Intraoperative blood loss during cervical laminoplasty correlates with the vertebral intraosseous pressure

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The systemic arterial pressure has been used as a guide for determining the susceptibility to surgical bleeding during controlled hypotensive anaesthesia. Arterial hypotension is not, however, necessarily accompanied by venous or intraosseous hypotension. The main source of bleeding during posterior spinal surgery is the bone and is venous rather than arterial.

The intraoperative blood loss, the intraosseous pressure (IOP) within the first thoracic vertebral body, and the systemic arterial pressure were measured in 27 patients during cervical laminoplasty for spondylotic myelopathy. The intraoperative blood loss correlated significantly with the vertebral IOP ($p = 0.0073$, $r = 0.499$), but not with systemic arterial pressure, age, or body-weight. The systemic arterial pressure did not correlate with the vertebral IOP. The mean value of the mean arterial pressure throughout the operation varied between 74 and 110 mmHg.

The findings suggest that the vertebral IOP parallels surgical bleeding during posterior spinal surgery under normotensive anaesthesia and that patients with a low arterial pressure do not necessarily have a low IOP.

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Blood loss is a major concern for every surgeon. Factors which affect the amount of bleeding from injured vessels include intravascular pressure and the systemic arterial pressure is sometimes used as a parameter to determine susceptibility to surgical bleeding.^{1,2} Arterial hypotension, however, is not necessarily accompanied by venous or intraosseous hypotension. During arterial hypotension induced by prostaglandin E_1 in anaesthetised rabbits, mild arterial hypotension was associated with intraosseous hypertension, although excessive arterial hypotension did lead to intraosseous hypotension.³

The spinal column is rich in collateral veins which are the main source of bleeding during posterior spinal surgery rather than small arteries. A positive relationship between the vertebral intraosseous pressure (IOP) and blood loss during posterior spinal surgery has been reported.⁴

Our study attempted to ascertain whether surgical blood loss during posterior cervical spinal surgery under normotensive anaesthesia, correlated with the vertebral IOP or the systemic arterial pressure.

Patients and Methods

In 27 patients the IOP within the first thoracic vertebral body and the systemic arterial blood pressure were measured during cervical laminoplasty between the third and seventh cervical vertebrae for spondylotic myelopathy.⁵ The mean age of the 19 men and 8 women was 58.6 years (32 to 75). All gave informed consent to participate in the study which was approved by the Review Board of the department. Patients with a history of cardiovascular, pulmonary or chronic liver disease, which may have caused venous hypertension, were excluded, as were those who were unable to walk unaided before operation, since blood flow in the lower limbs in such patients is decreased. Patients with a systolic arterial pressure of more than 160 mmHg at rest and those who had abnormal laboratory values for haemostasis such as platelet count, bleeding time, prothrombin time, activated partial thromboplastin time, or fibrinogen concentration were also excluded.

All operations were carried out under normotensive general anaesthesia and by the same surgeon (MK). The patients were premedicated with atropine sulphate (0.5 mg) and hydroxyzine (50 mg) intramuscularly one hour before induction. Anaesthesia was induced with intravenous sodium thiopentone (5 mg/kg) and vecuronium bromide (0.1 mg/kg). After intubation, it was maintained with 70% nitrous oxide and 30% oxygen, supplemented with iso-flurane (0.5% to 1.5%) and intermittent intravenous pancuronium bromide.

Midline dissection to expose the spinous processes was done with a scalpel. Electrical cautery was used for subperiosteal dissection and haemostasis. A metal cannula (2.0 mm in diameter) was inserted through the right pedicle into the body of the first thoracic vertebral as in the

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technique for pedicle screw fixation, and placed with its tip in the marrow of the vertebral body near the base of the pedicle, as previously described.⁴ The cannula, which was spontaneously filled with blood from the bone marrow, was flushed with a heparin solution. The IOP was measured continuously for five minutes, after allowing ten minutes for equilibration. Arterial pressure was measured during the operation through a catheter placed in the radial artery. A transducer (Transpac; Abbott Critical Care Systems, North Chicago, Illinois) and a monitoring system with amplifier (Life Scope 9; Nihon Koden, Tokyo, Japan) made continuous recordings of the IOP and arterial pressure. Throughout the study, the values for the IOP were given as the mean pressure $\pm$ SD. The surgeon was not informed of the measured values until the skin was closed. Blood loss was measured by weighing swabs and the blood collected in the suction bottle.

Statistical analysis. This was carried out using the Statview-J 5.0 statistical package (SAS Institute, Cary, North Carolina) for correlation analysis. A *p* value of less than 0.05 was considered to be significant.

Results

Values are expressed as the mean and SD. The duration of surgery was 208 ± 48 minutes and the intraoperative blood loss 270 ± 115 grams. During the five-minute sampling period, the mean value of the vertebral IOP was 7.7 ± 3.7 mmHg. The mean value of the mean arterial pressure (MAP) was 89.8 ± 14.8 mmHg, and the mean value of the systolic arterial pressure 125.8 ± 16.7 mmHg. During the operation the mean value of the MAP was 92.6 ± 10.7 mmHg and ranged from 74 to 110 mmHg.

Intraoperative blood loss correlated with the mean value of the vertebral IOP during the five-minute sampling period (Fig. 1, Table I), but not with mean value of MAP during the same period (Fig. 2, Table I) or of that throughout the operation (Table I). Nor did the mean value of the vertebral IOP during the five-minute sampling period correlate with mean value of MAP during the same period or with the mean value of MAP during the operation (Table I). There was, however, a correlation between the mean value of MAP during the five-minute sampling period and the mean

Fig. 1

Graph showing the correlation between the intraoperative blood loss and the mean value of the vertebral IOP during the five-minute sampling period ($p = 0.0073$, $r = 0.499$) (●, women; ○, men).

Fig. 2

Graph showing the correlation between the intraoperative blood loss and the mean value of the MAP during the five-minute sampling period ($p = 0.431$, $r = 0.159$) (●, women; ○, men).

Table I. Correlation between blood loss, IOP, MAP, age and operating time during cervical laminoplasty in 27 patients with spondylotic myelopathy

	Blood loss (g)		IOP*		MAP*		MAP†		Age		Operating time	
	r value	p value	r value	p value	r value	p value	r value	p value	r value	p value	r value	p value
IOP	0.499	0.0073										
MAP*	0.159	0.431 NS	0.337	0.085 NS								
MAP†	0.119	0.559 NS	0.137	0.499 NS	0.647	0.0002						
Age	-0.296	0.135 NS	-0.173	0.392 NS	-0.153	0.449 NS	-0.057	0.780 NS				
Operating time	0.188	0.351 NS	0.173	0.391 NS	-0.107	0.600 NS	0.135	0.507 NS	-0.370	0.057 NS		
Body-weight	-0.271	0.174 NS	-0.169	0.404 NS	0.132	0.516 NS	0.151	0.456 NS	-0.052	0.799 NS	-0.058	0.777 NS

* means of measurements during the 5-minute sampling period of IOP measurement

† means of all measurements throughout the operation

value of MAP during the operation (Table I), suggesting that the variation in the arterial pressure during the operation was slight.

Discussion

The principal veins within the vertebral body are the basivertebral veins which drain primarily into the epidural venous plexus. The IOP and nutrient venous pressure have been reported to be nearly identical in the canine tibia.⁶ Such a close relationship between the intraosseous and peripheral venous systems validates the use of the IOP as a parameter to determine changes in pressure in adjacent veins and thus the susceptibility to bleeding from both bone and veins. In this study, a positive correlation was observed between the vertebral IOP and intraoperative blood loss. Monitoring of the epidural venous pressure is not practical since it is invasive and technically difficult.

For a clinical study on the relationship of the IOP and blood loss, operations on limbs are not suitable, since they are usually carried out under an exsanguinating tourniquet and often require changes of position of the operative field neither of which occurs during posterior decompression of the spine. Furthermore, cervical laminoplasty is a uniform procedure with respect to the extent of the skin incision, muscle stripping and bony invasion. The mean operating time in this study was 208 ± 48 minutes.

The first thoracic vertebral body was chosen for two reasons. First, cervical laminoplasty extended from the third to the seventh cervical vertebra. Secondly, the insertion of a cannula is a straightforward and safe procedure

since a screw thicker than the cannula is inserted through the pedicle for internal fixation of the thoracic or lumbar spine. By contrast, the insertion of a cannula into a cervical vertebral body through the pedicle is more difficult and is rarely used.

The results show that susceptibility to surgical bleeding during posterior spinal surgery under normotensive anaesthesia is affected by the vertebral IOP and not by the systemic arterial pressure. A patient with a low arterial pressure does not necessarily have a low IOP. During operations on bone, monitoring of the IOP may be more useful in predicting the amount of bleeding and in controlling the arterial pressure during hypotensive anaesthesia.

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