

The Role of Pelvic Bone Anatomy in the Pathogenesis of Inguinal Hernia

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Rezumat

Rolul anatomiei bazinului osos în patogeneza herniei inghinale

Noțiuni generale: un număr restrâns de studii au sugerat prevalența anumitor caracteristici anatomice la pacienții cu hernie inghinală, caracterizate prin poziționare joasă a zonei inghinale, ce rezultă într-o verticalitate marcată a pliului inghinal. În baza acestei noțiuni am investigat posibila corelație dintre această caracteristică anatomică și dezvoltarea herniei inghinale, prin aplicarea unui protocol simplu de studiu clinic.

Metode: au fost formate două grupuri. Grupul de studiu a inclus 23 de pacienți adulți cu istoric de hernie inghinală sau hernie inghinală dovedită clinic în prezent și un grup martor compus din 10 persoane cu aceeași distribuție pe vârste și sex precum grupul de studiu, dar fără antecedente de hernie inghinală. Am măsurat pe radiografiile simple de bazin în incidență antero-posterioară unghiul lui Radoievitch, format între linia bispinoasă și linia ce unește spina iliacă superioară anterioară cu tuberculul pubic. Valorile medii ale unghiului lui Radoievitch din cele două grupuri au fost apoi comparate.

Rezultate: pacienții cu hernie inghinală au prezentat valori mai mari ale unghiului lui Radoievitch, diferența având semnificație statistică la compararea cu grupul martor ($p=0,004$).

Concluzii: variabilitatea individuală a configurației bazinului

osos al adultului este un factor important în dezvoltarea herniilor inghinale. Pelvimetria poate influența alegerea procedurii de soluționare al herniei, iar pelvimetria radiologică ar putea fi inclusă în bilanțul preoperator al herniilor.

Cuvinte cheie: hernie inghinală, anatomie pelvină, unghiul lui Radoievitch, tendon conjunct, ligament inghinal

Abstract

Background: a small number of reports have suggested that in patients with inguinal hernia, certain pelvic anatomical traits prevail, which are characterized by the low position of the groin, resulting in a marked verticality of the inguinal fold. Based on this notion we investigated a possible correlation of this anatomical characteristic with hernia development, by applying a simple clinical research protocol.

Methods: two groups were formed. A study group including 25 adult patients with a history of inguinal hernia or a clinically proven inguinal hernia and a control group of 10 individuals of the same age and sex distribution with the study group, but with no history of inguinal hernia. On antero-posterior pelvic plain x-rays, we measured Radoievitch's angle which is formed by the interspinal line and the line passing from the anterior superior iliac spine and the pubic tubercle. Mean values of Radoievitch's angle were then compared between the two groups.

Results: patients with inguinal hernia had greater values concerning Radoievitch's angle in a statistically significant manner when compared to controls ($p=0.004$).

Conclusions: individual variability in the configuration of the adult bony pelvis is an important factor in the development of

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inguinal hernia. Pelvimetry could affect the choice of hernia repair and radiological pelvimetry could be included in the preoperative planning of hernia repair.

Key words: inguinal hernia, pelvic anatomy, Radoievitch's angle, conjoint tendon, inguinal ligament

Introduction

Back in 1956, Henri Fruchaud, the French surgeon, hypothesized that hernia formation is due to the adoption of the upright bipedal posture by modern Homo (1). This new posture resulted in a shift in the direction of the intra-abdominal forces which led to respective changes in the course of the fibers of abdominal muscles. This transformation favored walking, but at the same time created a weak spot in the abdominal wall: the Fruchaud's area, that is delimited by the inguinal ligament, the upper aspect of the conjoint tendon, the outer border of the rectus abdominal muscle and the inner border of the psoas muscle (1). However, the adoption of the upright posture has also resulted in the transformation of the human pelvic structure that has since become broader, in order to serve proper balancing purposes (1). Few anatomical studies performed on cadaveric specimens have correlated the surface of Fruchaud's area to the bony pelvic configuration, with almost all concluding that the latter is the most important factor in the etiology of hernias (2-14).

It is in this context that we have planned a clinical study in order to investigate the potential correlation of pelvic bone anatomy to the development of inguinal hernia and the clinical significance of such a correlation.

Material and Methods

Institutional Board approval was acquired prior to conducting this study. The patient group concerned a total of 25 adults (22 males and 3 females) with a history of surgical repair of inguinal hernia or with a clinical diagnosis of inguinal hernia. An additional group, consisting of 10 individuals (6 males and 4 females) with no previous history of inguinal hernia repair or a hernia present at the time of the study served as a control group. Controls were patients that presented in the emergency department for trauma necessitating a pelvic radiological control in order to exclude pelvic fractures. Patients and controls were enrolled in the study after signing an informed consent.

In order to eliminate confounding factors, care was taken to exclude distribution differences of sex in the two groups. Furthermore, controls were matched with patients regarding age, so that the study group and the control group would not show any statistically significant differences in terms of age.

Radoievitch's angle, which is the angle that is formed between the interspinal line joining the two anterior

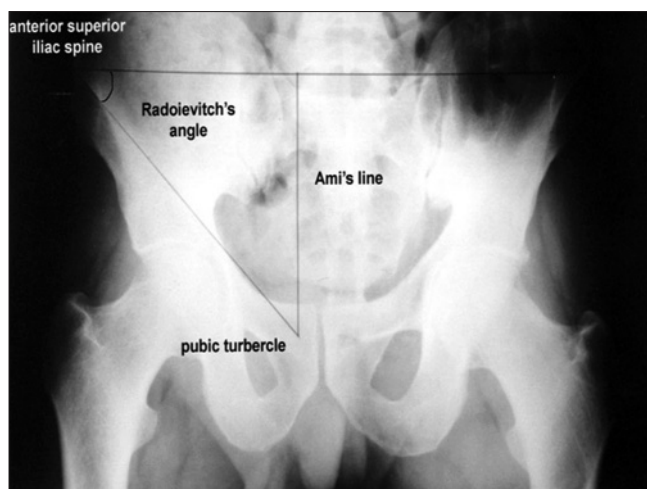


Figure 1. Radoievitch's angle measured on a plain X-ray film of the pelvis

superior iliac spines and Malgaigne's line joining the ipsilateral anterior superior iliac spine to the pubic tubercle (2-3), was measured in both groups on plain X-rays of the pelvis in anteroposterior views which were taken with the patient in the supine position (Fig. 1). All Radoievitch's angle measurements were performed by a single person (H.V.H), who was blinded regarding the category group of each X-ray. In two cases the pelvic X-ray examination was repeated in order to verify the reproducibility of the measurement as a means of excluding any possible effects on the angle measurements due to an eventually imperfect supine placement of the patient. In both cases, initial and sequential measurements were identical.

Individual t-tests were performed in order to compare age between the two groups, the difference in Radoievitch's angle mean values between men and women in each group and the difference in Radoievitch's angle mean values between the study group and the control group. Results are expressed as mean $\pm$ SD. Fisher exact test was used for comparing sex distribution between groups. The statistical package Statistica 7.0 (StatSoft®) was used.

Results

There was no statistical difference between groups regarding age. There was no statistical difference of sex distribution between groups ($p=0.15$). The two groups were comparable in terms of age (patients: 63.56 years, controls: 63.40 years; $p=0.97$). There was no statistically significant difference of Radoievitch's angle mean values between patients' sex (men: $43.48^\circ \pm 5.22^\circ$, women: $47.67^\circ \pm 1.53^\circ$; $p=0.16$) or between controls' sex (men: $39.17^\circ \pm 4.07^\circ$, women: $37.62^\circ \pm 2.56^\circ$; $p=0.48$).

A statistically significant difference of Radoievitch's angle mean value was documented between hernia patients and controls (patients: $43.98^\circ \pm 5.10^\circ$, controls: $38.55^\circ \pm 3.47^\circ$; $p=0.004$) (Fig. 2).

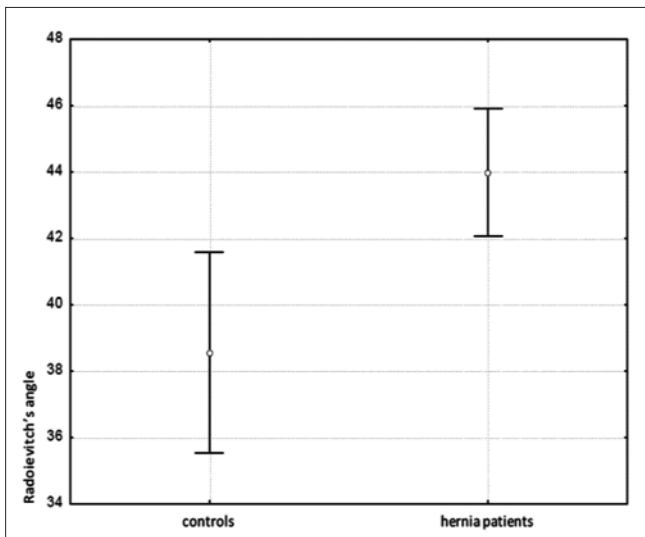


Figure 2. Mean values (with 95% confident intervals) of Radoievitch's angle of hernia patients and controls

Discussion

In quadrupeds the conjoint tendon is adherent to the pubic tubercle and the femoral vessels in such a way that it completely covers the posterior wall of the inguinal canal. However in man, due to the horizontal course of the muscular fibers as a result of him adopting the upright posture, the lower edge of the "conjoint tendon" is placed at various distances from the inguinal ligament. This creates a certain defect in the lower abdominal muscular structures, the Fruchaud's area, which is partially compensated by the presence of a firm fascia transversalis supporting the posterior inguinal wall in man, while in quadrupeds this fascia is either very thin or even absent (1). This fact results in the posterior inguinal canal wall being vulnerable to the repeated rises in intra-abdominal pressure, whenever any of the uniformly recognized risk factors (constipation, obstructive pulmonary disease, prostate hypertrophy and others) is present, thus predisposing to hernia formation.

However, fibro-muscular disposition of the inguinal region is closely linked to the pelvic bone anatomy, which in humans is characterized by the development along the transverse axis, in contrast to the longitudinal development that is seen in quadrupeds. It was this concept that led some researchers to study the form of human pelvis as a primordial factor to the development of an inguinal hernia (2-14). For this purpose, Radoievitch conducted a series of measurements on cadavers, calculating the angle that is created between the interspinal line passing from the two anterior superior iliac spines and Malgaigne's line which corresponds exactly to the course of the inguinal ligament passing from the anterior superior iliac spine and the pubic tubercle (Fig. 3). He concluded that the greater the angle the greater the prevalence of inguinal hernia (4). Radoievitch also studied the distance between the pubic tubercle and the interspinal line (Fig. 1) (5).

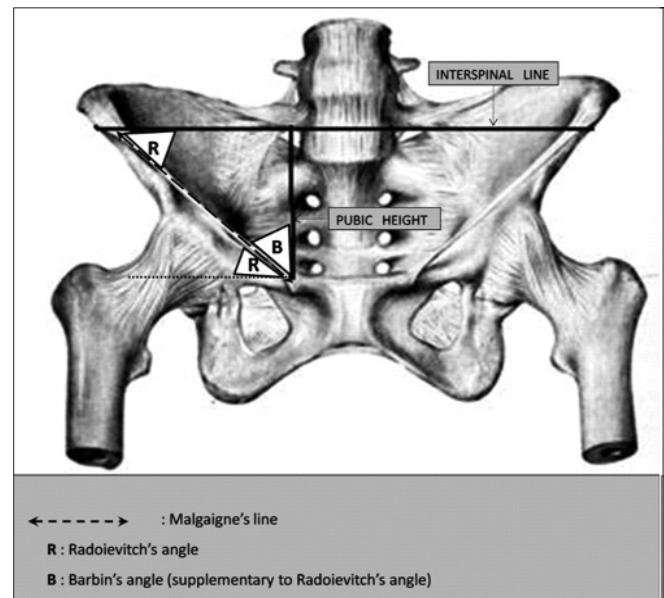


Figure 3. Drawing depicting the anatomical considerations regarding pelvic bone anatomy. Malgaigne's line is formed between the anterior superior iliac spine and the pubic tubercle. Radoievitch's angle is the angle that is formed by the interspinal line and Malgaigne's line

The same distance ("pubic height") was also measured by Ami (6). Pubic height and Radoievitch's angle are closely related (the greater the pubic height of Ami the greater the Radoievitch's angle) since the interspinal line does not differ significantly between hernia and non-hernia patients and does not depend on subject's sex (5,10,14). Both investigators concluded that the greater the distance of the pubic tubercle from the interspinal line, the more frequent is the development of inguinal hernia due to greater surface of Fruchaud's area. Clinically, a great height of pubis (or small Radoievitch's angle) corresponds to a low position of the groin and a marked verticality of the inguinal fold. According to Radoievitch, this remark was first made by the French professor in Bordeaux, Georges Chavannaz in the early 1920's (5). In a similar study, Panou de Faymoreau measured Barbin's angle (formed between the midline and Malgaigne's line) (8). Barbin's angle is also closely related to Radoievitch's angle, in a way that they are supplementary to each other (the smaller the Barbin's angle the greater the Radoievitch's angle). Panou de Faymoreau found that a value lower than 60° of Barbin's angle (corresponding to a Radoievitch's angle greater than 30°) is associated with a large weak area of the groin (8).

Other studies have also positively correlated the pubic height to the development of inguinal hernia (2,3,7,9,10,11) or the existence of a certain type of muscular inguinal anatomy predisposing to hernia (12). Harris and White, as early as 1937, emphasized the significance of the length of the inguinal ligament and its relationship with the development of hernia (15). Actually this length (Malgaigne's line) is proportional to the pubic height given the small differences of the interspinal line between hernia and non-hernia subjects. Thus, a great

length of inguinal ligament corresponds to great pubic height and a great Radoievitch's angle. The relationship between morphology of bony pelvis and hernia was disputed by only two isolated studies (13,14). All the above studies concern case-control studies usually without matching, while several among them are characterized by flaws in the reports of results regarding the statistical analysis. The results of our case-control study with matching regarding the confounding factors of sex and age together with blinding in measurements, confirm those of Radoievitch and others: greater values of Radoievitch's angle are correlated in a statistically significant manner to the presence of inguinal hernia. Contrary to Radoievitch and Lopez-Cano (5,12) we did not find a statistical difference between sexes but this is probably due to the small number of cases in our series. The above investigators have ascertained that in females the pubis is placed higher than in males (mean value of Radoievitch's angle is smaller in females), a fact that explains the lower incidence of inguinal hernia in females.

An important question arises from our study: is pubic height hereditary or acquired? The final configuration of the bony pelvis in man is accomplished until the age of twelve years (1). A study regarding the factors that influence this process during this certain period of life and which could play a potential role in the adult form of the pelvis is challenging. Identification of such factors (as for example early versus late walking age and sporting activities in childhood) could possibly lead to the prevention of inguinal hernia formation in adults. Existing studies, however, although not specifically designed for this purpose, show evidence in favor of the hereditary nature of the bony configuration of the pelvis (5,10,16,17). This fact strongly correlates to the current knowledge that positive family history of hernia is the only independent predictor for inguinal hernia development (18).

Important points of clinical significance also arise from our study. We agree with Ledinsky et al. and Stoppa who believe that a great pubic height detected by pelvimetry and usually resulting in a great Fruchaud's area, would prudently lead to choose a tension-free repair using some type of prosthetic material (10,19), since any effort to reconstruct this large posterior aspect of the inguinal canal without mesh implantation would be more likely to fail. Surgeons could use pelvimetry for the selection of patients who are more fitted for non-mesh repairs (small Radoievitch's angle, thus a low pubic height and smaller Fruchaud's area) such as the Shouldice technique (20). According to Stoppa, pelvimetry is "a very simple clinical examination to be perhaps routinely considered" (19). However, Radoievitch's study (as well as that of others) was mainly undertaken on prepared cadaveric specimens. On the other hand, pelvic measurements which are performed on the patient are not always accurate, since in many cases the interference of subcutaneous fat, especially in the obese, may significantly alter the outcome of pubic height. Our method using radiological pelvimetry overcomes this difficulty and could accurately be applied in all cases. However, the relatively small number of patients included may be considered as a limitation of the present study.

Concluding remarks

The following conclusions may be drawn: a) bony pelvis configuration seems to be a primordial etiological factor for inguinal hernia development b) identification of factors that could affect the formation of the pelvis during childhood could lead to the prevention of inguinal hernia formation in adults c) pelvimetry could affect the choice of hernia repair, and d) radiological pelvimetry is a simple and accurate method that could be included in the preoperative planning of hernia repair.

Author contributions

HV Harissis conceived and designed the study. GK Georgiou performed acquisition of data and data analysis. GK Georgiou wrote the manuscript and HV Harissis critically revised it.

Conflicts of interest and source of funding

None declared.

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