

# Lumbosacral Spine and Pelvic Inlet Changes Associated With Pelvic Organ Prolapse

JOHN K. NGUYEN, MD, LAWRENCE R. LIND, MD, JENNIFER Y. CHOE, MD,  
FRANCIS MCKINDSEY, MD, ROBERT SINOW, MD, AND NARENDER N. BHATIA, MD

**Objective:** To determine the association between advanced pelvic organ prolapse and changes in lumbar lordosis and/or pelvic inlet orientation.

**Methods:** Lateral lumbosacral spine/pelvic x-rays were taken of women with grade 2 or greater uterovaginal prolapse and women with grade 1 or less prolapse standing in their usual upright posture. The angles of lumbar lordosis and the pelvic inlet were measured by a radiologist who was masked to the pelvic examination findings.

**Results:** Twenty women with prolapse were matched with 20 women without significant prolapse. There were no significant differences in the mean ( $\pm$  standard deviation [SD]) age ( $55.3 \pm 9.0$  years compared with  $53.4 \pm 9.5$  years), body mass index (BMI) ( $28.9 \pm 5.6$  compared with  $28.4 \pm 5.2$ ), gravidity ( $5.6 \pm 3.5$  compared with  $5.0 \pm 2.7$ ), and vaginal parity ( $4.65 \pm 3.3$  compared with  $4.5 \pm 2.9$ ) between the prolapse and nonprolapse groups, respectively. All participants were vaginally parous. The mean lumbar lordotic angle in women with pelvic organ prolapse ( $32.0^\circ \pm 9.8^\circ$ ) was significantly lower than that of controls ( $42.4^\circ \pm 10.9^\circ$ ) ( $P < .003$ ). The mean angle of the pelvic inlet in women with pelvic organ prolapse ( $37.5^\circ \pm 7.0^\circ$ ) was significantly larger than that of controls ( $29.5^\circ \pm 7.3^\circ$ ) ( $P < .001$ ). The differences in the mean angles of lumbar lordosis and the pelvic inlet, between the case and control groups, remained significant after multivariable logistic regression was performed.

**Conclusion:** Women with advanced uterovaginal prolapse have less lumbar lordosis and a pelvic inlet that is oriented less vertically than women without prolapse. (Obstet Gynecol 2000;95:332–6. © 2000 by The American College of Obstetricians and Gynecologists.)

---

From the Division of Urogynecology and Reconstructive Pelvic Surgery, Department of Obstetrics and Gynecology, and the Department of Radiology, Harbor—University of California, Los Angeles, (UCLA) Medical Center, UCLA School of Medicine, Torrance, California; the Division of Urogynecology and Reconstructive Pelvic Surgery, Department of Obstetrics and Gynecology, North Shore University Hospital, New York University Medical Center, Manhasset, New York; and the Division of Urogynecology and Reconstructive Pelvic Surgery, Department of Obstetrics and Gynecology, Kaiser Permanente Group, San Diego, California.

Contemporary scientific literature has demonstrated an association between pelvic organ prolapse and neuromuscular and ligamentous connective tissue damage.<sup>1–8</sup> Weakness of the pelvic floor is thought to be a result of factors such as vaginal childbirth, pelvic surgery, and connective tissue disorders. Other factors that may contribute to prolapse of the pelvic viscera include obesity and activities associated with increased intra-abdominal pressure.<sup>9,10</sup>

Apart from a few anecdotal descriptions, the role of the bony pelvis and spinal curvature in providing support to the pelvic viscera has not been examined extensively. It has been proposed that the forward lumbar curve of the human spine and the orientation of the pelvis help support the abdominal viscera and deflect and/or absorb a fraction of the downward intra-abdominal forces before they reach the pelvic floor.<sup>11–13</sup> The protective effects of the spinal column and the bony pelvis, however, may be lost as a woman ages (Kaplan FS. Osteoporosis-prevention and management of osteoporosis. In: Erdely-Brown M, ed. Clinical symposia. Summit, New Jersey: Ciba-Geigy Co., 1995: 1–32).<sup>14,15</sup> Theoretically, these changes may result in a higher proportion of downward intra-abdominal forces exerted on the pelvic floor and predispose women to pelvic organ prolapse. Although Lind et al<sup>16</sup> previously found a significant association between thoracic kyphosis and advanced uterine prolapse, the relationship between pelvic organ prolapse and changes in the lumbar spine and/or bony pelvis has not been examined. This study was conducted to examine the relationship between uterovaginal prolapse with the degree of lumbar lordosis as well as the orientation of the pelvic inlet.

## Materials and Methods

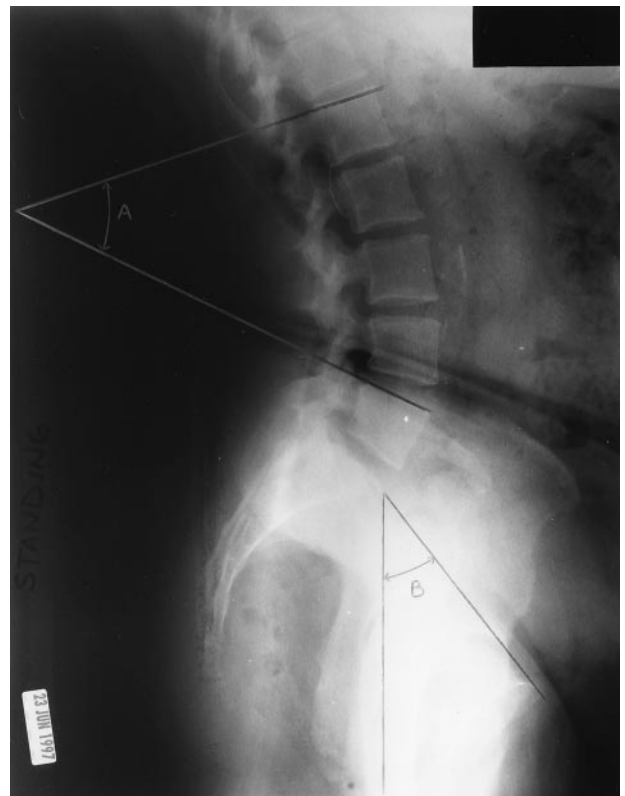
Approval for this study was obtained from the Institutional Review Board. Women who were evaluated in

the gynecology clinic at Harbor-UCLA Medical Center from January 1997 to June 1998 were asked to participate in this study. Recruitment was performed by residents and fellows. All participants were examined in the dorsal supine position with a maximal straining effort. Uterovaginal prolapse was graded using the system described by Baden and Walker.<sup>17</sup> All examination findings were confirmed by the first author (JKN).

Participants were matched on a one-to-one basis. Women with grade 2 or greater uterovaginal prolapse (case group) were asked consecutively to participate in the study. Once a prolapse patient was enrolled, a matching patient with grade 1 or less prolapse (control group) was enrolled in the study. The patients in the case group were matched to the patients in the control group with respect to age ( $\pm 5$  years), number of vaginal deliveries ( $\pm 1$ ), body mass index (BMI) ( $\pm 2$ ), race and menopausal status (premenopausal, postmenopausal on estrogen replacement, or postmenopausal not on estrogen replacement). Premenopausal status was defined as the presence of regular menses. Postmenopausal status was defined as 3 or more years since the last spontaneous menstrual period. Exclusion criteria included uncertain menopausal status, pregnancy, presence of a pelvic mass greater than 5 cm, previous pelvic irradiation or abdominal or pelvic surgery (including cesarean), tobacco use, chronic cough, history of pulmonary disease, connective tissue disease or conditions affecting the spinal cord or pelvic nerve roots, or unwillingness to participate in the study.

With the use of a standardized protocol, lateral lumbo-sacral spine/pelvic x-rays were taken with the participants standing in their usual upright posture, with their shoes on and their hands at chest level. Patients were instructed to wear flat, not high-heeled shoes, during the x-rays. The x-rays were taken by technicians and interpreted by a radiologist who was masked to the pelvic examination findings of the participants. From these x-rays, the angle of lumbar lordosis and angle of the pelvic inlet were measured (Figure 1). The angle of lumbar lordosis was calculated from the intersection of lines drawn across the tops of the first and fifth lumbar vertebrae.<sup>18</sup> The angle of the pelvic inlet was the angle between a line drawn from the sacral promontory to the top of the pubic bone and the vertical axis.<sup>15</sup> The x-ray landmarks used to make these measurements were identified easily by the radiologist. We therefore believed that these measurements were highly reproducible and did not require a second radiologist to repeat the measurements.

The data were analyzed with the use of the SPSS statistical software package (SPSS Inc.; Chicago, IL). When we used an alpha error of 5% and beta error of 10%, power analysis indicated that 22 patients in each



**Figure 1.** Measurements of the angle of lumbar lordosis (A) and the angle of the pelvic inlet (B).

group would be required to detect a  $15^\circ$  difference in either the angle of lumbar lordosis or the pelvic inlet. The distribution of the continuous data was examined for skewedness and kurtosis with the use of the SPSS software package. Analysis of the continuous data revealed that the mean ages and the angles of lumbar lordosis and pelvic inlet were distributed normally, and as such, were examined with use of the unpaired, two-tailed Student *t* test. Gravity, parity, and BMI did not fit a Gaussian distribution and were thus examined using the Mann-Whitney *U* test. Multivariable logistic regression was used to evaluate the association between pelvic organ prolapse (dependent variable) and the angles of lumbar lordosis and the pelvic inlet (independent variables). Statistical significance was set at  $P < .05$ .

## Results

A total of 40 women were enrolled in the study. Within the control group, 15 patients did not have uterovaginal prolapse, whereas five patients had grade 1 uterovaginal prolapse. Within the case group, six patients had grade 2 prolapse, six had grade 3 prolapse, and eight had grade 4 uterovaginal prolapse. All participants

**Table 1.** Demographic and Clinical Data for Patients With (Case) and Without (Control) Advance Pelvic Organ Prolapse

	Control (n = 20)	Case (n = 20)	P
Mean age ( $\pm$ SD)	53.4 $\pm$ 9.5	55.3 $\pm$ 9.0	.51*
Mean gravidity ( $\pm$ SD)	5.0 $\pm$ 2.7	5.6 $\pm$ 3.5	.65†
Mean parity ( $\pm$ SD)	4.5 $\pm$ 2.9	4.65 $\pm$ 3.3	.96†
Mean BMI ( $\pm$ SD)	28.4 $\pm$ 5.2	28.9 $\pm$ 5.6	.84†
Postmenopausal (%)‡	13 (65%)	13 (65%)	
Racial distribution			
Hispanic (%)	13 (65%)	13 (65%)	
White (%)	4 (20%)	4 (20%)	
Asian (%)	3 (15%)	3 (15%)	
Mean lumbar lordotic angle ( $\pm$ SD)	42.4° $\pm$ 10.9°	32.0° $\pm$ 9.8°	<.003*
Mean pelvic inlet angle ( $\pm$ SD)	29.5° $\pm$ 7.3°	37.5° $\pm$ 7.0°	<.001*

SD = standard deviation; BMI = body mass index.

\* Two-tailed Student *t* test.

† Mann-Whitney *U* test.

‡ All postmenopausal patients received hormone replacement therapy.

were vaginally parous. The demographic data of the participants are presented in Table 1. There were no significant differences in the mean ( $\pm$  standard deviation [SD]) age (55.3  $\pm$  9.0 years compared with 53.4  $\pm$  9.5 years,  $P = .51$ ), gravidity (5.6  $\pm$  3.5 compared with 5.0  $\pm$  2.7,  $P = .65$ ), vaginal parity (4.65  $\pm$  3.3 compared with 4.5  $\pm$  2.9,  $P = .96$ ), and BMI (28.9  $\pm$  5.6 compared with 28.4  $\pm$  5.2,  $P = .84$ ) of the prolapse and nonprolapse groups, respectively. The racial distribution of both groups was similar as well: 65% Hispanic, 20% white, and 15% Asian. Thirteen participants in each group (65%) were postmenopausal, and all received hormone replacement therapy (HRT). The mean ( $\pm$ SD) lumbar lordotic angle in women with pelvic organ prolapse (32.0°  $\pm$  9.8°) was significantly lower than that of controls (42.4°  $\pm$  10.9°) ( $P < .003$ ). A relative loss of lumbar lordosis was thereby demonstrated in the prolapse group. The mean angle of the pelvic inlet in women with pelvic organ prolapse (37.5°  $\pm$  7.0°) was significantly larger than that of the control group (29.5°  $\pm$  7.3°) ( $P < .001$ ). The differences in the mean angle of lumbar lordosis and the angle of the pelvic inlet, between the case and control groups, remained significant (.017 and .0087, respectively) after multivariable logistic regression was performed.

## Discussion

The connective tissue support system of the pelvic viscera has been studied extensively. Mengert<sup>3</sup> demonstrated in cadavers that the cardinal and uterosacral ligaments provided the principle connective tissue sup-

port to the uterus. Delancey,<sup>1</sup> however, describes three levels of vaginal support: the upper vagina (level I) is suspended from the sacrum and lateral pelvic walls by the uterosacral-cardinal ligament complexes; the mid-vagina (level II) is attached laterally to the arcus tendineus fasciae pelvis and superior fascia of the levator ani muscles; and the lower vagina (level III) is fused to tissues around the vaginal outlet. Detachment of the pelvic viscera from their connective tissue attachments may predispose women to pelvic organ prolapse. There also may be an inherent weakness in the pelvic connective tissues that can contribute to uterovaginal prolapse. Norton et al<sup>6</sup> found a higher proportion of a weaker collagen (type III collagen) in the pelvic connective tissue of women with pelvic organ prolapse compared with that of women without prolapse.

In addition to the endopelvic connective tissues, the levator ani muscles also support the pelvic viscera. The active basal tone of the levator ani muscles keeps the urogenital hiatus closed and the upper vagina and pelvic viscera supported over the levator plate.<sup>2,7,8</sup> These muscles also contract reflexively in response to coughing or other activities that increase intra-abdominal pressure. This reflex decreases the tension placed on the pelvic connective tissues during periods of increased intra-abdominal pressure. The deterioration of levator tone that occurs with denervation injury associated with vaginal deliveries<sup>5</sup> may result in damage to the endopelvic connective tissue and subsequent pelvic organ prolapse.

In contrast with the relative abundance of literature describing the association between prolapse and damage to the pelvic neuromuscular and ligamentous connective tissues, our knowledge of the association between spinal curvature abnormalities and pelvic organ prolapse is limited.<sup>11-13</sup> There is usually an accentuation of thoracic kyphosis with aging.<sup>14</sup> These changes may result theoretically in a higher proportion of intra-abdominal forces directed toward the pelvic floor and predispose women to pelvic organ prolapse. Lind et al<sup>16</sup> found a statistically significant association between thoracic kyphosis and advanced uterine prolapse. The mean difference in thoracic kyphosis was 4.6° between women with advanced uterine prolapse and those without prolapse. This difference remained significant after adjusting for the difference in the number of vaginal deliveries.

The above data<sup>16</sup> inspired our current investigation. We wanted to determine if there was an association between advanced pelvic organ prolapse and changes in lumbar lordosis and/or pelvic inlet orientation. We found that women with pelvic organ prolapse to or beyond the hymen had significantly less lumbar lordo-

sis than women without prolapse (32.0° compared with 42.4°).

It appears that lumbar lordosis is an adaptive change associated with an upright posture.<sup>19</sup> This forward lumbar curve of the human spine may help support the abdominal viscera and deflect their weight against the muscles of the anterior abdominal wall.<sup>11-13</sup> These adaptations may help prevent pelvic organ prolapse by deflecting and/or absorbing a fraction of the downward intra-abdominal forces before they reach the pelvic floor. A reduction in lumbar lordosis may increase the fraction of downward intra-abdominal force reaching the pelvic floor and thus predispose women to pelvic organ prolapse.

The decrease in lumbar lordosis associated with aging may be caused by anterior compression fractures of the lumbar spine associated with osteoporosis (Kaplan FS. Osteoporosis-prevention and management of osteoporosis. In: Erdely-Brown M, ed. Clinical symposia. Summit, New Jersey: Ciba-Geigy Co., 1995:1-32). This loss of lumbar lordosis, coupled with thoracic kyphosis, may result in a higher risk of pelvic organ prolapse. Although these osteoporotic changes may be prevented by HRT, adequate dietary calcium and vitamin D intake, regular exercise, limiting of alcohol intake, and smoking cessation, the efficacy of these treatments in reducing the risk of pelvic organ prolapse is undetermined presently.

The orientation of the pelvic inlet also is thought to be a protective mechanism against uterovaginal prolapse.<sup>13</sup> The pelvic inlet is oriented in an almost vertical position such that most of the downward intra-abdominal force is directed towards the pubic bone and rectus abdominis muscles before they reach the pelvic floor. Weed<sup>15</sup> noted that the angle of the pelvic inlet in women increased with aging. He did not, however, correlate these changes with prolapse. We found that women with advanced pelvic organ prolapse had a significantly higher pelvic inlet angle than women without prolapse (37.5° compared with 29.5°). That is, the pelvic inlet was oriented more vertically in women with normal pelvic organ support than in women with prolapse. This difference in pelvic inlet orientation may result theoretically in a higher proportion of intra-abdominal forces exerted on the pelvic floor and predispose women to pelvic organ prolapse.

In our study, we excluded women who had risk factors for prolapse, other than vaginal deliveries. Women with pulmonary diseases associated with chronic coughing, connective tissue diseases, or conditions affecting the spinal cord or pelvic nerve roots were not enrolled in our study as these conditions may be associated with an increased risk of developing uterovaginal prolapse.<sup>20-23</sup> Women with large pelvic masses,

previous abdominal or pelvic surgeries, or a history of pelvic irradiation were excluded because these were possible protective factors for pelvic organ prolapse. Although there may not be any scientific evidence that a large pelvic mass, scar tissue from previous surgery, or irradiation may prevent prolapse of the pelvic viscera, we elected not to include these women in our study.

We recognize that there are risk factors for uterovaginal prolapse for which we did not account. Factors such as chronic constipation, child birth weights, and occupation were not taken into consideration but may play an important role in uterovaginal prolapse. It would have been technically difficult to complete the study if participants were matched for all known risk factors for prolapse.

The x-rays were taken with the participants wearing their shoes and standing in their usual position. Patients were instructed routinely not to wear high-heeled shoes during the x-rays. Opila et al<sup>24</sup> demonstrated lumbar flattening and a backward tilting pelvis in patients who wore high-heeled shoes compared with those who were barefoot. Although the effect of positive heel inclination on lumbar spine curvature and pelvic inclination should be considered when interpreting the data, we believe that this effect is negligible since all patients wore flat-heeled shoes. Ideally, we would have preferred all participants to be barefoot during the x-rays; however, some patients may not have been compliant with this protocol and thus would have altered our measurements.

The racial distribution is somewhat skewed, and our results may not be generalizable to a larger population. There was an insufficient number of patients to make comparisons between races meaningful. Enrolling more patients may have facilitated this comparison. Thus, we limit our conclusions mainly to the Hispanic population.

We believe that we have presented valuable information on a relatively unexplored subject. Although a causal relationship was not demonstrated by our study, there appears to be a significant and independent association between uterovaginal prolapse and a decrease in the mean angle of lumbar lordosis as well as a less vertically oriented pelvic inlet in our patient population. Although these bony changes result theoretically in a greater amount of intra-abdominal force exerted on the pelvic floor, we did not measure or compare the intra-abdominal pressures of the participants. This relationship may be the subject of future studies. It also is unclear from our study if these bony changes may be prevented with early lifestyle modifications that minimize the risk of osteoporosis. It would be presumptuous to conclude or assume that preven-

tion of these bony changes may help reduce the risk of pelvic organ prolapse. Clearly, the pelvic viscera are supported by a complex and dynamic interaction between the spinal column, bony pelvis, and the nerves, muscles, and connective tissues of the pelvis. Whereas the function of the pelvic nerves, muscles, and ligamentous connective tissues have been reported by numerous studies, the role of the spinal column and bony pelvis remains relatively obscure. Additional studies are needed to evaluate further this aspect of functional anatomy.

## References

1. Delancey JOL. Anatomic aspects of vaginal eversion after hysterectomy. *Am J Obstet Gynecol* 1992;166:1717-28.
2. Delancey JOL. Anatomy and biomechanics of genital prolapse. *Clin Obstet Gynecol* 1993;36:897-909.
3. Mengert WF. Mechanisms of uterine support and position. *Am J Obstet Gynecol* 1936;31:775-82.
4. Richardson AC, Lyon JB, Williams NL. A new look at pelvic relaxation. *Am J Obstet Gynecol* 1976;126:568-73.
5. Smith ARB, Hosker GL, Warrell DW. The role of partial denervation of the pelvic floor in the aetiology of genitourinary prolapse and stress incontinence of urine: A neurophysiological study. *Br J Obstet Gynaecol* 1989;96:24-8.
6. Norton P, Boyd C, Deak S. Abnormal collagen ratios in women with genitourinary prolapse. *Neurourol Urodyn* 1992;11:2-4.
7. Strohbehm K. Normal pelvic floor anatomy. *Obstet Gynecol Clin North Am* 1998;25:683-705.
8. Gill EJ, Hurt WG. Pathophysiology of pelvic organ prolapse. *Obstet Gynecol Clin North Am* 1998;25:757-69.
9. Bump RC, Sugerma HJ, Fantl JA, McClish DK. Obesity and lower urinary tract function in women: Effect of surgically induced weight loss. *Am J Obstet Gynecol* 1992;167:392-7; discussion 397-9.
10. Jorgensen S, Hein HO, Gyntelberg F. Heavy lifting at work and risk of genital prolapse and herniated lumbar disc in assistant nurses. *Occup Med* 1994;44:47-9.
11. Ulfelder H. The mechanism of pelvic support in women: Deductions from a study of the comparative anatomy and physiology of the structures involved. *Am J Obstet Gynecol* 1956;72:856-64.
12. Elftman HO. The evolution of the pelvic floor of primates. *Am J Anat* 1932;51:307-41.
13. Zacharin RF. Pelvic floor anatomy and the surgery of pulsion enterocele. New York: Springer-Verlag/Wein, 1985:3-22.
14. Fon GT, Pitt JP, Thies AC. Thoracic kyphosis: Range in normal subjects. *AJR Am J Roentgenol* 1980;134:979-83.
15. Weed JC. Pelvic anatomy from the point of view of a gynecologic surgeon. *Clin Obstet Gynecol* 1972;15:1035-47.
16. Lind LR, Lucente V, Kohn N. Thoracic kyphosis and the prevalence of advanced uterine prolapse. *Obstet Gynecol* 1996;87:605-9.
17. Baden WF, Walker TA. Genesis of the vaginal profile. *Clin Obstet Gynecol* 1972;15:1048-54.
18. Wiltse LL, Winter RB. Terminology and measurement of spondylolisthesis. *J Bone Joint Surg* 1983;65-A:768-72.
19. Lansman HH. Pelvic relaxations. *South Caribbean J Obstet Gynecol* 1988;5:7-24.
20. Bump RC, McClish DK. Cigarette smoking and urinary incontinence in women. *Am J Obstet Gynecol* 1992;167:1213-8.
21. Norton PA, Baker JE, Sharp HC, Warenski JC. Genitourinary prolapse and joint hypermobility in women. *Obstet Gynecol* 1995;85:225-8.
22. DeMola JRL, Carpenter SE. Management of genital prolapse in neonates and young women. *Obstet Gynecol Surv* 1996;51:253-60.
23. Findley P. Prolapse of the uterus in nulliparous women. *Am J Obstet Dis Women* 1917;75:12-21.
24. Opila KA, Wagner SS, Schiowitz S, Chen J. Postural alignment in barefoot and high-heeled stance. *Spine* 1988;13:542-7.

Address reprint requests to:

*John K. Nguyen, MD*  
*Harbor-UCLA Medical Center*  
*Department of Obstetrics and Gynecology*  
*1000 West Carson Street, Box 489*  
*Torrance, CA 90509*  
*E-mail: neygun@earthlink.net*

*Received June 7, 1999.*

*Received in revised form August 24, 1999.*

*Accepted September 2, 1999.*

Copyright © 2000 by The American College of Obstetricians and Gynecologists. Published by Elsevier Science Inc.