intact animals, heart rate, cardiac output, myocardial contractility and oxygen consumption were increased as a result of hypoxaemia; oxygen transport was not affected. In the splenectomized animals the changes in cardiac output and myocardial contractility were small, and oxygen availability was decreased.

The canine spleen changes in size under various conditions. It is small and contracted when the dog is awake, excited or receives adrenaline. Barbiturate anaesthesia causes the spleen to enlarge greatly so that 5–20% of the blood volume may be sequestrated (Barcroft and Stephens, 1927; Dellenback, Usami and Gregersen, 1969). Despite these changes, splenectomy is not always performed before commencing haemodynamic studies in the dog.

This study was undertaken to determine the effect of hypoxaemia on the circulation and oxygen transport in intact and splenectomized animals.

METHODS

Thirteen beagle dogs weighing 8–15 kg were studied. Six were intact and seven had undergone splenectomy 2–3 weeks before the study.

In each dog anaesthesia was induced with a sleep-dose of thiopentone, the trachea was intubated, and anaesthesia was maintained with 0.5–1% halothane in air. Suxamethonium was given i.v. and the dogs were ventilated artificially with a Volgyesi ventilator (Volgyesi and Nisbet, 1972). \( \text{Pa}_2 \text{O}_2 \) was maintained within normal limits.

Catheters were placed in the right atrium and both ventricles for measurement of the ventricular pressures, and the cardiac output by the dye dilution technique. The left ventricular pressure signal was differentiated electronically to provide an index of myocardial contractility (\( \text{dp/dt} \)). Arterial and venous blood were sampled via the catheters and the following were measured: haemoglobin, oxygen and carbon dioxide tension and pH. Appropriate corrections were made to tension measurements for changes in the dog’s body temperature. However, such changes were minimized by placing the dog upon a heated blanket. Whole-body oxygen consumption was measured by spirometry.

The following were calculated: stroke volume, cardiac index, arterial oxygen content, arterio-venous oxygen difference or extraction ratio, and left ventricular \( \text{dp/dt} \).

At least 2 h after induction of anaesthesia, control measurements were made, while the dog was being ventilated with air. The inspired oxygen concentration was then reduced by adding nitrogen to the mixture. The measurements were repeated 20 min later. The significance of changes was assessed by the paired \( t \) test and Student’s \( t \) test.

RESULTS

\( \text{Pa}_2 \text{O}_2 \), \( \text{Pa}_2 \text{CO}_2 \) and pH were not significantly different between splenectomized and intact animals, whether breathing air or the low oxygen mixture (table I).

In the control period there were significant differences in the heart rate, left ventricular systolic pressure, stroke volume and haemoglobin concentrations between the intact and the splenectomized animals (tables II and III); however, cardiac output, left ventricular end-diastolic pressure, oxygen extraction and oxygen consumption were similar in both groups.

In the intact animals heart rate, cardiac output, cardiac index, left ventricular systolic pressure (LVSP) and left ventricular \( \text{dp/dt} \) (LV \( \text{dp/dt} \)) were all increased significantly during the period of hypoxaemia. This did not occur in the splenectomized animals. Stroke volume (SV) remained unchanged in both groups (table II).
During hypoxaemia oxygen consumption \( (\dot{V}O_2) \) was increased in both the intact and the splenectomized dogs, but the haemoglobin concentrations were increased only in the intact animals (table III). A large increase in the oxygen extraction ratio occurred in the splenectomized dogs, in whom oxygen transport decreased. The intact dogs maintained oxygen transport at values close to those measured during the period of air breathing (table III).

**DISCUSSION**

Splenectomized dogs under the control conditions had a significantly higher heart rate and left ventricular systolic pressure than the intact dogs; however, cardiac output and oxygen consumption were similar in the two groups. These changes following splenectomy have not previously been noted and the mechanism is unknown; however, several authors have commented upon the haemodynamic variability in intact and splenectomized dogs (Smith, Foster and Muller, 1962; Gold and Murray, 1969).

In the intact dogs under inhalation anaesthesia, the effects of hypoxaemia were, in general, similar to those described in other studies (Cullen and Eger, 1970; Gray et al., 1973). During hypoxaemia increases in heart rate, cardiac output and haemoglobin concentration maintained oxygen delivery to the tissues.

In the splenectomized animals a similar degree of hypoxaemia was associated with a much smaller...
change in cardiac output. Because of this, and the failure of haemoglobin to increase, transport of oxygen to the tissues decreased and the oxygen extraction ratio increased. The intact dogs are presumed to have received an auto-transfusion from the spleen during hypoxaemia. The resultant increase in haemoglobin and blood volume increased the ability of the cardiovascular system to compensate and maintain oxygen transport in spite of a reduction in alveolar \( P_{O_2} \).

The apparent role of the canine spleen in circulatory adjustments following hypoxia and the fact that many previous haemodynamic studies have been performed in intact animals may account for the conflicting results that have been reported by various authors.

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**REFERENCES**


**EFFET DE LA SPLENECTOMIE SUR L'ADAPTATION CIRCULATOIRE A L'HYPOXEMIE CHEZ LE CHIEN ANESTHESIE**

**RESUME**

Six chiens intacts et sept chiens ayant subi une splénectomie ont été soumis au même degré d’hypoxémie alors qu’ils se trouvaient sous légère anesthésie avec ventilation artificielle. Chez les animaux intacts, le rythme et le régime cardiaques, la contractilité du myocarde et la consommation d’oxygène ont augmenté en raison de l’hypoxémie; le transport d’oxygène n’a pas été affecté. Chez les animaux ayant subi une splénectomie, les modifications du régime cardiaque et de la contractilité du myocarde ont été faibles, et les disponibilités en oxygène ont diminué.

**ZUSAMMENFASSUNG**


**EL EFECTO DE ESPLENECTOMIA SOBRE LOS REAJUSTES CIRCULATORIOS A LA HPOXEMIA EN EL PERRO ANESTESIADO**

**SUMARIO**

Se sometió a seis perros intactos y a siete esplenectomizados, un grado similar de hipoxemia mientras estaban bajo anestesia ligera y ventilación artificial. En los animales intactos, aumentaron la frecuencia y débito cardiacos, la contractilidad miocárdica y el consumo de oxígeno, como resultado de hipoxemia: el acarreo de oxígeno no se vió afectado. En los animales esplenectomizados fueron pequeños los cambios en el débito cardiaco y contractilidad miocárdica, y estaba disminuida la disponibilidad de oxígeno.