

Arcuate Line of Douglas: Localization from Surface Anatomic Landmarks of Anterior Abdomen during Laparoscopic TEPP Hernioplasty

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Abstract

Surface marking of the arcuate line of Douglas has attained surgical importance not only in the open surgery including rectus abdominis flap harvest and stoma formation but also the laparoscopic surgery such as the total extraperitoneal preperitoneal (TEPP) inguinal hernioplasty. Present study used four surface landmarks (Umbilicus, pubic symphysis, xiphisternum and anterior interspinous line, the line joining the two anterior superior iliac spines) during TEPP hernioplasty to assess the location of the arcuate line. Mean distances of the arcuate line from the umbilicus, pubic symphysis, xiphisternum and interspinous line were $5.37 \pm SD 1.62$ cm (Range 2.5-11.5 cm), $10.67 \pm SD 2.44$ (Range 1.5-14.5 cm), $20.11 \pm SD 1.88$ (Range 15.5-26.5 cm), and $3.71 \pm SD 2.32$ (Range, -1.5 to 9.5 cm). Arcuate line was found located at $2/3^{\text{rd}}$ of the pubis-to-umbilicus distance and at $1/3^{\text{rd}}$ of the pubis-to-xiphisternum distance, confirming the recent reports. Upper border of the pubic symphysis is recommended as the optimal reference point as compared to other three surface landmarks for surface marking and localization of the Arcuate line of Douglas, albeit with a little caution in the overweight /obese patients.

Index Terms: Arcuate line level, surface marking, TEPP hernioplasty, rectus abdominis flap, stoma formation

1. INTRODUCTION

Exact preoperative localization of Arcuate line of Douglas, the lower crescent border of the incomplete posterior rectus sheath, is relevant

before harvesting the TRAM (transverse rectus abdominis myocutaneous) flap during reconstructive surgery for breast, etc., and harvesting the muscle cranial to the level of the arcuate line is likely to prevent the postoperative incisional hernia (Rizk, 1991; Salgado et al, 2000; Cunningham et al, 2004; Lipa, 2007; Mwachaka et al, 2010; Pipkorn and Nussenbaum, 2017). Knowledge of arcuate line position is an important during stoma siting because making the stoma site above the arcuate line is likely to reduce the risk of postoperative parastomal herniation (Al-Momani et al, 2014). Arcuate line is also important surgical landmark open ventral hernia repair (Johnson et al, 2014) Moreover, the arcuate line has attained paramount surgical importance as an essential anatomic landmark to guide the surgical dissection during the laparoscopic total extraperitoneal preperitoneal (TEPP) hernia repair (Spitz and Arregui, 2001; Ely and Arregui, 2003; Meyer et al, 2010; Putnis and Berney, 2012; Iuoamoto et al, 2015; Abd-Raboh et al, 2017).

It is ironical that the medical students are still taught in the anatomy classroom the classical location of the arcuate line at half of the umbilico-pubic distance (Warwick and Williams, 1973; Strauch and Yu 1993; Cunningham et al, 2004; Farquharson et al, 2015), although current anatomic literature provides evidence for its more proximal position (Cunningham, et al, 2004; Loukas et al, 2008; Ansari, 2017a,b). Skandalakis et al (2006) opined that the exact location of the arcuate line is debatable. The variable positions of the arcuate line reported in the older as well as the recent literature may stem from the fact that the position of the arcuate line is traditionally measured from the umbilicus but the position of the umbilicus itself is not fixed and highly variable in individuals of

different body habitus. Present study measured the arcuate line position in relation to not only the umbilicus but also the fixed bony abdominal landmarks of pubic symphysis, xiphisternum and anterior superior iliac spine.

2. MATERIALS & METHODS

A prospective doctoral research for award of PhD (Surgery) was designed and carried out in the Department of Surgery, J. N. Medical College Hospital, A.M.U, Aligarh (India) since April, 2010 and completed in November, 2016. Patients with uncomplicated primary inguinal hernia undergoing laparoscopic total extraperitoneal preperitoneal (TEPP) hernioplasty under ethical clearance and informed consent were studied in the period from February, 2011 when the first case of TEPP hernioplasty was done, to November, 2016. Criteria for selection/ inclusion/ exclusion into/from the study and surgical technique of 3-midline-port for laparoscopic TEPP hernioplasty were consistently same as reported earlier (Ansari, 2013; Ansari, 2015; Ansari, 2017a,b,c).

The patient was anaesthetized with relaxant general anaesthesia with endotracheal intubation. Then the lower border/tip of the xiphisternum, the upper border of the pubic symphysis and the anterior superior iliac spines (ASIS) were marked after painting and draping of the abdomen. The distance between the lower border of the umbilicus and the upper border of the pubic symphysis (U-PS) and the distance between the tip of the xiphisternum and the upper border of the pubic symphysis (Z-PS) were measured with a sterile stainless steel scale. The anterior interspinous line was also drawn horizontally between the two ASIS. A small vertical/transverse incision was then given in the midline at about 2.5 cm below the umbilicus, the ipsilateral anterior rectus sheath opened and then the ipsilateral rectus abdominis muscle was retracted laterally. First 11-mm blunt optical port was then placed in the ipsilateral retromuscular space and air-seal was obtained with a strong silk ligature (1-0) over a gauze piece. CO₂ insufflation was started at a pressure of 12 mmHg. A 10-mm 0° laparoscope was put in the posterior rectus canal and controlled gentle telescopic dissection was performed. Posterior rectus sheath were carefully visualized and its termination was documented. Position of the arcuate line, if present, was ascertained by the percutaneous needle insertion (**Fig. 1**) and its distance was measured flat from the umbilicus, the xiphisternum, the upper border of the pubic symphysis and the interspinous line with help of the rigid scale. Body mass index (BMI) was calculated by the Deurenberg's formula

(Deurenberg et al, 1991). Microsoft Excel 2007 and Tools were used for the simple statistical analysis.

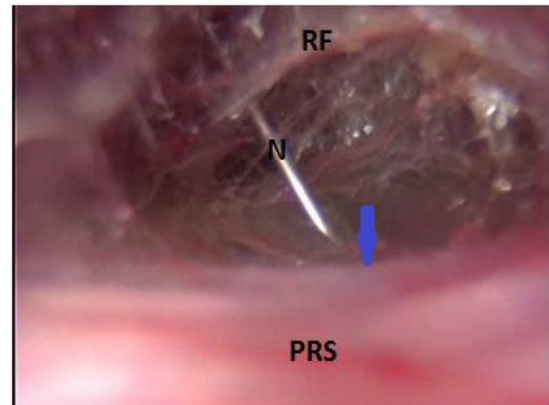


Figure 1: Dissection within Posterior Rectus Canal with Percutaneous Needle Confirmation of Arcuate Line: N, hypodermic needle inserted percutaneously at the level of arcuate line; RF, rectus abdominis muscle anteriorly; PRS, incomplete posterior rectus sheath with formation of an arcuate line (arrow) posteriorly;

3. RESULTS

Sixty eight uncomplicated primary inguinal hernias (right side 17; left side 35; bilateral 8) were successfully operated by the laparoscopic TEPP technique through the posterior rectus approach in about five and half years. All patients were adult male. Incomplete posterior rectus sheath with formation of a terminal primary arcuate line (of Douglas) was observed in only 54 out of 68 cases, while in the remaining 14 cases, the posterior rectus sheath was complete extending upto the pubic bone with absence of the primary arcuate line. Secondary arcuate lines documented in 10 out of the 68 cases (3 cases with the incomplete posterior rectus sheath, and 7 cases with complete posterior rectus sheath) were excluded from data analysis for clarity of presentation and comparative evaluation.

Actual positions of the arcuate lines with respect to the umbilicus are depicted in **Table 1**. Mean distances of the arcuate line level from the umbilicus, the xiphisternum, the pubic symphysis and the interspinous line (line joining the two anterior superior iliac spines [ASIS] of the body) are presented in the **Table 2**, along with the mean distance from xiphisternum to pubic symphysis, from umbilicus to the pubic symphysis.

The arcuate line was found situated at an average location at about 1/3rd of the distance from the umbilicus to the pubic symphysis (U-PS) or about

2/3rd of the distance from the pubic symphysis to the umbilicus, and at the 2/3rd of the distance from the xiphisternum to the pubic symphysis (Z-PS) (**Table 2** and **3**).

Mean levels of the arcuate line with respect to the umbilicus (U-AL), the xiphisternum (Z-AL), the pubic symphysis (AL-PS) and the interspinous line (AL-ASIS) did not differ significantly ($p > 0.05$) with respect to the age and the occupation of our patients. Pearson Correlations were also not statistically significant ($p > 0.05$). However, mean levels of the Arcuate line (U-AL) in the normal-weight patients ($BMI < 25 \text{ Kg/m}^2$) and the overweight/obese patients ($BMI > 25 \text{ Kg/m}^2$) was $5.68 \pm SD 1.52$ cm (range 3.5-11.5 cm) and 2.63 ± 0.25 cm (range 2.5-3.0 cm) which were significantly different ($p < 0.001$). Pearson Correlation was also very significant ($p < 0.01$). All the same, the mean BMI of the patients with the classical, high and low positions of the arcuate line was also different significantly ($p < 0.001$). Post Hoc Tests (Scheffe and Tukey HSD) revealed that BMI of patients with the high arcuate line was significantly much higher ($p < 0.01$) as compared to those with the classical or low level of the arcuate line, and the difference between the later two was statistically insignificant (> 0.05). Moreover, arcuate line measurements were dissimilar on the two sides of the body in half of the patients with bilateral inguinal hernias, but the mean levels were not different significantly between patients with similar levels and patients with dissimilar levels on the two sides of the body ($p > 0.05$).

4. DISCUSSION

Accurate knowledge of the arcuate location is essential not only in the open surgery in raising a rectus abdominis flap (Rizk, 1991; Salgado et al, 2000; Cunningham et al, 2004; Lipa, 2007; Mwachaka et al, 2010; Pipkorn and Nussenbaum, 2017) or stoma formation (Al-Momani et al, 2015), but also during the Laparoscopic TEPP repair for inguinal hernia (Spitz and Arregui, 2001; Ely and Arregui, 2003; Meyer et al, 2010; Putnis and Berney, 2012; Iuamoto et al, 2015; Abd-Raboh et al, 2017). However, despite apparent textbook accord, wide variation in the location of the Arcuate line (of Douglas) have been reported in the literature (Anson et al, 1960; McVay, 1974; Monkhouse and Khalique, 1986; Lange et al, 2002; Cunningham et al, 2004; Skandalakis et al, 2006; Loukas et al, 2008).

Current evidence suggest that the Arcuate line is generally located more proximal that its traditional location at half of the umbilico-pubis distance (Cunningham et al; Loukas et al, 2008; Ansari,

2015 and 2017a,b). Present study confirmed the average position of the arcuate line, if one is present, at 2/3rd of the pubis-to-umbilicus distance or 1/3rd of the pubis-to-xiphisternum distance which is in full agreement with the findings of Cunningham et al (2004) and Loukas et al (2008) (**Table 4**), and this location of the arcuate line has been endorsed recently by Rosen et al (2016) in the 41st edition of the Gray's Anatomy.

However, the position of the Arcuate line with respect to the anterior superior iliac spine (anterior interspinous line) was found significantly much higher in the present study as compared to the findings of Cunningham et al (2004) and Loukas et al (2008), although a few of them extended even below the interspinous line (**Table 4**). This discrepancy may be a reflection of different body habitus of the Indian population as compared to the Americans or Europeans. A minority of the Arcuate lines in our patients was situated either very high (5.6%), especially in the overweight/obese individuals, or very low (5.6%) (**Table 1**).

The umbilicus is not a fixed point and the interspinous line may be variable in different populations. Therefore both the umbilicus and anterior superior iliac spine may not be good reference points in preoperative assessment of the arcuate line position for planning of the relevant open or laparoscopic procedure as its assessment in a particular patient is subject to variation with respect to the body habitus of the person concerned. Moreover, the xiphisternum, although fixed in nature may also not be an adequate reference point for assessment of the arcuate line location for two reasons. Firstly, difficulty is encountered during the horizontal measurement of the distance of the arcuate line from the xiphisternum due to the anterior curvature of the anterior abdominal wall. Secondly, external measurement may not be a true internal measurement of the arcuate line due to the anterior abdominal curvature and abdominal wall thickness. Assessment of the arcuate line position with respect to the upper border of the pubic symphysis was found consistent and fully comparable between the present study and the previous studies (Cunningham et al, 2004; Loukas et al, 2008). Therefore, the upper border of the pubic symphysis is an optimal reference point for locating the position of the Arcuate line of Douglas, and hence strongly recommended for its use during the preoperative planning during the open reconstructive and stoma surgery as well as the laparoscopic TEPP hernioplasty. High definition preoperative imaging, if available, especially by an interested radiologist, may enhance the surgeon's confidence immensely for accurate marking and execution of the procedure.

5. CONCLUSION

Mean distances of the arcuate line from the umbilicus, pubic symphysis, xiphisternum and anterior interspinous line were $5.37 \pm SD 1.62$ cm (Range 2.5-11.5 cm), $10.67 \pm SD 2.44$ (Range 1.5-14.5 cm), $20.11 \pm SD 1.88$ (Range 15.5-26.5 cm), and $3.71 \pm SD 2.32$ (Range, -1.5 to 9.5 cm) respectively. Arcuate line was found located at $2/3^{\text{rd}}$ of the pubis-to-umbilicus distance and at $1/3^{\text{rd}}$ of the pubis-to-xiphisternum distance, confirming the recent reports (Cunningham et al, 2004; Loukas et al, 2008; Rosen et al, 2016). Upper border of the pubic symphysis is recommended as the optimal reference point as compared to other three surface landmarks for surface marking and localization of the Arcuate line of Douglas, albeit with a little caution in the overweight /obese patients.

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Table 1: Distribution of Positions of the Arcuate Line from the Umbilicus

S. No.	Arcuate Line Position From Umbilicus			Average Position of Arcuate Line (U-AL) (Mean±SD) (cm)
	Distance from Umbilicus to Arcuate Line (U-AL) (cm)	Number of Arcuate Lines (N)	Number of Arcuate Lines (%)	
1.	2.5	3	5.56	5.37±SD1.62
2.	3.0	1	1.85	
3.	3.5	3	5.56	
4.	3.75	1	1.85	
5.	4.0	3	5.56	
6.	4.5	6	11.11	
7.	5.0	6	11.11	
8.	5.5	11	20.37	
9.	6.0	10	18.52	
10.	6.5	7	12.96	
11.	8.0	1	1.85	
12.	10.5	1	1.85	
13.	11.5	1	1.85	
	Total	54	100	

(Adapted with permission from Ansari, MM. Thesis for PhD (Surgery) titled - "A Study of Laparoscopic Surgical Anatomy of Infraumbilical Posterior Rectus Sheath, Fascia Transversalis & Pre-Peritoneal Fat/Fascia during TEPP Mesh Hernioplasty for Inguinal Hernia", Aligarh Muslim University, Aligarh, India, 2016)

Table 2: Levels of Arcuate Line (N=54) With Respect to Different Anatomic Landmarks in Patients with Incomplete Posterior Rectus Sheath

S. No.	Distance	N	Mean (cm)	⁷ S.D. (cm)	Range (cm)
1.	¹ U - AL	54	5.37	1.62	2.5 to 11.5
2.	² Z - AL	54	20.11	1.88	15.5 to 26.5
3.	³ Z - PS	60	30.25	1.93	19.0 to 34.0
4.	⁴ U - PS	60	15.74	1.41	11.5 to 18.5
5.	⁵ AL - PS	54	10.67	2.44	1.5 to 14.5
6.	⁶ AL-ASIS	54	3.71	2.32	-1.5 to 9.5

¹U - AL, umbilicus to arcuate line; ²Z - AL, xiphisternum to arcuate line; ³Z - PS, xiphisternum to umbilicus; ⁴U - PS, umbilicus to pubic symphysis; ⁵AL - PS, arcuate line to pubic symphysis; ⁶AL-ASIS, arcuate line to interspinous line (between two anterior superior iliac spines (ASIS)); ⁷S.D., standard deviation. (Adapted with permission from Ansari, MM. Thesis for PhD (Surgery) titled - "A Study of Laparoscopic Surgical Anatomy of Infraumbilical Posterior Rectus Sheath, Fascia Transversalis & Pre-Peritoneal Fat/Fascia during TEPP Mesh Hernioplasty for Inguinal Hernia", Aligarh Muslim University, Aligarh, India, 2016)

Table 3: Location of Arcuate Line with respect to Umbilicus, Xiphisternum, Pubic Symphysis and Interspinous Line in Adult Patients Undergoing Laparoscopic TEPP Hernioplasty

S. No.	Measurements (Mean)	Location of Arcuate line (% of Distance)
1.	Umbilicus to Pubic Symphysis (U-PS) (15.74 cm)	34.12% of U-PS Distance
2.	Xiphisternum to Pubic Symphysis (Z-PS) (30.25 cm)	66.48% of Z-PS Distance
3.	Pubic Symphysis to Umbilicus (PS-U) (15.74 cm))	67.79% of PS-U Distance
4.	Pubic Symphysis to Xiphisternum (PS-Z) (30.25 cm)	35.27% of PS-Z Distance

U-PS, distance from the umbilicus to upper border of pubic symphysis;
 Z-PS, distance from xiphisternum to upper border of pubic symphysis;
 PS-U, distance from upper border of pubic symphysis to xiphisternum;

Table 4: Comparative Analysis of Arcuate Line Location

S. No.	Distance	Location of Arcuate Line			p-value
		Present Study (N=54)	Cunningham et al (2004) (N=32)	Loukas et al (2008) (N=200)	
1.	Pubic Symphysis to Umbilicus	66.48%	74.6%	70.2%	>0.05
2.	Umbilicus to Pubic Symphysis	34.12%	NA	NA	-
3.	Pubic Symphysis to Xiphisternum	35.23%	32.7%	33.9%	>0.05
4.	Xiphisternum to Pubic Symphysis	66.48%	NA	NA	-
5.	Superior to ASIS Line (Mean±SD)	3.71±2.32 cm (Range, -1.5 to 9.5)	1.8 ± 1.7 cm (Range, NA)	2.1 ± 2.3 cm (Range, NA)	<0.001