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Prone *Versus* Knee-Chest Position for Microdiscectomy: A Prospective Randomized Study of Intra-abdominal Pressure and Intraoperative Bleeding

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Study Design. Prospective randomized study.

Objectives. To compare two support systems for positioning patients during microdiscectomy (*i.e.,* prone on a modified Relton-Hall spine support *vs.* knee-chest position on an Andrews-type table) regarding their effects on intra-abdominal pressure and surgical bleeding.

Summary of Background Data. Intra-abdominal pressure is an indicator of epidural venous pressure, which affects bleeding during microdiscectomy. The ideal patient's position during surgery reduces bleeding by minimizing abdominal compression and vertebral venous engorgement. The results of previous studies on the relationship between intra-abdominal pressure and blood loss during spinal surgery are not consistent, and hardly comparable because they used different measurement systems and support frames.

Methods. A total of 30 patients with the American Society of Anesthesiologists physical status I or II undergoing elective, single-space lumbar microdiscectomy had their intra-abdominal pressure measured through a urinary bladder catheter, together with airway pressure: (1) supine after anesthesia induction; (2) in prone position (group P) or knee-chest position (group K), according to randomization; or (3) at the end of surgery before repositioning the patient supine.

Results. Baseline intra-abdominal pressure did not differ between groups, and intra-abdominal pressure did not vary significantly from baseline in both groups throughout the study. Baseline airway pressure did not differ between groups. Airway pressure was significantly increased from baseline at the recording before incision in group K and at the end of surgery in both groups. Recordings before incision and at the end of surgery differed significantly from one another in both groups. Such airway pressure variations did not differ between groups. Bleeding was significantly more prominent in group K ($P = 0.007$). No correlation between bleeding and intra-abdominal pressure or airway pressure was found.

Conclusions. Intra-abdominal pressure did not differ between prone position on a modified Relton-Hall frame and knee-chest position on an Andrew-type table. Both positions provide good conditions for lumbar microdiscectomy.

Key words: intra-abdominal pressure, Relton-Hall frame, Andrews table, transurethral bladder pressure, microdiscectomy. **Spine 2005;30:1918–1923**

Good exposure of the contents of the spinal canal is a *sine qua non* in surgery for lumbar disc herniation. The quality of the exposure is directly influenced by the position of the vertebrae in relation to each other during the procedure and indirectly by the amount of intraoperative bleeding. The latter is one of the main concerns of the neurosurgeon because even minor bleeding can impair the surgeon's field of vision. Many anesthesiologists provoke a relative controlled arterial hypotension to minimize bleeding in this setting. Anyway, this technique does not always succeed because the source of such a bleeding is usually an increase in the venous system pressure, which can be determined by the inappropriate positioning of the patient. In fact, an inappropriate positioning of the patient can lead to compression of the abdomen, which invariably increases the epidural venous pressure through the inferior caval system.

In our hospital, the most frequently used position for microdiscectomy is the prone position on a modified Relton-Hall spine support (Figure 1).[1] This type of support warrants a safe and stable prone positioning of the patient with spinal lumbar flexion. However, incorrect placement of the two spinal supports can cause an increase in the intra-abdominal pressure in two ways: (1) if the distance between them is improperly wide, the patient would slide down, resulting in his/her abdomen pressed against the operating table; and (2) if they happen to be too cranial, they would directly compress the abdominal wall.

An alternative position for microdiscectomy is the knee-chest position on an Andrews-type table (Figure 2),[2,3] which also warrants a safe and stable positioning of the patient with a good spinal lumbar flexion. Even with this position, abdominal compression may ensue as a result of the forward sliding of the patient against the operating table. Still, when the positioning is correct, there might be differences between prone and knee-chest position, but the choice of the patient's position by the neurosurgeon is based on personal criteria and habits because little is known, so far, about these differences.

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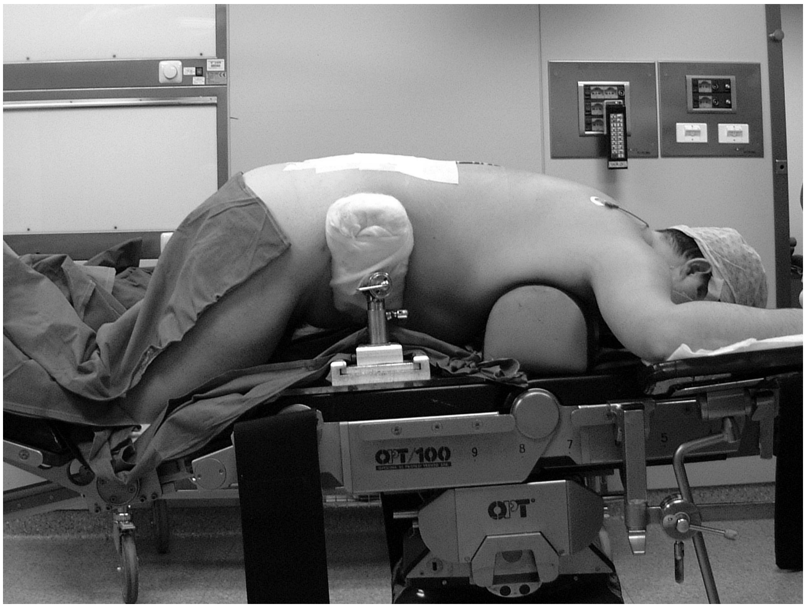

Figure 1. Patient positioned on a modified Relton-Hall frame.

Distefano[4] and Lee[5] *et al* have registered the inferior caval pressure during different types of positioning for spinal surgery to evaluate indirectly the variation of the pressure in the vertebral venous system, but they did not study the relationship between caval pressure and bleeding. Böstman *et al*[6] measured the blood loss in two different positions during microdiscectomy, but they did not register the caval pressure.

So far, two studies examined the relationship between intra-abdominal pressure and blood loss in patients undergoing spinal surgery. Park[7] found a significant correlation between blood loss and intra-abdominal pressure, which was indirectly monitored by measurement of rectal pressure. McNulty *et al*[2] directly measured central venous pressure through a catheter. They showed that increased blood loss was not associated with increased inferior or superior caval pressure. They also showed that patients on the Andrews frame had significantly decreased central venous pressure compared to the Cloward surgical saddle or longitudinal bolsters. The results of these two studies are not consistent and hardly comparable because two different measurement systems and different frames had been used. Moreover, the measurement of the rectal pressure as an indicator of the abdominal pressure has been less reliable than the urinary bladder pressure,[8] which is a valid indicator of intra-abdominal pressure[9] and is presently considered the gold standard for this purpose.[10]

In our prospective randomized study we wanted to determine the effects of two different prone support systems (*i.e.,* a modified Relton-Hall spine support and an Andrews-type table) on urinary bladder pressure, as an indicator of the abdominal and epidural venous pressure, and on airway pressure in patients undergoing mi-

Figure 2. Patient positioned on an Andrews-type table.

crodiscectomy. We also wanted to study the relationship among frame type, intra-abdominal pressure, and bleeding.

Methods

This was a prospective randomized study of 30 patients classified as physical status I or II according to the American Society of Anesthesiologists classification, scheduled for elective single-space lumbar microdiscectomy. Our Institutional Human Investigation Ethic Committee approved the study, and written informed consent was obtained from each patient. No patient had undergone previous spinal surgery. Patients who had hypertension, central nervous system, cardiac, respiratory, liver, or renal disorders, or obesity with body mass index (BMI) >35 kg/m^2 or any contraindications to the placement of transurethral bladder catheter were excluded. Any difficulty in positioning the transurethral bladder catheter was considered a contraindication to the continuation of the study, and the patient would have been excluded. Patients entering the study were randomly allocated to 1 of the two groups: group P (n = 15), prone position on a modified Relton-Hall support (Figure 1); or group K (n = 15), knee-chest position on an Andrews-type table (Figure 2).

All patients were premedicated with 0.1 mg/kg diazepam orally and 0.5 mg atropine intramuscularly an hour before anesthesia. Anesthesia was induced with 1–2 μg/kg fentanyl, 2 mg/kg propofol, and 0.2 mg/kg cis-atracurium. Anesthesia was maintained with 60% N_2O in O_2, propofol, and remifentanil, as needed, to maintain mean arterial pressure between 65 and 85 mm Hg. The muscular relaxation was maintained with cis-atracurium in bolus (0.03 mg/kg every 20 minutes). Ventilation was adjusted to maintain $ETCO_2$ between 30 and 35 mm Hg. We performed the standard monitoring used during this type of surgery (*i.e.,* electrocardiogram with 3 derivations, peripheral hemoglobin saturation ([SpO_2] and noninvasive arterial pressure measurement).

Before positioning the patient on the operating table, a Foley transurethral bladder catheter was placed. The positioning of the patient was performed according to the previous randomization. Before starting surgery, the anesthesiologist had to verify the correct positioning of the patient. Intra-abdominal pressure was measured in the following positions in both groups: (1) supine after the induction; (2) after correct positioning of the patient in prone position (group P) or knee-chest position (group K), respectively; and (3) at the end of surgery before repositioning the patient supine. At the same time as the bladder pressure, the airway peak pressure displayed by the Cato® respirator monitor (Dräger Medical, Lübeck, Germany) was registered.

Measurement Technique of Intra-abdominal Pressure. The technique used to measure intra-abdominal pressure was based on the procedure described by Kron *et al.*[11] According to it, intra-abdominal pressure can be indirectly determined through the measurement of transurethral bladder pressure because the wall of urinary bladder behaves as a passive diaphragm when the bladder volume is between 50 and 100 mL in an adult patient.[11–13]

Each measurement was performed by injecting 50 mL 0.9% sterile saline in the empty bladder through the indwelling Foley catheter. The sterile tubing of the urinary drainage bag was connected to the indwelling Foley catheter, and we let the fluid

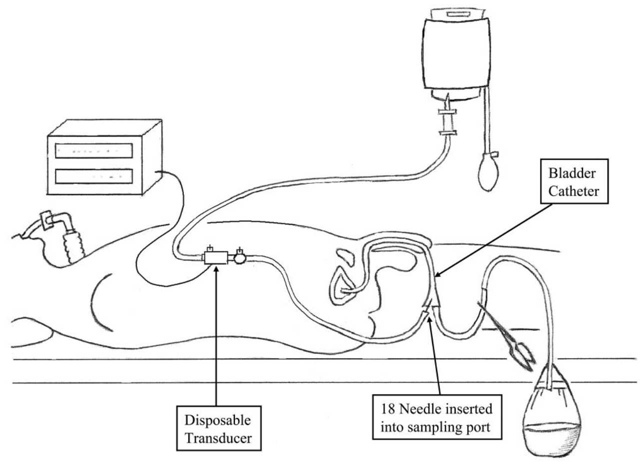

Figure 3. Schematic illustration of a patient in supine position with the monitoring system of the bladder pressure.

from the bladder fill the catheter tubing to eliminate air from the drainage catheter. We then cross-clamped the tubing of the urinary drainage just after the connection point. An 18-gauge needle was then inserted through the catheter sampling port and connected to a pressure transducer. The pubic symphysis was used as the reference point for each measurement. The bladder was continuously emptied between measurements (Figure 3). Because the abdominal pressure varies during the ventilation phases, mean pressure measurements were recorded at the end of the expiratory phase.

At the end of surgery, the neurosurgeon was asked to evaluate intraoperative bleeding. The degree of bleeding was defined as the level of impairment of the visual field by blood: 0, no impairment; 1, slightly impaired; 2, impaired; or 3 heavily impaired. To minimize the variability of such an evaluation, all cases were operated on by the same neurosurgeon, who was blinded to the values of the bladder pressures recorded.

Statistical Analysis. The sample size of the study (15 patients per group) was calculated accepting a 5% α error and a 10% β error to show a difference between groups' intra-abdominal pressure of at least 5 mm Hg, with a standard deviation (SD) of 4 mm Hg. The statistical analysis was performed with Systat software (version, 7.0, SPSS Inc., Chicago, IL).

Age, BMI, and baseline pressure values were compared with the Student *t* test. Repeated measure analysis of variance was applied to abdominal and airway pressure readings analysis. Qualitative data were analyzed with the Pearson χ^2 test or, if ordered, with the Cochran linear trend test. $P < 0.05$ was considered significant. Continuous variables were presented as mean ± SD.

Results

No significant difference was observed between groups regarding age, sex, and BMI (Table 1). Baseline intra-abdominal pressure did not differ significantly between groups, and intra-abdominal pressure did not vary significantly from baseline in both groups before the surgical incision and at the end of surgery. This result holds true also when correction for the BMI was applied (Table 2). No correlation between intra-abdominal pressure and BMI was apparent at any time.

Table 1. Anthropometric Data

	Group P* (n = 15)	Group K† (n = 15)
Mean age ± SD (yrs)	45.5 ± 13.5	50.6 ± 14.6
Mean BMI‡ ± SD (kg/m^2)	24.9 ± 2.9	25.8 ± 4.3
No. of males/females	8/7	9/6

*Prone position on a modified Relton-Hall support.
†Knee-chest position on an Andrews-type table.
‡BMI is weight (kg)/height (m)^2.

Baseline airway pressure also did not differ between groups. However, airway pressure was significantly increased from baseline at the recording before incision in group K and at the end of surgery in both groups. Recordings before incision and at the end of surgery differed significantly from one another in both groups. Anyway, such airway pressure variations did not differ between groups, even after correcting for BMI (Table 2). No correlation between airway pressure and BMI was apparent at any time. Bleeding was significantly more prominent in group K than in group P ($P = 0.007$) (Table 3). No correlation between bleeding and intra-abdominal pressure or airway pressure was found.

Discussion

Various support systems for positioning the patient for spinal surgery are available. Many of them are designed to reduce the physiologic lumbar lordosis and warrant optimal operative conditions. Correct positioning also aims at minimizing abdominal compression and at allowing optimal mechanical ventilation.[1–6,14–17] Of the most frequently used patient positions during spinal surgery, two are the prone position on the Relton-Hall frame and the knee-chest position on an Andrews-type table. However, neither has ever yielded better operative conditions. The choice of the position is usually a matter of surgeon's preference.

Our study shows that there are no differences in terms of abdominal pressure between the Relton-Hall frame and the knee-chest position on an Andrews-type table, although bleeding was significantly more severe in the latter. It is known that epidural veins are connected to the inferior caval vein by a valveless venous system. In the prone position, the abdominal pressure increases, causing a compression of the caval vein, which increases the pressure in the epidural venous circuit. This additional pressure may increase the bleeding during spinal surgery.

Table 3. Bleeding Evaluation in Two Different Positions After Lumbar Microdiscectomy

Bleeding	Group P*	Group K†
0	3	2
1	12	5
2	0	4
3	0	4

*Prone position on a modified Relton-Hall support.
†Knee-chest position on an Andrews-type table.
0 = no impairment; 1 = slightly impaired; 2 = impaired; 3 = heavily impaired.

Böstman *et al*[6] have shown that the blood loss during lumbar discectomy is much less when the patient lays on a modified Hasting frame rather than in the prone position on bolsters. They believe that this effect was caused by a reduction in the inferior caval vein pressure, although they did not measure it or the abdominal pressure.

In a cross-over study, Lee *et al*[5] have studied the differences in the inferior caval vein pressure when the patient is positioned either in the traditional prone position on a conventional pad or on the Relton-Hall frame. Their study included various types of surgery, and they could not estimate the effect of positioning on the rate of bleeding. On the contrary, Sunden *et al*[15] showed that using a Wilson support increases both the pressure in the epidural lumbar veins and blood losses in comparison with using a negative pressure cushion in patients undergoing surgery for lumbar canal stenosis. However, they did not measure the intra-abdominal pressure.

In both our study groups, the intra-abdominal pressure did not vary significantly between baseline (supine patient) and operative position, both before the surgical incision and at the end of surgery. Moreover all mean intra-abdominal pressure values we registered were in the "normal abdominal pressure" range (4–8 mm Hg), as defined by Sanchez *et al*[18] This result suggests that the patients were in an ideal resting condition during sur-

Table 2. Abdominal and Airways Pressure in Supine and in Prone Position During Lumbar Microdiscectomy

		Prone	
	Baseline*	Before Incision	End of Surgery
Intra-abdominal pressure group P (mm Hg)†	5.33 ± 4.32	5.33 ± 3.88	5.40 ± 6.02
Intra-abdominal pressure group K (mm Hg)‡	6.07 ± 3.71	5.33 ± 6.26	7.23 ± 6.03
Airway pressure group P (mm Hg)†	13.33 ± 2.02	13.87 ± 1.85	14.93 ± 1.91§,‖
Airway pressure group K (mm Hg)‡	14.00 ± 3.09	15.47 ± 3.18§	16.80 ± 3.32§,‖

Data are presented as mean ± SD.
*Supine after induction.
†Prone position on a modified Relton-Hall support.
‡Knee-chest position on an Andrews-type table.
§$P < 0.05$ *versus* baseline.
‖$P < 0.05$ *versus* before incision.

gery, without any compression on the abdomen that could increase the abdominal pressure. The abdominal pressure between groups did not differ statistically at any time, indicating that both positions offered the same resting conditions.

This effect holds true even after correction for BMI, and no significant correlation between BMI and abdominal pressure was found. A possible explanation is that all our patients were "normal weight" ($18.5 \leq$ BMI ≤ 24.9 kg/m^2) or "overweight" ($25 \leq$ BMI ≤ 29.9 kg/m^2), according to the BMI classification.[19] The study by Sanchez *et al*[18] showed that no significant intra-abdominal pressure differences occurred between "normal weight" and "overweight" patients, while a significant intra-abdominal pressure increase in the group of "obese patients" ($30.0 \leq$ BMI ≤ 39.9 kg/m^2) compared to the "normal weight" and "overweight" patients was apparent.

In a recent study, Park[7] examined the relationship between intra-abdominal pressure and blood loss in patients undergoing spinal surgery using the Wilson frame. He showed that maintaining the Wilson frame pads at the right distance reduces the pressure on abdominal wall and blood losses. Indeed, Park states that it is difficult to satisfy simultaneously the two goals of lumbar kyphosis and abdominal decompression with the Wilson frame. This contrasts with the fact that neurosurgeons prefer positions that can reduce lumbar lordosis and open interlaminar spaces. In this study, the intra-abdominal pressure was measured by rectal pressure, which has been less reliable than the urinary bladder pressure as an index of intra-abdominal pressure. In fact, the urinary bladder pressure has been recently defined as the gold standard indicator of intra-abdominal pressure by Fusco *et al*,[13] who standardized its measurement, which was previously illustrated by Kron *et al*.[11] Other investigators arrived at the same conclusions both on animal[20] and human models.[9,21] Moreover, an editorial by Sugrue[10] suggested that the method of choice to measure the intra-abdominal pressure must be the measuring of the bladder pressure.

Although no difference in intra-abdominal pressure was observed in our study, patients in the knee-chest position had more bleeding than patients in the prone position. The neurosurgeon made the evaluation of bleeding on a qualitative scale. This evaluation has some drawbacks. The neurosurgeon (AR) participating in this study is a senior and experienced spine surgeon who routinely uses equally both positions in his clinical practice to perform microdiscectomy. Nevertheless, he was not blind to the patient's position, and this might have affected his evaluation. However, he was blind to intra-abdominal pressure data, therefore, not influenced by intra-abdominal pressure values. Furthermore, intra-abdominal pressure is in no way the only determinant of bleeding in spinal surgery, and interpatient variability is high.

Moreover, bleeding during microdiscectomy is usually little, and a large volume of saline solution is used to wash the surgical field; at the end of surgery, the suction bag contains a large volume of saline solution mixed to little blood. This result makes estimation of blood loss really difficult and not accurate. This bleeding is so little that it does not affect the hemodynamic stability of the patient. However, such little bleeding is enough to impair the surgeon's field of vision because the microscope amplifies it.

It might be possible to measure adequately the amount of saline used to wash the surgical field. The amount of saline in the bags could be used as an indirect index of intraoperative bleeding. Estimation of bleeding *via* this technique is approximate, therefore, not precise. Furthermore, this technique is affected by the duration of the surgery. The amount of saline used is directly proportional to the duration of the surgery. As a matter of fact, there are no validated techniques for quantitative estimation of surgical blood loss in the scientific literature. Because of all these reasons, we decided to adopt the subjective evaluation of a senior and experienced spine surgeon as a technique to grade bleeding. In conclusion, there are no differences in term of intra-abdominal pressure between prone position on the Relton-Hall frame and knee-chest position on an Andrews-type table. Both positions provide good conditions for lumbar microdiscectomy.

■ Key Points

- Intraoperative bleeding is one of the main concerns of the neurosurgeon during microdiskectomy because even minor bleeding can impair the surgeon's field of vision.
- Intra-abdominal pressure is an indicator of epidural venous pressure.
- The ideal patient's position during spinal surgery reduces bleeding by minimizing abdominal compression and vertebral venous engorgement.
- Intra-abdominal pressure did not differ between the prone position on a modified Relton-Hall frame and knee-chest position on an Andrew-type table. Both positions provide good conditions for lumbar microdiskectomy.

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