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RESEARCH PAPER

Subarachnoid pressures and cardiorespiratory parameters during cisternal myelography in isoflurane anaesthetized dogs

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Abstract

Objective To measure subarachnoid pressures, systemic circulatory and respiratory effects, and to calculate cerebral perfusion pressure during cisternal myelography.

Study design Prospective clinical study.

Animals Forty-three client owned dogs with clinical signs of spinal disease, weighing 6–56 kg.

Methods Dogs were premedicated with butorphanol and diazepam intravenously (IV) and anaesthesia was induced with propofol and maintained with isoflurane vaporized in oxygen. Ventilation was spontaneous. Heart and respiratory rates, invasive mean arterial blood pressure (MAP), end tidal carbon dioxide and isoflurane concentration were measured continuously. Initial subarachnoid pressure (SaP_0) was measured in the cisterna magna with a needle pressure gauge. Iohexol 0.3 mL kg^{-1} was injected at a rate of 4.1 mL $minute^{-1}$ into the cerebellomedullary cistern. The SaP was recorded during and at 120 seconds after contrast administration. The maximum SaP (SaP_{max}) and minimum calculated cerebral perfusion pressure (CPP_{min}) were recorded for each case.

Results Prior to contrast injection, mean ± SD, MAP was 73 ± 20 mmHg and SaP_0 was 10 ± 3 mmHg. The cerebral perfusion pressure (CPP) was 64 ± 20 mmHg. The contrast injection increased the SaP_0 to 73 ± 33 mmHg (SaP_{max}). After injection, MAP increased to 97 ± 25 mmHg and the CPP decreased to 14 ± 34 mmHg. A negative correlation was found between the lowest CPP and body weight ($\rho = -0.77$, $p < 0.0001$). Nine dogs had bradycardia, apnoea and hypertension, 21 dogs had at least one of these signs. The number of clinical signs showed significant correlation with body weight ($\rho = -0.68$, $p < 0.0001$), SaP_{max} ($\rho = -0.66$, $p < 0.0001$) and CPP_{min} ($\rho = -0.73$, $p < 0.0001$).

Conclusions and clinical relevance Cerebral perfusion can severely decrease during cisternal myelography using the standard dose of iohexol. Bradycardia, apnoea and systemic hypertension were associated with decreased CPP.

Keywords anaesthesia, cerebral perfusion pressure, isoflurane, myelography, subarachnoid pressure.

Introduction

Contrast radiography of the subarachnoid space, a relatively simple and effective diagnostic method, remains a useful tool for the diagnosis of compressive spinal lesions despite the advancements in diagnostic 3D imaging techniques. One of the main disadvantages of myelography, however, is that it is an invasive procedure. Neurological deterioration and a prolonged recovery from anaesthesia have been reported as occurring in some animals (Lewis &

Hosgood 1992; Barone et al. 2002). Understanding the characteristics of the side effects of myelography may help to prevent and/or to reduce their occurrence. Iodinated contrast media can cause chemical irritation and meningitis; this is well documented as a possible cause of clinical signs in dogs (Lewis & Hosgood 1992; Carlisle et al. 1995).

The skull and the vertebral column represent a rigid space, such that any increase in volume (brain, blood, CSF) will increase the ICP. Therefore, an increase in any one of its compartments must be the at the expense of the other two. This principle is referred to as the Monroe-Kellie doctrine. In the 1960s and 1970s pressure-volume relationships of the craniospinal CSF space were intensely studied in human medicine and it was shown that a relatively small increase in volume within the craniospinal space significantly increases the ICP. In their study with dogs, Ivan & Choo (1982) found that physiological saline injection into the cisterna magna at a rate of 2 mL minute^{-1} resulted in a steady state cisternal pressure slightly above 60 mmHg. Repeated injections of 1 mL of fluid with a higher rate (4.1 mL minute^{-1}) resulted in peak cisternal pressures of 25–30 mmHg in those animals. Numerous studies have concluded that the magnitude of ICP is influenced by several factors such as the injected volume, the rate of injection, individual anatomy, existing circulatory parameters (i.e. MAP, CVP, ICP) and pathological conditions (Gilland 1965; Löfgren & Zwetnow 1973). In our earlier pilot study (Arany-Toth et al. 2008), 0.38–0.54 mL kg^{-1} of contrast media was found to increase the subarachnoid pressure (SaP) quite considerably in some individuals. These findings suggested a possibility that a pressure increase of the cerebrospinal fluid (CSF) space might contribute to a reduction of cerebral circulation and thus the development of neurological complications following myelography.

Cerebral perfusion pressure (CPP) represents the gradient acting across the cerebrovascular bed; it is one of the determinants of cerebral blood flow. The CPP can be calculated as the difference between the vascular pressure (MAP) and the intracranial pressure (ICP); (i.e. CPP = MAP - ICP). The ICP and the cisternal SaP have a high correlation and can be used interchangeably with normal intracranial anatomy (Ivan & Choo 1982). The normal value of ICP in healthy, anaesthetized, laterally recumbent dogs is in the range of 5–12 mmHg (Simpson & Reed 1987; Bagley 1996). An increase of the ICP decreases the CPP, which induces compensation in the form of systemic hypertension and bradycardia. Providing that the CPP is normal, the cerebral blood flow (CBF) depends on the diameter of cerebral arteries; CBF = CPP/CVR (cerebrovascular resistance [CVR]). The vascular response is adjusted to the metabolic requirements of the brain and controlled by vascular and chemical autoregulatory mechanisms, the latter mainly based on the arterial partial pressure of CO_2 ($PaCO_2$) (Bagley 1996). Systemic hypertension results in cerebral vasoconstriction, whereas systemic hypotension causes cerebral vasodilation to maintain the cerebral blood flow at a constant rate. The CBF is independent of the systemic blood pressure within a wide range (50–150 mmHg). Outside the capability of autoregulation (MAP < 50 mmHg or >150 mmHg) the blood flow is directly proportional to the cerebral perfusion pressure. Thus, with an MAP of <50–60 mmHg, there may be cerebral hypoperfusion even if the intracranial pressure is normal (Plöchl et al. 1988). Anaesthetic management can influence the cerebral blood flow at several points, for example by influencing MAP or $PaCO_2$, by causing hypothermia, and also through direct effects of the anaesthetic agents on cerebrovascular autoregulation. The increased ICP and the effect of anaesthesia during myelography result in a unique haemodynamic situation, which has been rarely discussed or investigated in the literature (Praestholm & Moller 1977; Gray et al. 1987; Nishimori et al. 2005).

The aim of this study was to investigate the change in SaP in conjunction with the cardiovascular and respiratory parameters of dogs during cisternal myelography, and to calculate the changes in the cerebral perfusion pressure. The pressure-volume index of the CSF space during myelography on these same dogs has been published elsewhere (Arany-Toth et al. 2012).

Material and methods

All procedures were performed with the dog owners' approval in accordance with the regulation of the Institutional Animal Care Committee. Dogs enrolled in the study had been referred for myelography to the Radiology Unit of the clinic for investigation of clinical signs of spinal cord dysfunction (ASA physical status: II:21 dogs, III:13 dogs, IV:9 dogs). Further inclusion criteria were a minimum body weight of 5 kg, myelography performed with a cervical cisternal puncture and no concurrent cerebral or other systemic disease. Routine haematology and blood biochemistry were performed prior to the procedure.