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In vivo study of acute effects of hip and knee positions on blood flow in canine sciatic nerve

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Abstract We studied blood flow in the canine sciatic nerve using a laser Doppler flowmeter. Blood flow was measured in 20 hind limbs of ten adult dogs at varying angles of hip flexion, hip rotation and knee flexion. Blood flow decreased as flexion and internal rotation of the hip increased and also with only slight flexion of the knee. With 90° knee flexion, the mean blood flow did not change significantly when the hip was internally rotated from 0° to 30°. When the knee was straight, the blood flow changed significantly during the same procedure. To prevent sciatic nerve palsy, attention should be paid to the positioning of the hip and knee during total hip arthroplasty.

Résumé Nous avons étudié le courant sanguin dans le nerf sciatique canin en utilisant un débitmètre Doppler laser. Le débit du sang a été mesuré dans 20 membres postérieurs de 10 chiens adultes à angles variables de flexion et rotation de la hanche et de flexion du genou. Le débit a diminué à l'augmentation de flexion et rotation interne de la hanche et aussi lors de la flexion légère du genou. Avec le genou fléchi à 90°, le débit moyen a peu changé pendant la rotation interne de la hanche de 0° à 30°. Quand le genou était en extension le débit a nettement changé pendant la même manœuvre. Pour prévenir la paralysie du nerf sciatique, il faut faire attention au positionnement de la hanche et du genou pendant l'arthroplastie totale de la hanche.

Introduction

Sciatic nerve palsy, a complication associated with total hip arthroplasty (THA), reportedly occurs in 0.28–3.0%

of primary arthroplasties and 2.6–7.6% of revision arthroplasties [1, 4, 7, 10]. Sciatic nerve palsy can result from direct injury caused by retractor- or haematoma-associated compression, over-traction during limb lengthening, or malpositioning of hip and knee joints during surgery. These injuries basically can be categorised as due to either tissue ischemia or mechanical deformation. Several reports [4, 6] have indicated that the most significant contributing event is stretching by over-lengthening, leading to the suggestion that lengthening should be limited to 4 cm. However, little is known about the effects of traction due to the positions of the hip and knee joint. A more complete understanding of the effects of hip and knee joint positions on blood flow to the sciatic nerve in vivo may facilitate more effective prevention and treatment of sciatic nerve palsy. We therefore investigated the effects of hip and knee positions on blood flow in the canine sciatic nerve.

Materials and methods

Twenty hind limbs were examined in ten adult mongrel dogs weighing 10–18 kg each. Anaesthesia was induced with ketamine (10 mg/kg) and xylazine (5 mg/kg). Animals were placed in the lateral position on a specially constructed operating frame. Arterial and venous catheters were placed in a foreleg for monitoring blood pressure and drug infusion. Animals were intubated and ventilated with room air, and anaesthesia was maintained using ketamine (10 mg/kg per hour). Using a posterior surgical approach, the sciatic nerve was exposed and a site 2 cm distal to the greater trochanter was selected for blood flow measurement. Blood flow rate in the sciatic nerve was measured using a laser Doppler flowmeter (Advance Co., Ltd., ALF21). The probe of the flowmeter (diameter 0.8 mm) was gently placed in contact with the surface of the sciatic nerve. Care was taken to avoid compressing the nerve and to measure the same area (Fig. 1). The baseline was defined as a line passing through the centre of the shoulder and hip joints. We defined a hip joint flexion angle of 90° as a right angle to the baseline. We defined a knee joint flexion angle of 0° as full extension of the knee. Blood flow rate in the sciatic nerve was measured 5 minutes after positioning the hip joint at varying angles of flexion (90°, 150°) and internal rotation (0°, 30°), and the knee joint at varying angles of flexion (0°, 90°).

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Fig. 1 Photograph demonstrating the measurement of the blood flow in the sciatic nerve. *Black arrow* shows the probe of the laser Doppler flowmeter. *White arrow* shows the greater trochanter. *White arrow-head* shows the sciatic nerve

Results

Blood pressure in each animal was observed to be stable during this experiment. Blood flow rate in the sciatic nerve decreased as hip flexion angle and internal rotation angle of the hip joint increased. Blood flow rate also decreased with a smaller flexion angle of the knee joint. Mean blood flow rate was 10.2 ml/min per 100 g when the hip joint was positioned at 90° flexion and the knee joint at 90° flexion (Fig. 2). When hip flexion was increased by 60°, mean blood flow rate decreased by 7.8% to 9.4 ml/min per 100 g. When the hip joint was positioned at 150° flexion and the knee joint at 0°, mean blood flow rate was 4.0 ml/min per 100 g, a decrease of 60.8% from the value of the initial position. Mean blood flow rate was 9.7 ml/min per 100 g when the hip joint was positioned at 90° flexion and 30° internal rotation and the knee joint was positioned at 90° flexion. When hip flexion was increased by 60°, mean blood flow rate decreased by 7.2% to 9.0 ml/min per 100 g. When the hip joint was positioned at 150° flexion and 30° internal rotation with the knee straight (0° flexion), the mean blood flow rate decreased by 67% to 3.2 ml/min per 100 g. No significant difference in average blood flow rate was observed between 0° and 30° internal rotation of the hip with the knee joint flexed to 90°. The blood flow rate decreased by 4.9% with the hip joint at 90° of flexion, and by a further 4.3% when flexion was increased to 150°. A significant difference in average blood flow rate was observed between 0° and 30° internal rotation when knee flexion was 0°. The blood flow rate decreased by 15.7% with the hip joint at 90° of flexion, and by a further 20% at 150° of flexion.

Fig. 2 The blood flow rate in the sciatic nerve (ml/min per 100 g). No significant difference in average blood flow was observed between 0° (*unshaded*) and 30° (*shaded*) internal rotation of the hip when the knee flexion was 90°. When the knee flexion was 0°, there was a significant difference between 0° and 30° internal rotation of the hip

Discussion

Stretching in peripheral nerves is widely reported to affect both extrinsic and intrinsic vascular supplies. Lundborg and Rydevik [8] reported that blood supply to rabbit tibial nerves began to reduce at 8% elongation beyond resting length, and became completely arrested at 15% elongation. Ogata and Naito [9] reported similar findings when they measured blood flow to the sciatic nerve of rabbits using the hydrogen washout technique. In their study, blood flow became completely arrested at an average elongation of more than 15.7%. Therefore, the most significant risk factor for sciatic nerve palsy in THA is considered to be stretching of the nerve due to overlengthening. Johanson et al. [6] reported a relationship between the degree of leg lengthening and onset of nerve palsy following THA. They suggested that lengthening was the cause of more than 30% of nerve palsy cases. Edwards et al. [4] reported that lengthening by 3.8 cm may damage the peroneal division of the sciatic nerve, and that lengthening the nerve by more than 4.0 cm could induce sciatic nerve palsy. However, Eggli et al. [5] detected no statistical correlations between degree of lengthening and incidence of sciatic nerve palsy. Among the eight cases of nerve palsy detected from a cohort of 508 THA cases, they concluded that nerve injury was more commonly caused by direct or indirect mechanical trauma than by limb lengthening. Excessive stretching of a nerve may cause some degree of mechanical damage or ischemia in the nerve. However, the possibility of a direct relationship between degree of limb lengthening and onset of nerve palsy following THA remains a matter of contention.

Several studies have examined the relationship between joint position and nerve characteristics. Breig et al. [2] examined the effect of medial hip rotation on ten-

sion in the sciatic nerve in six cadavers and found that tension increased significantly with increased medial hip rotation. They suggested medial hip rotation could be a useful addition to the straight-leg-raising test. Furthermore, Wall et al. [11] noted a 4–8% variation in strain on rabbit tibial nerves with varying joint positions. Brown et al. [3] reported 15% strain with the ankle in dorsiflexion produced a significant drop in compound motor action potentials amplitude. The present in vivo study revealed that blood flow in the sciatic nerve decreased with increasing angles of flexion and internal rotation of the hip joint. Moreover, the decrease in blood flow was particularly pronounced with decreased knee flexion.

We utilised a canine model in our experimental study. The structure of the canine hip and knee joint differs significantly from the human. The angles of hip and knee position used in this study and the rates of blood flow reduction observed within the sciatic nerve are therefore not directly applicable to human subjects. However, the anatomical position of the sciatic nerve in the canine model is similar to that in humans, running close to the hip and knee, and we believe that the position of the hip and knee could exert significant effects on blood flow within the sciatic nerve of humans.

Black et al. [1] monitored somatosensory-evoked potential (SEP) during THA and found that SEP was affected when the hip was in extreme internal rotation and adduction during femoral preparation. However, they did not report changes associated with knee extension. In the present study, the angle of knee flexion would appear to exert a significant effect on blood flow in the sciatic nerve. During THA, either tissue ischemia or mechanical deformation associated with stripping procedures or direct compression by a retractor and reduction of blood flow due to over-lengthening are likely to have been already induced in the sciatic nerve. Incautious positioning of the hip and knee may result in further ischemia, leading to sciatic nerve palsy. In particular, the hip is generally in a position of flexion, adduction and internal rotation during femoral preparation in the lateral position. To prevent sciatic nerve palsy, it is therefore important that attention is paid to the positions of the knee and hip during THA. Excessive extension of the knee during THA

procedures is to be avoided. If sciatic nerve symptoms have already developed, benefit may be gained by controlling the positions of the hip and knee in order to promote early recovery of intraneural blood flow.

In conclusion, although the present study was conducted in a canine model, we believe our findings are applicable to clinical practice. We consider that the effects of hip and knee positions on blood flow in the sciatic nerve would be significant in vivo and would exert a substantial effect on the onset of sciatic nerve palsy following THA. This hypothesis would explain the incongruities between degree of limb lengthening and onset of nerve palsy following THA.

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