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Rupture of the knee capsule from articular hyperpressure

Experiments in cadaver knees

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We used 10 cadaver knees to estimate the safe pressure during arthroscopy by measuring the volumes and pressures of irrigation fluid at different flexion angles. Maximum volumes could be contained at 35° of flexion. Pressures of 200 to 450 mmHg were measured, and all the knees ruptured by extension or flexion after they were filled to 100 mmHg at 35° of flexion. Fifty milliliters of irrigation fluid had to be removed if the pressure remained constant when extending from 35° and 70 ml when flexing to 90°. Totally, 100 ml irrigation fluid had to be removed when flexing from 35° to 120°.

Our investigation indicates that a pressure of 150 mmHg can be tolerated by all knees. Both flexion and extension from the 35° position must be done gently and slowly using a large bore, wide-open inflow and outflow tubes allowing egress of irrigation fluid to prevent capsular rupture, extravasation of irrigation fluid, vascular compromise, or compartment syndrome.

During arthroscopy, we have, on several occasions, noted collapse of the knee in spite of a constant inflow of irrigation fluid under pressure. Compartment syndrome (Peek and Haynes 1984, Johnson 1986) or vascular compromise (Noyes and Spievack 1982) caused by leaking fluid during arthroscopy has been described. We have studied the relationship between intrarticular volume, pressure, and the degree of knee flexion to establish the upper limit of the safe pressure range.

Materials and methods

Ten cadaver knees were investigated less than 24 hours postmortem. The knees were filled with irrigation fluid, and intraarticular volumes were measured with constant pressures at intervals of 50 mmHg ranging from 50–250 mmHg and with the knees in full extension and 35°, 90°, and 120° of flexion. In a second part of the study, the knees were filled with saline at 35° flexion to 100 mmHg. The 35° of flexion was chosen because the knee in this position could contain maximum volumes of fluid. The pressures were monitored while moving the knee into different positions. During these procedures the fluid volume was kept constant.

Two Stille Werner® arthroscopy drains with inner diameters of 2.8 mm were placed in each knee — one for inflow and outflow and the other connected to a mercury manometer. The angles were measured with a protractor. A ruptured capsule was followed by a sudden decrease of intraarticular pressure.

Results

Volumes contained at the pressures investigated ranged from 25 ml at 120° of flexion and a pressure of 50 mmHg to 240 ml at 35° and 250 mmHg (Table 1). It was not possible to obtain data at all the pressures in all the knees because some knees ruptured at pressures below 250 mmHg.

Volumes were greatest in the 35° position. Fifty milliliters of fluid had to be removed when moving from this position to full extension, 70 ml to reach 90°, and 100 ml to reach 120° of flexion if the pressure was to be kept constant.

In the second part of the investigation, the knees were filled at 35° of flexion to a pressure of 100 mmHg, and were subsequently extended and flexed if they had not already ruptured. All the knees ruptured by this maneuver. The median pressure monitored at

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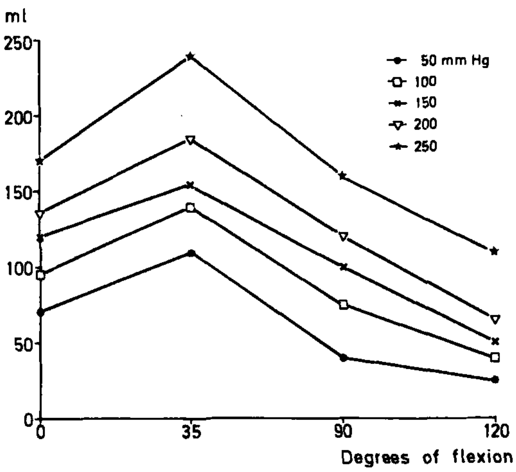
Table 1. Intraarticular volumes (mL) at different pressures (mmHg) and flexion angles. Median (range)

Flexion	Pressure				
	50	100	150	200	250
0°	70 (40–90)	95 (70–120)	120 (80–130)	135 (90–180)	170 (120–200)
35°	110 (80–140)	140 (120–190)	155 (140–180)	185 (150–220)	240 (180–270)
90°	40 (30–100)	75 (50–110)	100 (90–120)	120 (110–130)	160 (140–200)
120°	30 (10–50)	40 (20–60)	50 (30–70)	65 (40–100)	110 (50–120)



rupturing was 250 (200–450) mmHg. On one occasion, a popping sound was heard. After rupture a swelling was noted at the medial and superior borders of the knee extending to the groin in a short time. It was impossible to keep the knees distended in spite of a constant inflow, and the intraarticular pressures fell rapidly to very low levels.

Discussion

Leakage of fluid or gas through the capsule during arthroscopy can lead to compartment syndrome (Gillquist 1984, Peek and Haynes 1984, Oretorp and Elmersson 1986, Johnson 1986), vascular compromise (Noyes and Spievack 1982), pneumoscrotum (Henderson et al. 1982), gas in the peritoneum, pericardium, and subcutaneous emphysema (Shupak et al. 1984), and pneumoperitoneum and acidosis (Lotman 1987) causing prolonged convalescence (Bergström and Gillquist 1986). This leakage of fluid or gas can result when a capsular lesion is present before arthroscopy, i.e., in acute cases with major ligamentous lesions, or as a complication of the procedure itself when too high intrarticular pressures have occurred.

It is well known that knees in acute cases of hemarthrosis assume a position of 35° of flexion (Eyring et al. 1963). In agreement with other investigations (Noyes and Spievack 1982), we found that the intraarticular pressure rises markedly when flexing from this position. Further, our study shows that high pressures, with risk of rupture, can also result by extending the knee from the 35° position.

During arthroscopy, these maneuvers are done frequently and at high-angle velocities. The magnitude of the volume changes during motion make great demands on the irrigation system in maintaining distension and constant pressure. If the joint is moved from 35° of flexion to full extension within 1 s, fluid must leave the joint at a speed of 3 L/min. The drainage device used in our study allowed an outflow of only approximately 330 mL/min. To avoid pressure, with the possible risk of capsular rupture, the drainage system must have a wide caliber, must be fully opened, must not be kinked (Bergström and Gillquist 1986), and must not be blocked with synovium, blood clots, or cut pieces of meniscus (O'Connor and Shahriaree 1984). Likewise, the inflow tubing should be open and a large bore used, allowing egress of fluid from the joint.

All the joint movements during arthroscopy should be performed gently, very slowly, using a large bore and wide open inflow and outflow systems. The intraarticular pressure should be as low as possible and never exceed 150 mmHg. This leaves a margin for a pressure rise during motion.

Our results confirm the report by Kohn et al. (1988), which reached us at the proof stage of our article.

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