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Original Research Article

ANATOMICAL STUDY ON THE INTERNAL ILIAC ARTERY IN FETUS AND ITS IMPLICATIONS IN UMBILICAL ARTERY CATHETERIZATION

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ABSTRACT

Introduction: Umbilical artery catheterization (UAC) is a procedure for investigation and treatment purpose. The catheter negotiates the umbilical artery, internal iliac artery, common iliac artery to reach aorta of desired level. Studies so far have not correlated the type of internal iliac artery associated with the complications encountered during or after the procedure.

Materials and Methods: Forty four pelvic halves, from ten males and twelve female full term fetus of Manipuri population were used to determine the incidence of type of branching pattern of internal iliac artery. The length of the portion of the artery from the umbilical ring upto the bifurcation of aorta was measured.

Results: Only Type I-IV were observed. Type I was observed more in males (40.9%) and Type IV was more in females (36.4%). The total length of the artery from umbilical ring to aortic bifurcation was 7.3± 0.35 and 7.4± 0.29 on right and left side respectively. Discussion: The study emphasise the importance of the 'bend', the branches issued from the bend present in the internal iliac artery from perspective of UAC.

Conclusion: The study presents a baseline data of length of the artery negotiated by the catheter. The study hypothesises the possible association of a type II & IV of internal iliac artery with complications associated with the UAC. Detail knowledge of anatomy of arteries traversed by the catheter would be of paramount significance for the clinicians, radiologists and academicians alike.

KEY WORDS: Umbilical artery, internal iliac artery, variation, umbilical artery catheterization

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INTRODUCTION

In fetus, umbilical arteries are the major channels from the aorta to the placenta. They are initially paired ventral branches of dorsal aorta that course to the placenta in close association with the allantois. During the fourth week, each artery acquires a secondary connection with the dorsal branch of aorta, the common iliac artery, and loses its earliest origin. After birth the proximal portions of umbilical arteries persist as the internal iliac and superior vesical arteries, and

the distal parts are obliterated to form the medial umbilical ligaments. From the newly formed secondary vessel there arises the inferior gluteal artery, the first formed main artery of the lower limb. Later, a second branch becomes the external iliac artery and the femoral arteries of the adult. Finally, the portion of the umbilical stem dorsal to external iliac becomes the common iliac artery, and the ventral part becomes the internal iliac artery. But the part of the original umbilical artery that runs to the umbilicus, and on to the placenta, is still called the umbilical artery [1,2]. Functionally, the umbilical arteries close few minutes after birth, although the actual obliteration of the lumen by fibrous proliferation may take two to three months. Initial closure of the arteries is accomplished by contraction of the smooth musculature in their walls which is influenced by thermal stimuli, mechanical stimuli and change in oxygen tension [1].

In adults internal iliac artery divides into anterior and posterior branch. These two divisions give parietal and visceral branches to the pelvic structures. The larger anterior division breaks up into as many as nine branches, namely –superior vesical, obliterated umbilical, inferior vesical, middle rectal, uterine, vaginal, obturator, internal pudendal, inferior gluteal artery. Posterior division breaks up into 3 branches, namely – iliolumbar, lateral sacral and superior gluteal. The umbilical artery is usually the first and highest branch to arise from anterior division and in adult it is merely a fibrous remnant of the erstwhile umbilical artery of fetal stage [3]. However, umbilical artery is important clinically because it is used as a route to extract arterial blood gas sample in newborn with respiratory problem. In this procedure called umbilical artery catheterization (UAC), catheter is passed in the lumen of one of the artery in the umbilical cord. Catheter is passed gently under constant tension to overcome the resistance encountered at two points where the artery turns just below the skin surface and where the arteries turn upward toward the iliacs [4]. Therefore, anatomy of branching pattern of internal iliac artery in newborn is important from perspective of umbilical artery catheterization. Variations in the branching pattern of internal iliac artery documented in anatomy textbooks are based on studies on adult [5]. There is paucity of reference data of full term fetus. Review of literatures suggests studies done on adult cadavers with implication in adult patients only. Present study is therefore, an attempt to study the variations in the branching pattern of internal iliac artery in fetus and secondly, to measure the combined length of the artery - umbilical artery, internal iliac and common iliac artery which is negotiated by the catheter in full-term fetus.

MATERIALS AND METHODS

This is a pilot study of descriptive type performed on forty four pelvic halves from 22 full-term human fetus (9 males , 13 females) used by the postgraduate trainees for different research work in the Department of Anatomy, Regional Institute of Medical Sciences, Imphal from 2012-2015. The fetuses were collected from Obstetrics & Gynaecology Department, RIMS after ethical clearance from the institutional ethics committee. The fetuses were free of malformation affecting cardiovascular anomalies. The anterior abdominal wall is reflected inferiorly to expose the internal surface of the anterior abdominal wall (FIG 1). The pelvic viscera were already removed wholly or partially in most of the fetuses. The pelvic walls were removed of pelvic fascia to expose the internal iliac artery and its branches. The internal iliac veins and its tributaries were removed to get a clear exposure of the branches. The intra abdominal umbilical artery, internal iliac artery and its branches were followed by meticulous dissection. Adachi used four principal parietal branches as criteria of classifying the variations in origins: umbilical, superior gluteal, inferior gluteal, internal pudendal into five types [6]. Adachi's classification was used in the present study because it is widely accepted by many researchers and also lends itself best to our purpose.

Vernier caliper was used to measure the total length of the artery from point of exit of umbilical artery (umbilical ring) via internal iliac artery and common iliac upto bifurcation of the abdominal aorta. This distance (AD) gives the

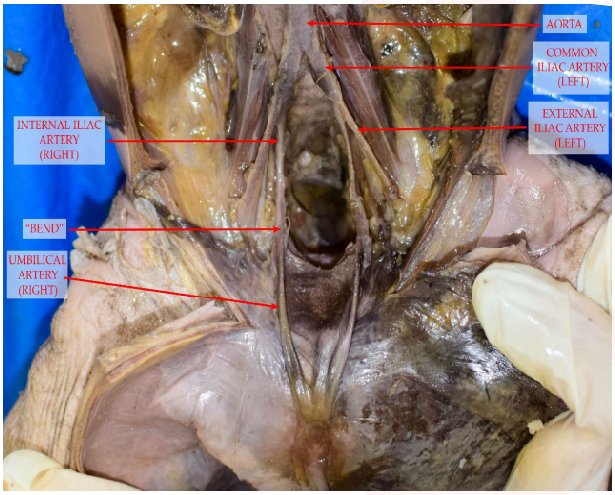
total distance of the artery negotiated by the catheter from the umbilical ring to the aortic bifurcation. The parameters measured are:

1) AB= Distance between umbilical ring to the 'bend' in the internal iliac artery

2) BC= From the 'bend' to the point of bifurcation of common iliac

3) CD= From the point of bifurcation of common iliac to the bifurcation of aorta

Fig. 1: Anterior abdominal wall reflected inferiorly to expose the intra abdominal course of umbilical artery, internal iliac artery, external iliac artery, common iliac artery and aorta. The 'bend' in the internal iliac artery is the part where internal iliac artery makes a U-turn



RESULTS

We observed that the common iliac artery divides into external and internal iliac artery. The internal iliac is the bigger division of common iliac artery in fetal life and it is double the size of external iliac artery. External iliac artery continues from common iliac in a straight course. On the other hand, internal iliac artery begins at the common iliac bifurcation and descends vertically level with greater sciatic notch where it curves acutely at a 'bend' to ascend over the posterior surface of anterior abdominal wall towards the umbilicus.

According to our measurements the combined length AD ranged between 7.0 cm and 7.9 cm, mean value 7.4 ± 0.29 on right side and 6.7 cm and 7.9 cm, mean value 7.3 ± 0.36 cm on left side. The difference in the mean value between right and left side was statistically non-significant. No major differences between male and female were also observed. The distance between umbilical ring and 'bend' in internal iliac artery (AB) is 4.5± 0.44 cm and 4.5 ± 0.41 cm on right and left side respectively. The distance BC is 1.2±0.15 cm and 1.1 ±0.24 cm on right and left side respectively. The distance between point of bifurcation of common iliac to the point of bifurcation of abdominal aorta (CD) are 1.6± 0.39 and 1.55± 0.37 on right and left side respectively (Table 1).

Table 1: Total length of the artery from umbilical ring (point of exit through abdominal wall) to aortic bifurcation.

Parameters	Right side (cm)	Left side (cm)
AB	4.5±0.44	4.5±0.41
BC	1.2±0.15	1.1±0.24
CD	1.6±0.38	1.5±0.37
Total	7.45±0.29	7.3±0.35

CRL (cm)=30.1±1.27 ; weight (kg)=2.8±0.33 ; n=44; p value>0.05

AB=umbilical ring to the 'bend' in the internal iliac artery; BC=from the 'bend' to the point of bifurcation of common iliac artery; CD=bifurcation of common iliac artery to aortic bifurcation

Table 2: Variation in the origin of the three parietal branches of internal iliac artery.

Types	Right side		Left side	
	No. of cases	Percentage	No. of cases	Percentage
I	9	40.90%	6	27.30%
II	3	13.60%	3	13.60%
III	5	22.70%	5	22.70%
IV	5	22.80%	8	36.40%
V	None	-	None	-
Total	22	100%	22	100%

On right side Type I variety was the commonest (40.9%), Type II was observed in 13.6% , Type III was observed in 27.7% , Type IV was observed in 22.7%. On the left side, Type IV was the commonest (36.4%), Type I (27.3%), Type III (22.7%) and Type II (13.6%) (Table2). We failed to observe Type V of Adachi. The three parietal branches of the internal iliac artery issued in relation to the 'bend' are as follows:

1) Type I: the superior gluteal artery arose proximal to the 'bend' and the common trunk that gave rise to the inferior gluteal artery and the internal pudendal artery arose from the trunk (FIG 2)

2) Type II: the common trunk that gave rise to the superior gluteal artery and the inferior gluteal artery arose from the 'bend' and the internal pudendal artery arose as independent

branch distal to the 'bend'(FIG 3)

3) Type III: All the three parietal branches arose independently as the superior gluteal artery, the inferior gluteal artery and the internal pudendal artery proximo-distally. The inferior gluteal artery always issued from the 'bend' (FIG 4). Calibre of all the three parietal branches are similar but smaller than the internal iliac artery

4) Type IV: All the three branches arose from a single trunk. The common trunk always issued at the 'bend'. The caliber of the common trunk is similar to the caliber of both the umbilical artery and the internal iliac artery (FIG 5)

The 'bend' in the internal iliac artery was observed to be at a distance of 4.5 cm from the umbilical ring. All the branches were given out from single trunk of internal iliac artery as it continued as umbilical artery and exit through the umbilicus. None of the internal iliac arteries were seen dividing into anterior and posterior divisions as reported in adult specimens.

Fig. 2: Type I internal iliac artery. UA-umbilical artery, IIA-internal iliac artery, EIA-external iliac artery, SG-superior gluteal artery, IG-inferior gluteal artery, IP- internal pudendal artery.

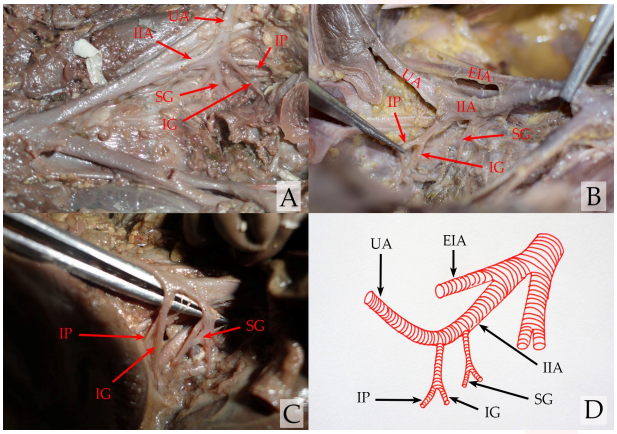


Fig. 3: Type II internal iliac artery.

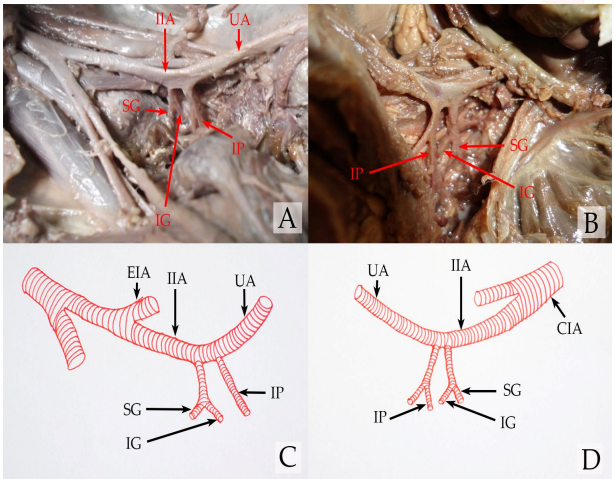


Fig. 4: Type III internal iliac artery.

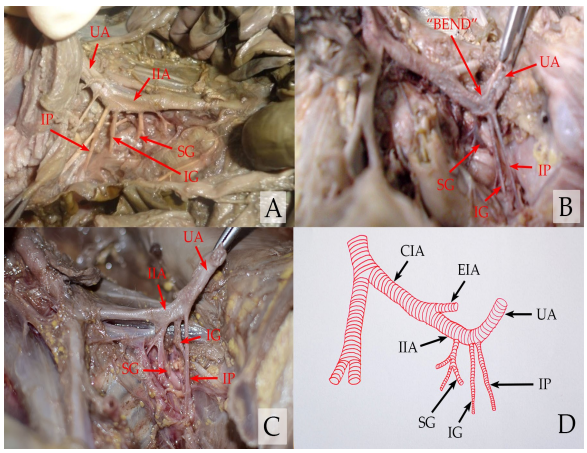
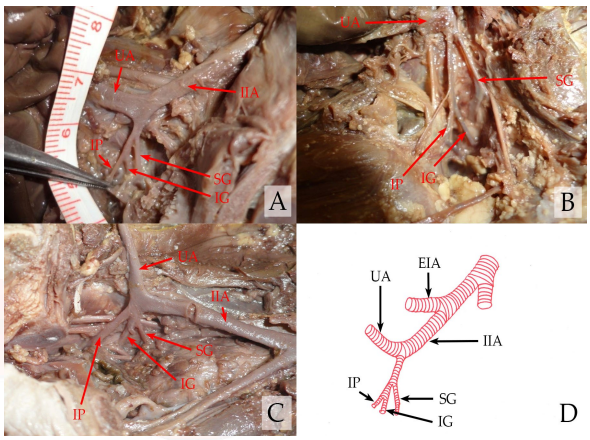


Fig. 5: Type IV internal iliac artery.



DISCUSSION

A thorough anatomical knowledge is essential before any vascular intervention and also in interpretation of neonatal radiographs for optimal patient care. The umbilical artery begins to constrict within seconds after birth and functionally close within a few minutes of birth. However, they can be dilated and cannulated during the first 5-7 days of life and rarely used after 7-10 days [7]. UAC is indicated in a numerous medical condition – respiratory failure, cardiovascular collapse to assess arterial blood gas sampling in newborn. Clinician uses a surface measurement and assumes the required length of the catheter needed to be inserted or refer to the charts given in the standard text books [5]. The placement of an umbilical artery is easy in principal but often challenging in practice. UAC can accidentally enter branches of internal iliac artery and give rise to complications like vascular embolization, thrombosis, spasms, perforation, infection, accidental haemorrhage, hypertension and

impairment of circulation to a leg with subsequent gangrene and amputation [8]. Catheter associated complications may lead to death in upto 12% of infants with umbilical artery catheters [9]. Numerous studies on branching pattern of internal iliac artery were carried out in adult patients or cadaver. Almost all the studies have referred to Adachi's classification of internal iliac artery. Adachi classified internal iliac artery into five types based on the origin of three main parietal branches namely, the superior gluteal, the inferior gluteal and the internal pudendal arteries. It was also highlighted that Umbilical artery was the continuation of the main stem of internal iliac artery and all the three parietal branches were principal branches of umbilical artery. Adachi's five types of branching pattern of internal iliac artery are summarized below:

Type I. The superior gluteal artery arise independently as the first and the most posterior branch and the inferior gluteal and internal pudendal arteries arise from a common trunk more anteriorly.

Type II. The superior and the inferior gluteal arteries arise by a common trunk, and the internal pudendal and the umbilical arteries also spring from a common trunk.

Type III. The superior gluteal, the inferior gluteal and the internal pudendal arise separately from the internal iliac artery.

Type IV. The superior gluteal, the inferior gluteal and the internal pudendal arteries arise from a common stem below the origin of the umbilical artery.

Type V. A common trunk gives rise to the superior gluteal and internal pudendal arteries, while the inferior gluteal and umbilical arteries arise from a common stem.

In fetus, internal iliacs are the bigger division of common iliac artery and are in direct line with the common iliacs, essentially a continuation of it. This is because internal iliac artery supply pelvic organs, and then continue as umbilical artery to reach the placenta [10,11]. Present study agrees with the previous study wherein the diameters of the internal iliac artery are observed to be greater than those of external iliac artery. Contrary to fetal anatomy, the external iliac arteries are of larger caliber than the internal iliac arteries.

Reference data for the total length of intra abdominal umbilical artery, internal iliac artery and common iliac artery are scarce in human fetuses. We observed that the total length of the artery ranged between 7.0 cm and 7.9 cm. It is worth mentioning that the common trunk in type IV variety always issued from the 'bend' which had same caliber as internal iliac artery. This observation, to our knowledge, has not yet been reported. Although, it was reported that a resistance is present as the catheter negotiates the curved course of the umbilical artery [4]. We had observed the curve part of umbilical artery also and have designated as the 'bend'. We observed that the 'bend' in the internal iliac artery was observed at a distance of 4.5 cm from the umbilical ring. This length is very important for the clinicians because of two reasons, a high possibility of tip of catheter entering the common trunk of arteries in type IV as caliber of internal iliac artery and the common trunk is almost equal. Secondly, resistance is encountered at the 'bend' which if not negotiated gently may lead to complications. Knowledge of variation as researched in the present study is essential for understanding the genesis of complications following vascular intervention especially the UAC. This vascular intervention is associated with a number of complications associated with catheterization of the three parietal branches [12-14].

Gangrene of the buttock and sciatic nerve palsy following displacement of the tip of the catheter into the inferior gluteal artery following UAC was reported. Previous authors have not mentioned the type of internal iliac artery associated with the complications. Some authors had speculated that the displacement of the tip of the catheter was associated with the maldevelopment of normal branching patterns of arteries [15]. On the contrary, the present study argues the aforementioned interpretation in line of origin of inferior gluteal artery from internal iliac artery. In type II variety the inferior gluteal artery issue from the strategic location where the "bend" of internal iliac artery is present. Type IV variety also has the common trunk that trifurcates into three

parietal branches also arises at the "bend". Umbilical artery again curves upwards at the pelvic brim above the superior ramus of pubis towards the umbilicus.

Variation in adult internal iliac artery is documented widely [16-19]. Data provided by this investigation seem to establish the fact that there are great many variations in the branching of internal iliac artery in fetus too. A study on the length of the internal iliac between Japanese and Romanian patients showed minor difference whereas, a significant differences was noted between Romanian and English persons [19]. A thorough research in net showed that earlier studies were undertaken in adult patients or cadaver and we failed to find comparable research on fetus or newborn. Unlike internal iliac artery in adult, the present study showed that in full term fetus there is no discernible anterior or posterior trunk of internal iliac artery. In fetus, internal iliac artery continues as umbilical artery and the branches are given out either medially or inferior to main trunk of internal iliac artery. At what age of infancy or early childhood, the adult anatomy of division of internal iliac artery into two trunks occurs needs to be explored. It is assumed that major restructuring of internal iliac artery occurs after birth. Of the many research carried out earlier, Adachi's classification suits best for fetus and neonatal studies because the study took the umbilical artery into consideration while classifying the internal iliac artery into five major types. Later classifications were based on adult cadaver. Four groups of branching pattern were presented in Yamaki's classification in which type V of Adachi was included in type IV. They observed varying origin of umbilical artery, e.g., from the main stem of internal iliac artery, the superior gluteal artery, the inferior gluteal artery, the internal pudendal artery or the common trunks of these arteries.

However, umbilical artery was considered unimportant afterbirth. They observed no significant differences either between male and female groups or between the right and left sides in each group. Similar to our study, Type III superseding Type II was reported by some researchers [20-24]. All observed type II accounting nearly 24% except Talalwah, who observed 34.8%. In our study, we observed Type III in 22.7%. Adachi and Yamaki had Type II preponderance over Type III. Although Adachi reported Type V, it was not observed in many subsequent studies. (Table III). Hence, the present study opens new vista for research in the age related change in the branching pattern of iliac artery.

Our study observed that the internal iliac arteries shows the predominance of type I in males and type I & IV in females in fetus of Manipur. The other types are equally distributed among both sexes. Our data with highest percentage of type I endings (41%) is similar to those reported in other studies on different ethnical groups. A study on Caucasoid reported Type I(51%) [16], in Polish population it was 38%[25]Japanese population it was 51% [6] to 58% [18] and a high percentage of 60% and 83.5% in two south Indian population respectively [26,27] was observed (Table 3). Type V of Adachi was rare in previous study and was not observed in the present study. We observed predominance of Type I on the right side and Type IV on the left side (Table 3). And, no gender preponderance was observed. Our study is not similar with other studies on Indian population. This is because, Manpuri population mainly comprises of Meiteis and Highlanders, both belonging to Mongoloid race. Hence, the result of the present study show more inclination towards Japanese studies.

The present study brings forth the variation in the branching pattern of internal iliac artery in full term fetus. It is assumed that the Type IV pose a challenge during UAC because of the large caliber of the common trunk that give rise to superior gluteal artery, the inferior gluteal artery and the internal pudendal artery. The common trunk issued from the 'bend' of internal iliac artery near the posterior part of pelvic brim where internal iliac artery ascends to join the external iliac artery. The 'bend' is the strategic location of internal iliac artery during UAC. Therefore, it is assumed that there is high possibility of misplaced tip of the catheter to enter the trunk and cause ischemic changes to the area supplied by the branches from the common trunk. In type II variety, the superior and inferior gluteal artery also arises from the

Table 3: Several studies on internal iliac artery branch variability in different populations using the Adachi classification types.

Study	Specimen	Type I(%)	Type II(%)	Type III(%)	Type IV(%)	Type V(%)
Jastschinski (1891) [25]	-	38	22.8	32.5	7.3	1.2
Adachi (1928) [6]	-	59	16.2	22.7	1.2	0.5
Tsukamoto(1929) [20]	Adult	56.5	8.4	22	12.9	0
Hoshai(1938) [21]	Adult	55.1	16.1	26.1	2.6	0
Braithwaite(1952) [22]	Adult	58.5	15.3	22.5	3.6	0
Roberts-Krishinger(1969) [16]	Adult	50.9	27	14.4	7.2	0
Morita et al (1974) [23]	Adult	49.1	22.5	21.7	6.7	0
Yamaki et al (1998) [18]	Adult	58	13.6	22.8	5.4	0.2
Fatu et al (2006) [19]	Adult	60	20	10	1	0.8
Naveen et al(2011) [27]	Adult	83.5	6.6	9.9	0	0
Ramakrishna(2012) [26]	Adult	60	8	30	2	0
Talalwah(2014) [24]	Adult	36.1	5.3	34.8	2.3	0
Present study	Fetal	34.1	13.6	22.7	29.5	0

bend through a common stem and therefore, such variety also has a high chance of catheter entering this parietal trunk jeopardizing the structures supplied by these arteries. In type III all the three parietal branches are issued independently from internal iliac artery and all are of small caliber, chances of tip of catheter entering them is less probable. However, embolism, thrombosis or spasm of artery cannot be underestimated. The present study therefore, hypothesises that type IV and II could be the variety where complication can arise out of wrong entry of catheter in these vessels. There is high possibility of catheter tip entering the origin of common trunk causing vasospasm or a thrombotic or embolic incident. To address the side effect of UAC, the knowledge of variation of internal iliac artery with reference to umbilical artery would be of use in neonates and the knowledge gathered from the study could be of use during UAC.

An exhaustive review of literature on branching pattern of internal iliac artery suggests that Adachi's classification is one of the pioneers in the study of internal iliac artery and later studies are modifications from Adachi. The authors feel that in the interventional procedure in fetal and neonatal Adachi classification suit the best and are the simplest and workable in all instances.

CONCLUSION

The present study highlights the incidence of various types of branching pattern in internal iliac artery. The study also brings forth the unique arterial anatomy in newborn highlighting the non existence of adult pattern of two divisions of internal iliac artery. The study hypothesises the possibility of the type IV & II of internal iliac artery with complications associated with the UAC. Detail knowledge of anatomy of the arteries traversed by the catheter would be of paramount significance for the clinicians, radiologists and academicians alike. Hence, the study opens new vista for further research in fetus or newborn with larger samples.

Conflicts of Interests: **None**

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