Acta Orthop. Scand. 57, 501–504, 1986

Hip joint pressure after femoral neck fracture

The hip joint pressure in 40 patients with intracapsular femoral neck fractures was measured on the fracture table prior to surgery. All but 1 patient had pressures well below 20 mmHg with the hip unreduced. When the hip was extended and internally rotated, the pressure rose to values exceeding the normal arteriolar pressure in most patients, with a peak pressure of 135 mmHg. In nine of 22 Garden IV fractures, the pressure remained low despite extension and inward rotation. Injection of contrast medium in three of these hips indicated a rupture of the joint capsule. The pressure response to extension and internal rotation was less marked in fractures older than 72 hours.

The findings do not support the hypothesis that a hip-joint tamponade is a common etiologic factor for the development of femoral head necrosis following fracture. However, prolonged reduction maneuvers with the hip joint in extension and internal rotation can create intracapsular pressures high enough to temporarily jeopardize the circulation of the femoral head.

Per-Erik Melberg
Lars Körner
Olle Lansinger

University of Göteborg, Department of Orthopedics, Östra sjukhuset, S-416 85 Göteborg, Sweden

Necrosis of the femoral head after cervical hip fracture is caused by a deficient vascular supply, but details of the pathogenesis remain obscure. It has been suggested that an intraarticular tamponade secondary to a hip fracture plays an important role (Soto-Hall et al. 1964). It is also known that very high intraarticular pressures can be produced by the extension and internal rotation necessary for reduction of femoral neck fractures. The reported pressures in this position are so high that they often exceed the normal venous pressure and, in extreme cases, even the arterial systolic pressure (Soto-Hall et al. 1964). Reduction in blood supply to the femoral head has indeed been demonstrated after operation of hip fractures (Bauer et al. 1980, Strömqvist et al. 1983, 1984).

We have studied the hip joint pressure in cervical hip fractures, unreduced and with the hip in different positions.

Patients and methods

Fifty-two patients with a unilateral femoral neck fracture were studied under epidural or general anesthesia on the operation table prior to surgery. The fractures were classified from the preoperative radiographs according to Garden (1961). Patients with a displaced fracture received preoperative tibial pin traction. Twelve of the fractures had to be excluded from the study because of the inability to obtain a free-needle position within the hip joint, resulting in unreproducible pressure levels when the hip was moved. Of the remaining 40 patients, 33 were women and 7 were men. The mean age was 75 (54–88) years. Two fractures were classified as Garden I, seven II, nine III, and 22 as Garden IV. The average time between injury and the measurement was 48 hours (6 hours-14 days).

The intraarticular pressure was recorded using a needle with two side holes, 2 and 5 millimeters from the tip, to assure free communication between the hip joint and the pressure-recording system. Through a pressure tube containing saline, the needle was connected to a Bentley Trantec electronic pressure transducer followed by an amplifier and a chart recorder. Before each recording, the pressure system was checked for calibration and for free passage between the needle and the joint space.

Under image intensifier radiographic control, the needle was inserted into the hip joint anteriorly. When the image showed an intraarticular needle position, the hip joint was gently manipulated. If this resulted in a typical pressure-response pattern, the needle position was accepted. If not, the patient was excluded. To avoid leakage of the hip joint capsule from interfering with the pressure recording, no hips

Table 1. Intra-articular pressure (mm Hg) in different hip positions and Garden groups, mean (SE)

	Unreduced	External rotation and traction	Neutral rotation and traction	Internal rotation and traction
Garden I+II	5.6(4.3)n 4	5.6(2.6)n 8	9.0(3.5)n 8	39.1(9.8)n 9
Garden III	11.6(6.7)n 5	10.3(5.4)n 6	17.8(6.4)n 8	69.1(10.3)n 9
Garden IV	6.0(1.4)n 17	6.4(1.3)n 20	16.9(4.1)n 20	46.1(7.1)n 22

Table 2. Intra-articular pressure (mm Hg) in different hip positions at various time intervals after injury, mean (SE)

	Unreduced	External rotation and traction	Neutral rotation and traction	Internal rotation and traction
<24 hours	6.3(2.9)n 7	5.7(2.1)n 9	18.1(7.7)n 10	55.0(9.8)n 13
25–48 hours	8.4(2.7)n 13	7.9(2.2)n 17	15.4(3.5)n 17	51.8(8.0)n 18
49–72 hours	8.3(5.2)n 3	6.8(3.8)n 4	15.2(3.4)n 5	54.4(7.7)n 5
>72 hours	1.7(1.7)n 3	3.0(3.0)n 4	8.3(6.0)n 4	17.0(11.8)n 4

were punctured twice. The recordings were carried out without injection or aspiration of fluid.

The intraarticular pressure was measured with the fracture unreduced in external rotation without traction in 26 patients. After applying traction the pressure was measured in maximum inward rotation in all 40 patients, in neutral rotation in 36 patients, and in external rotation in 34 patients. In 9 patients, injection of contrast medium Isopaque® through the needle was performed immediately after the pressure measurements. The reason for the difference in observations in the four groups was that the study started as a pilot study; the first patients were not measured in all positions.

The study was approved by the Ethics Committee of the Medical Faculty of the University of Göteborg.

Results

With no traction and with the hip externally rotated, 25 of the 26 hips had pressures below 20 mmHg, and in 20 of these the pressure was less than 11 mmHg. One hip had a pressure of 35 mmHg. The mean pressure was 6.8 (SE 1.64) mmHg.

As expected, the highest pressures were observed when the hips were extended and internally rotated (Table 1). The highest pressure, 135 mmHg, was recorded in a Garden III fracture. In all the Garden III fractures, the intraarticular pressure was higher than 25 mmHg when the hip was extended and internally rotated, and the majority, six of nine fractures, had pressures above 50 mmHg.

Nine out of 22 Garden IV fractures showed no or just a slight increase in the intraarticular pressure in extension and inward rotation, but there were also high pressures. Injection of contrast medium was performed in nine Garden IV fractures, six with high pressures (50–75 mmHg) and three with low pressures (2–25 mmHg). The radiographs showed leakage of contrast medium outside the capsule in the three latter patients; in the 6 patients with high intraarticular pressures, no leakage occurred.

The intraarticular pressure was lower when more than 72 hours had passed since the fracture occurred (Table 2).

Discussion

The hip joint capsule is intact in several intraarticular fractures of the femoral neck, making it possible for a posttraumatic hemarthrosis to cause an increased intracapsular pressure (Garden 1961). Several authors have reported necrosis of the femoral head after hip tamponade in animals (Woodhouse 1964, Tachdjian & Grana 1968, Ganz et al. 1981, Launder et al. 1981, Lucht et al. 1983). Our study does not support this tamponade hypothesis because the pressures in the unreduced position were rather low. Admittedly, we were not able to perform pressure recordings immediately after injury. Therefore, there is still a possiblility

that the intraarticular pressure was higher before the time of measurement. However, the stable joint pressures in the unreduced hips measured within 72 hours after injury suggest that the posttraumatic pressure level in the joint is fairly stable. Drake and Mayers (1984) found low intraarticular pressures in patients with acute femoral neck fractures, measured with the hip in its unreduced position. However, traumatic hip-joint tamponade with high intraarticular pressure and femoral head necrosis has recently been reported (Strömqvist et al. 1985, Wingstrand et al. 1986).

The volume of the hip is greatest when it is in flexion and external rotation and decreases with extension and inward rotation (Lloyd-Roberts 1953). This accords with our results from Garden I-III fractures measured during the first 72 hours after injury. Later, absorption of the intracapsular hematoma results in a less marked increase of the intraarticular pressure when the reduction maneuver is carried out. The more pronounced increase in pressure observed in displaced fractures is probably caused by a rather large intracapsular hematoma.

The mean value of the intraarticular pressure among the Garden IV fractures was lower than that of the Garden III fractures. Further, we found a relatively large individual variance of the joint pressure in the Garden IV group; both very high and very low pressures were observed. Nine out of 22 of the Garden IV fractures had only a minimal increase of the intraarticular pressure on extension and inward rotation. All of these nine fractures were examined within 48 hours after injury. The results of the contrast injection suggest that a rupture of the hip joint capsule is the reason for the low pressures recorded in these fractures.

When the hip was extended and internally rotated, the intraarticular pressure often exceeded 40 mmHg, the normal arteriolar pressure (Ashton 1975). Animal studies have shown radiographic and histologic changes in the femoral head when kept in prolonged extension and inward rotation (Henard & Calandruccio 1971), and that a joint tamponade can produce necrosis of the femoral head (Woodhouse 1964, Tachdjian & Grana 1968, Ganz et al. 1981). Therefore, bringing the hip into extension and internal rotation must cause at least a transient disturbance in the perfusion of the femoral head in a substantial number of hip fractures.

Studies using staining with tetracycline and 99m-TC-MDP-scintimetry have shown that intracapsular hip fractures with preoperatively normal femoral head circulation postoperatively may display vascular insufficiency, indicating that in some of the cervical hip fractures the surgical trauma may contribute to necrosis of the femoral head (Bauer et al. 1980, Strömqvist et al. 1983, 1984). Possibly the position of the patient on the operation table may be detrimental to the blood supply.

From this point of view, we recommend that prolonged traction and internal rotation should be avoided. Postoperative radiography on the fracture table should be carried out with the femur in a neutral position and without excessive traction.

References

Ashton, H. (1975) The effect of increased tissue pressure on blood flow. *Clin. Orthop.* **113**, 15–26.

Bauer, G., Weber, D. A., Ceder, L., Darte, L., Egund, N., Hansson, L. I. & Strömqvist, B. (1980) Dynamics of Technetium-99m methylene diphosphonate imaging of the femoral head after hip fracture. *Clin. Orthop.* **152**, 85–92.

Drake, J. K. & Meyers, M. H. (1984) Intracapsular pressure and hemarthrosis following femoral neck fracture. *Clin. Orthop.* **182**, 172–176.

Ganz, R., Lühti, U., Rahm, B. & Perren, S. M. (1981) Intraartikuläre Druckhöhung und epiphysäre Durchblutungsstörung. Ein experimentelles Untersuchungsmodell. *Orthopäde* **10**, 6–8.

Garden, R. S. (1961) Low-angle fixation in fractures of the femoral neck. *J. Bone Joint Surg.* **43-B**, 647–663.

Henard, D. C. & Calandruccio, R. A. (1971) Experimental production of roentgenographic and histological changes in the capital femoral epiphysis following abduction, extension and internal rotation of the hip. *Surg. Forum.* **222**, 442–444.

Launder, W. J., Hungerford, D. S. & Jones, L. H. (1981) Hemodynamics of the femoral head. *J. Bone Joint Surg.* **63-A**, 442–448.

Lloyd-Roberts, G. C. (1953) The role of capsular changes in osteoarthritis of the hip joint. *J. Bone Joint Surg.* **35-B**, 627–642.

Lucht. U., Bünger, B., Hjermind, J. & Bülow, J. (1983) Blood flow in the juvenile hip in relation to changes of the intraarticular pressure. *Acta Orthop. Scand.* **54**, 182–187.

Soto-Hall, R., Johnson, L. H. & Johnson, R. A. (1964) Variations in the intra-articular pressure of the hip joint in injury and disease. *J. Bone Joint Surg.* **46-A**, 509–516.

Strömqvist, B., Hansson, L. I., Palmer, J., Ceder, L. & Thorngren, K-G. (1983) Scintimetric evaluation of nailed femoral neck fractures with special reference to type of osteosynthesis. *Acta Orthop. Scand.* **54**, 340–347.

Strömqvist, B., Hansson, L. I., Ljung, P., Ohlin, P. & Roos, H. (1984) Pre-operative and postoperative scintimetry after femoral neck fracture. *J. Bone Joint Surg.* **66-B**, 49–54.

Strömqvist, B., Wingstrand, H., Egund, N., Carlin, N-O., Gustafson, T., Herrlin, K., Nilsson, L. T., Thorngren, K-G & Önnerfält, R. (1985) Traumatic hip joint tamponade. Two cases with femoral head ischaemia. *Acta Orthop. Scand.* **56**, 81–85.

Tachdjian, M. O. & Grana, L. (1968) Response of the hip joint to increased intra-articular hydrostatic pressure. *Clin. Orthop.* **61**, 199–212.

Wingstrand, H., Strömqvist, B., Egund, N., Gustafson, T., Nilsson, L. T. & Thorngren, K. G. (1986) Hemarthrosis in undisplaced cervical fractures. Tamponade may cause reversible femoral head ischemia. *Acta Orthop. Scand.* **57**, 305–308.

Woodhouse, C. F. (1964) Dynamic influences of vascular occlusion affecting the development of avascular necrosis of the femoral head. *Clin. Orthop.* **32**, 119–129.