

Poorly recognized age-related downward deviation of the inguinal ligament

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Abstract

Objective: To determine factors affecting actual inguinal ligament course in live human subjects.

Introduction and hypothesis: Although the expected inguinal ligament course is supposedly a straight line extending from anterior superior iliac spine to pubic tubercle, the actual inguinal ligament course is frequently depicted a priori by a downward bowing dotted line. There are no studies in a live subject supporting this assumption. We hypothesized this assumption is indeed valid and is related to among other factors a lifelong effect of gravity and lax abdominal musculature on the inguinal ligament course.

Methods: We retrospectively reviewed 54 consecutive computed tomography scans of the abdomen and pelvis randomly distributed across all age groups. Actual inguinal ligament course was visualized by reconstructing images using Terracon software. Vertical distance from the lowest point of actual inguinal ligament course to the expected inguinal ligament course was measured. We used multiple linear regression analysis to study the correlation between degree of inguinal ligament deviation and several variables.

Results: Actual inguinal ligament course was below the expected inguinal ligament course in 52 of 54 patients. The mean deviation was 8.2 ± 5.9 mm. Advanced age was significantly associated with greater downward bowing of the inguinal ligament ($p = 0.001$).

Conclusion: Actual inguinal ligament course is often well below the expected inguinal ligament course; this downward bowing of the inguinal ligament is especially pronounced with advancing age. Operators need to be mindful as this downward bowing can lead to supra-inguinal sticks causing vascular complications.

Keywords

Cardiac catheterization, femoral artery punctures, anatomic landmarks

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Introduction

Proper localization of the common femoral artery (CFA) for arterial access is paramount for safe femoral arterial puncture. CFA is the continuation of the external iliac artery from the inguinal ligament (IL) above to its bifurcation into superficial and deep femoral arteries well below the inferior border of the femoral head. The IL marks the lower border of the abdominal cavity and punctures above the IL may potentially cause a retroperitoneal bleed.¹ Anatomically, the IL is formed by the aponeurosis of the external oblique muscle. It extends from the anterior superior iliac spine (ASIS) to the pubic tubercle (PT). Traditionally, several different techniques have been employed to locate the appropriate puncture site

in CFA and historically include the point of maximal pulsation, inguinal crease, the palpable bony landmark method, and fluoroscopy of the femoral head.^{2–5} By the traditional palpable bony landmark method, the expected inguinal

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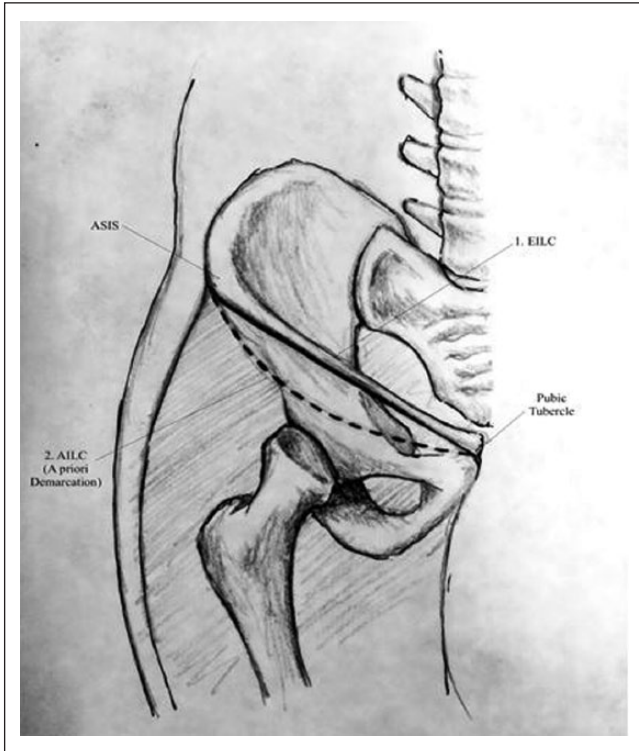


Figure 1. Frequent a priori representation of the AILC by a downward curved line.

ligament course (EILC) is marked on the body surface by a straight line from ASIS to PT. Generally, the puncture is made well below this line with the aim to enter the CFA below the IL in order to avoid supra-inguinal punctures. Based on a single small cadaver postmortem study,⁶ IL has been depicted a priori by a dotted downward curved line (Figure 1). There are no clinical data in the live patient actually testifying to this downward bowing of the IL. Therefore, we aimed to corroborate, in the live human subject, this presumed downward bowing of the IL in order to delineate the actual inguinal ligament course (AILC) as opposed to its expected course and further determine how age, sex, weight, height, body mass index (BMI), and prior surgery affect it. A lower AILC would suggest operators may need to increasingly rely on fluoroscopy and ultrasound to avoid cephalad punctures and vascular complications.

Study design and methods

We retrospectively reviewed 54 consecutive patients who had an abdominal computed tomography (CT) scan performed for any reason at our hospital. Population characteristics such as age, sex, BMI, history of prior abdominal surgeries (including inguinal hernia repairs), diabetes mellitus, systemic hypertension, coronary artery disease (CAD), and smoking were recorded. Not commonly realized by the general medical community is the fact that the IL cannot be



Figure 2. Abdominal CT imaging reconstructed using Terracon software showing: arrows A—AILC; arrows B—EILC.

visualized on a routine abdominal CT scan.⁷ Therefore, Terracon software was used to reconstruct the images from raw data. Using this unique method of reconstruction, a three-dimensional (3D) matrix was created for each CT scan and IL was actually visualized (arrows “A” in Figure 2). ASIS and PT were identified on the radiographic images and the EILC was marked digitally by a straight line joining them (arrows “B” in Figure 2). The lowest point of the inferior epigastric artery loop was marked as the lowest point of the actual IL as well. The vertical distance from the lowest point of the AILC to EILC was then measured (Figure 2).

Statistical analysis

We used multiple linear regression analysis to study the relationship between degree of deviation of IL and different clinical variables. Minitab 14.0.1 was used for statistical analysis. Study population characteristics were shown as mean, standard deviation (SD), and percentages. A scatter graph showing Pearson’s correlation (r) was also plotted. A p -value of <0.05 was considered statistically significant.

Results

The mean age of the population was 53 ± 18 (mean \pm SD) years with 48% males and 52% females. Population characteristics are shown in Table 1. AILC was found to be below EILC in 52 of 54 patients. The mean deviation was 8.2 ± 5.9 mm. Linear regression analysis correlating different variables to IL deviation is shown in Table 2. Age was significant correlated to the degree of deviation of the IL ($r = -0.45$, $p = 0.001$, degree of freedom (df) = 53). Thus, AILC was found to be increasingly downward bowing with advancing age. A scatter plot showing linear correlation of age with deviation of

Table 1. Baseline demographics and clinical characteristics (n = 54).

	Mean ± SD or n (%)
Age (years)	53.2 ± 18.5
Male gender	26 (48.1%)
Weight (lbs)	165 ± 11.5
BMI	28.7 ± 7.2
DM	21 (38.9%)
HTN	33 (61.1%)
CAD	13 (24.1%)
Smoker	25 (46.3%)
Previous surgery	29 (53.7%)
IL-deviation (mm)	8.2 ± 5.9

SD: standard deviation; BMI: body mass index; DM: diabetes mellitus; HTN: systemic hypertension; CAD: coronary artery disease; IL: inguinal ligament.

Table 2. Correlation of different variables with deviation of inguinal ligament.

Clinical variables	r (Pearson's correlation)	p-Value
Age (years)	-0.45	0.001
BMI	-0.08	0.55

BMI: body mass index.

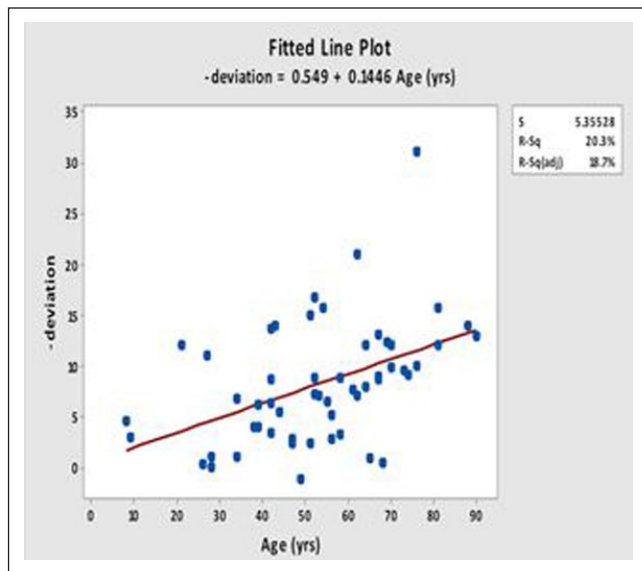


Figure 3. Scatter plot showing age-related deviation of the AILC.

the IL is shown in Figure 3. A regression equation was drawn from this linear correlation (deviation (mm) = 0.55 + 0.15 × age (years)). Residual plots were prepared to check for adequacy and distribution of the above fitted model (Figure 4). Hypertension, gender, height, weight, BMI, history of prior

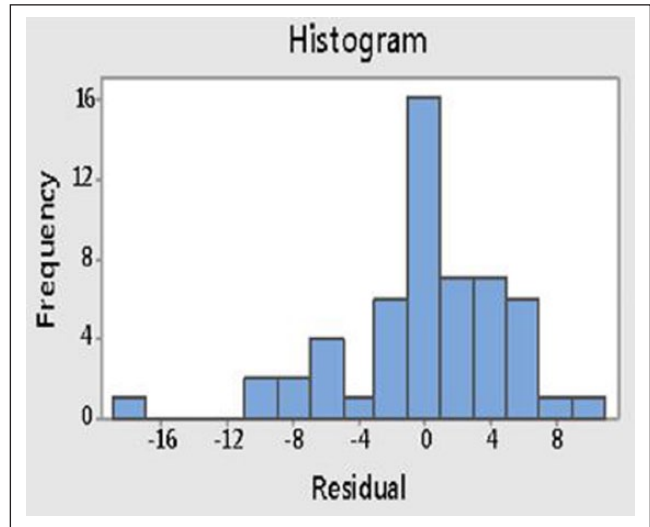


Figure 4. Histogram showing distribution of deviation (in mm) on x-axis and number of patients with deviation on y-axis.

abdominal surgeries, CAD, and smoking were not significantly correlated with IL deviation.

Discussion

To our knowledge, this is a first study to demonstrate that AILC is lower than EILC in an overwhelming majority of patients. The lowest point of IL was below its expected course in almost all our patients with an average deviation of nearly 1 cm. In a previous, small postmortem study of 10 human cadavers, Rupp et al.⁶ demonstrated by dissection a downward bowing of the IL ranging from 7.8 to 15.2 mm depending on the method they employed to determine the EILC. However, our study supplements the literature with actual live patient clinical data demonstrating that AILC is not along its expected course but rather well below it. This may lead to a higher or supra-inguinal puncture when traditional palpable bony landmarks alone are used to determine the course of the IL. Since the actual IL can be up to 1.5 cm lower, the puncture site should be lowered accordingly, aiming to enter the CFA at a point opposite to the mid portion of the femoral head on fluoroscopy.⁸

Second, we were unable to demonstrate a relationship between BMI and deviation of the IL probably because of smaller number of study subjects and lack of power to detect a small difference. However, in a larger study by Yaganti et al.,⁹ using the inferior epigastric artery as a surrogate marker for AILC, it was noted that in 12% of the patients who underwent CFA catheterization, the IL was displaced significantly downward, at times as low as the centerline of the femoral head. In these patients, the study observed a significantly higher BMI (p = 0.018) when compared with the rest of the group. Therefore, femoral head fluoroscopy alone, though well-established, may pose some hazard as well, especially in the obese patient.

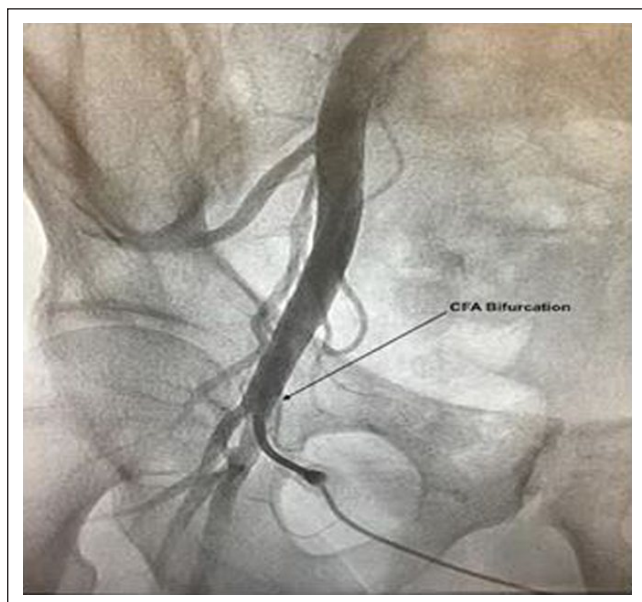


Figure 5. Angiogram of a high bifurcation of the common femoral artery (CFA).

Third, since the CFA bifurcation can be high (at, or superior to the inferior border of the femoral head but inferior to the midpoint of the femoral head) in 26% of cases or very high (at or superior to the midpoint of the femoral head) in 4% of cases,¹⁰ one may not be able to avoid the CFA bifurcation despite aiming for the middle third of the femoral head radiologically (Figure 5). Similarly, Yaganti et al.⁹ concluded in their study that approximately 15% of patients had a high CFA bifurcation. Arterial puncture at the bifurcation is fraught with the hazard of pseudoaneurysm formation¹¹ and limits the choice of closure devices that can be safely used at the end of the case.¹²

Finally, and most importantly, we observed that there is greater downward bowing of the IL with advancing age. Looking at the scatter plot in Figure 3, it is apparent that the IL is a straighter line in the earlier years of life with minimal downward deviation, but with age it starts to bow downward. The cause of this downward deviation of the IL is unknown. We hypothesize that the long-standing effects of gravity in the upright posture might be primarily responsible for this downward deviation. Another explanation can be the increased laxity of the abdominal muscles and IL fibers with advancing age. Based on our data, we derived an equation (deviation (mm) = $0.55 + 0.15 \times \text{age (years)}$) to quantify the degree of downward bowing of the IL in relationship to patient's age that might help the operator in estimating the location of IL. However, this equation needs to be validated in a larger cohort of patients.

Operators should be mindful of this age-related downward bowing of IL. In addition to fluoroscopic localization of the femoral head, palpation of bony landmarks to predict AILC as it relates to EILC based on our findings might help

in reducing supra-inguinal punctures and the associated risk of retroperitoneal hemorrhage. Although the incidence of retroperitoneal bleeding is small, it is associated with significantly increased mortality of 7%–10%.^{13–15} Moreover, it leads to significant morbidity requiring multiple blood transfusions, increase in length of hospital stay, and at times emergent vascular surgery.^{13,14,16} Multiple studies demonstrate high femoral access as an independent predictor for increased retroperitoneal hematomas.^{13,16,17} Newer methods utilizing ultrasound guidance for CFA punctures have also been evaluated. In the Femoral Arterial Access with Ultrasound (FAUST) trial, ultrasound guidance for CFA access resulted in significantly improved first-pass success rate, reduced number of attempts, and reduced vascular complications.¹⁸ Similarly, in another study, ultrasound was used to determine the location of the IL, and the position of the IL correlated better with the inferior epigastric artery loop on completion angiography when compared to fluoroscopy.¹⁹ Since the AILC is frequently lower than the EILC and the CFA bifurcation can be high or very high in up to 30% of cases, using multiple imaging modalities simultaneously such as bony landmark palpation, fluoroscopy of the femoral head and ultrasound may reduce complications. A radial artery approach will also obviate these risks.

We recognize limitations of our study which include a small sample size and a retrospective study design. In addition to factors studied in this study, there are other factors that could lead to downward deviation of IL such as multiparity and connective tissue disorders. As shown in our previous study that higher BMI is associated with more caudad deviation, one would expect that multiple childbearing can have similar effect on IL course. This was not assessed in our study. Furthermore, there are no known studies demonstrating the effect of connective tissue disorders on IL course. Given the low incidence of connective tissue disorders with Sjögren's syndrome having highest prevalence ranging between 0.5% and 3% in general population²⁰, a large number of patients need to be studied to determine its correlation with IL course. None of our patients had connective tissue disorders so we cannot comment on its correlation with AILC in our study.

Conclusion

IL is often not a straight line, but rather bowed downward. Advancing age results in greater downward deviation of the IL. Operators must take into consideration this age-related downward deviation during vascular access to avoid complications, and use a combination of strategies for optimal puncture of the CFA, including the use of palpable bony landmarks, fluoroscopy, and ultrasound to delineate the AILC, rather than relying on a single modality. Irrespective of the strategy used for an optimal puncture, it is important to recognize the fact that the IL is bowed downward especially with advancing age.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

Ethics approval for this study was waived by institutional review board (IRB study # 2014.61) at Newark Beth Israel Medical Center as this was a retrospective study with evaluation of imaging and demographic data. No drugs or interventions were used and patients were deidentified and investigators were blinded during analysis.

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Informed consent

Written informed consent was not sought to the IRB at Newark Beth Israel Medical Center because this was a retrospective study with no use of patient identifiers and thus HIPAA waiver was granted.

References

1. Sreeraam S, Lumsden AB, Miller JS, et al. Retroperitoneal hematoma following femoral arterial catheterization: a serious and often fatal complication. *Am Surg* 1993; 59: 94–98.
2. Grier D and Hartnell G. Percutaneous femoral artery puncture: practice and anatomy. *Br J Radiol* 1990; 63: 602–604.
3. Lechner G, Jantsch H, Waneck R, et al. The relationship between the common femoral artery, the inguinal crease, and the inguinal ligament: a guide to accurate angiographic puncture. *Cardiovasc Inter Rad* 1988; 11: 165–169.
4. Irani F, Kumar S and Colyer WR Jr. Common femoral artery access techniques: a review. *J Cardiovasc Med* 2009; 10: 517–522.
5. Dotter CT, Rösch J and Robinson M. Fluoroscopic guidance in femoral artery puncture. *Radiology* 1978; 127: 266–267.
6. Rupp SB, Vogelzang RL, Nemcek AA Jr, et al. Relationship of the inguinal ligament to pelvic radiographic landmarks: anatomic correlation and its role in femoral arteriography. *J Vasc Interv Radiol* 1993; 4: 409–413.
7. Cherian PT and Parrnell AP. Radiologic anatomy of the inguinofemoral region: insights from MDCT. *AJR Am J Roentgenol* 2007; 189: W177–W183.
8. Fitts J, Ver Lee P, Hofmaster P, et al. Fluoroscopy-guided femoral artery puncture reduces the risk of PCI-related vascular complications. *J Interv Cardiol* 2008; 21: 273–278.
9. Yaganti V, Mejevoi N, Hasan O, et al. Pitfalls associated with the use of current recommendations for fluoroscopy-guided common femoral artery access. *Catheter Cardiovasc Interv* 2013; 81: 674–679.
10. Gupta V, Feng K, Cheruvu P, et al. High femoral artery bifurcation predicts contralateral high bifurcation: implications for complex percutaneous cardiovascular procedures requiring large caliber and/or dual access. *J Invasive Cardiol* 2014; 26: 409–412.
11. Kim D, Orron DE, Skillman JJ, et al. Role of superficial femoral artery puncture in the development of pseudoaneurysm and arteriovenous fistula complicating percutaneous transfemoral cardiac catheterization. *Cathet Cardiovasc Diagn* 1992; 25: 91–97.
12. Dauerman HL, Applegate RJ and Cohen DJ. Vascular closure devices: the second decade. *J Am Coll Cardiol* 2007; 50: 1617–1626.
13. Ellis SG, Bhatt D, Kapadia S, et al. Correlates and outcomes of retroperitoneal hemorrhage complicating percutaneous coronary intervention. *Catheter Cardiovasc Interv* 2006; 67: 541–545.
14. Kent KC, Moscucci M, Mansour KA, et al. Retroperitoneal hematoma after cardiac catheterization: prevalence, risk factors, and optimal management. *J Vasc Surg* 1994; 20: 905–910.
15. Manoukian SV, Feit F, Mehran R, et al. Impact of major bleeding on 30-day mortality and clinical outcomes in patients with acute coronary syndromes: an analysis from the ACUITY trial. *J Am Coll Cardiol* 2007; 49: 1362–1368.
16. Farouque HM, Tremmel JA, Raissi Shabari F, et al. Risk factors for the development of retroperitoneal hematoma after percutaneous coronary intervention in the era of glycoprotein IIb/IIIa inhibitors and vascular closure devices. *J Am Coll Cardiol* 2005; 45: 363–368.
17. Tiroch KA, Arora N, Matheny ME, et al. Risk predictors of retroperitoneal hemorrhage following percutaneous coronary intervention. *Am J Cardiol* 2008; 102: 1473–1476.
18. Seto AH, Abu-Fadel MS, Sparling JM, et al. Real-time ultrasound guidance facilitates femoral arterial access and reduces vascular complications: FAUST (Femoral Arterial Access With Ultrasound Trial). *JACC Cardiovasc Interv* 2010; 3: 751–758.
19. Yun SJ, Nam DH and Ryu JK. Femoral artery access using the US-determined inguinal ligament and femoral head as reliable landmarks: prospective study of usefulness and safety. *J Vasc Interv Radiol* 2015; 26: 552–559.
20. Gaubitz M. Epidemiology of connective tissue disorders. *Rheumatology* 2006; 45(Suppl. 3): iii3–iii4.