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Indian Journal of Anatomy

Indexing Information: Index Copernicus, Poland; Google Scholar; Genamics JournalSeek; WorldCat; Gaudeamus Academia; The International Committee of Medical Journal Editors (ICMJE).

Printed at Saujanya Printing Press, B-303, Okhla Industrial Area Phase-1, New Delhi - 20.

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The Indian Journal of Anatomy (pISSN: 2320-0022, eISSN: 2455-622X) is a print and online journal of the **Red Flower Publication Pvt. Ltd.** publishes original and peer-reviewed articles, for the dissemination of anatomical knowledge with clinical, surgical and imaging guidance. Includes articles of history, reviews and biographies, locomotors, splachnology, neuroanatomy, imaging anatomy, anatomical variations, anatomical techniques, education and pedagogy in anatomy, Human Anatomy, Veterinary Anatomy, Embryology, Gross Anatomy (Macroscopic), Microscopic Anatomy (Histology, Cytology), Plant Anatomy (Phytotomy), Comparative Anatomy, editorials, letters to the editor, and case reports. Articles of veterinary anatomy, comparative and other morphological sciences are accepted. Indian Journal of Diabetes and Endocrinology.

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Indian Journal of Anatomy

Volume 9 Number 1
January – March 2020

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Original Articles

Case Report

STATEMENT ABOUT OWNERSHIP AND OTHER PARTICULARS
"Indian Journal of Anatomy" (See Rule 8)

1. Place of Publication	:	Delhi
2. Periodicity of Publication	:	Quarterly
3. Printer's Name	:	**Dinesh Kumar Kashyap**
Nationality	:	Indian
Address	:	3/259, Trilokpuri, Delhi-91
4. Publisher's Name	:	**Dinesh Kumar Kashyap**
Nationality	:	Indian
Address	:	3/259, Trilokpuri, Delhi-91
5 Editor's Name	:	**Dinesh Kumar Kashyap**
Nationality	:	Indian
Address	:	3/259, Trilokpuri, Delhi-91
6. Name & Address of Individuals	:	**Red Flower Publication Pvt. Ltd.**
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Original Article

Indian Journal of Anatomy
Volume 9 Number 1, January – March 2020
DOI: http://dx.doi.org/10.21088/ija.2320.0022.9120.1

Study on the Nutrient Foramen of Long Bones of Upper Limb

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How to cite this article:
Chakka Sreekanth, Lattupalli Hema. Study on the Nutrient Foramen of Long Bones of Upper Limb. Indian J Anat. 2020;9(1):9-15

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Received 17.10.2019 | **Accepted** 13.11.2019

Abstract

The success of any transplant lies in the surgeons ability to preserve its vascular supply and its rapid reconstruction, especially in free vascularized bone grafts, which preserve viability of osteocytes, act as a space filler and introduce a new vascular bed for the reconstruction of defects following trauma, tumour resection, congenital pseudoarthrosis and any cases of difficult non-union bones.

Aims and Objectives: The aim of the present study is to:

1. To determine the number and position of the nutrient foramina in the upper and lower limb long bones.
2. To determine the location and direction of nutrient canal.
3. To determine whether the nutrient foramina obey the general rule that is directed away from the growing end of long bone.

Materials and Methods: The present study is carried out on 150 human cleaned and dried bones of the Upper limb. The samples were taken from Narayana Medical College, Chinthareddypalem, Nellore and Sri Venkata Padmavathi College (SVIMS), Tirupathi of Andhra Pradesh. The long bones included for the study was as follows: Humeri – 50, Radii – 50, Ulnae – 50. All the bones that were taken for the study were normal and had no pathological changes were present. The age and the sex of the bone were unknown. In all these bones after determining the side of bone, the "Nutrient Foramen" were studied in regards with:

1. The number of foramina on the shaft of the bone;
2. Surface on which it was located;
3. Direction from growing end;
4. Location in relation with length of the shaft.

Observations and Results: Total 150 long bones of upper limb of right and left side of unknown age and sex were taken for the study. The parameters studied were depending on the number of nutrient foramina, direction of foramina and their distribution at various levels. The results and observations of the study are presented as tables.

Conclusions: Importance of nutrient foramen is relevant to fracture treatment. Combined periosteal and medullary blood supply to the bone cortex helps to explain the success of nailing of long bones fractures particularly in the weight bearing like femur and tibia uses of vascularized fibula bone in bony defects due to trauma. Currently, the detailed study of blood supply to long bone is a determining factor for the success of newer techniques and resection in orthopedics.

Keywords: Nutrient foramina; Nutrient artery; Humerus; Radius; Ulna bones.

Introduction

The nutrient artery is the principal source of the blood to along bone particularly during its growth period in the embryo and fetus as well as during early phases of ossification (Lewis, 1956)[8]; Patake and Mysorekar, 1977[10]; Forriol C0mpos et al., 1987)[4] during childhood, long bones receive about 80% of the interosseous blood supply from the nutrient arteries, and in the case of their absence, the vascularization occurs through the periosteal

vessels (Trueta, 1953).[12] Because the artery of the shaft of the long bone is largest it is called the "Nutrient Artery". Nutrient canal typically becomes slanted during the growth, the direction of slant from surface to marrow cavity point towards the end that has grown least rapidly. This is due to greater longitudinal growth at the faster growing end, hence the derivation of the axiom that foramina "seek the elbow and flee from the knee". Bones are structures that adapt to their mechanical environment, and from the fetal age adapt to a naturally occurring holes. The holes or nutrient foramina, allow blood vessel to pass through the bone cortex (Gotzen et al., 2003)[5] The cavities conducting the blood vessels and peripheral nerves on the surface of shaft of long bones are called as "Nutrient Foramen". The role of nutrient foramen is evident from the term "Nutrient" itself. The nutrient foramina has been studied in the past by Havers (1691)[2], Berard (1835)[2]; Schwalbe (1876)[11], Langer (1876).[7]

The location of nutrient foramen is important in longitudinal stress fractures, as they can either initiate from the nutrient foramina or the supero medial aspect: Longitudinal stress fractures are more commonly associated with tibia, but occasionally occur in femur, fibula and patella (Craig et al., (2003).[1] Clinical fracture of a long bone is usually accompanied by the rupture of the nutrient artery with variable disruption of the peripheral vessels associated with periosteal detachment. Following fracture the ruptured nutrient artery and the periosteal vessels, together with those in the adjacent soft tissue, start bleeding (Trueta, 1974).[12] An understanding of the location and the number of the nutrient foramina in long bones is, therefore, important in orthopedic surgical procedures such as joint replacement therapy, fracture repair bone grafts and vascularized bone microsurgery as well as medico legal cases (Trueta, 1974)[12]; Forriol Campos et al., 1978).[4]

Detailed data on the blood supply to long bones and the association with the areas of bone supplied has been, and continues to be, a major factor in the development of new transplantation and resection techniques in orthopedics (Kirschner et al., 1998)[6] However, there is still a need for a greater understanding of the location and number of nutrient foramen in bones such as Humerus, Radius and ulna. By defining this restricted area of "Nutrient Artery" entering into the nutrient canal, surgeons can void that during surgical operations and thereby prevent damage to nutrient artery and minimize or lessen the chances of non–union of fracture of the bone.

Aim and Objectives

The aim of the present study is to:

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Humeri – 50,

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Ulnae – 50.

All the bones that were taken for the study were normal and had no pathological changes were present. The age and the sex of the bone were unknown. In all these bones after determining the side of bone, the "Nutrient Foramen" were studied in regards with

1. The number of foramina on the shaft of the bone;
2. Surface on which it was located;
3. Direction from growing end;
4. Location in relation with length of the shaft.

Nutrient foramina were distinguished by the presence of a well-marked groove leading to the foramen, and by a well-marked often slightly raised edge of the foramen at the commencement of the canal. In doubtful cases a dissecting microscope was used to locate the foramen. For direction of canal fine stiff wire was passed through the foramen to confirm its direction. The size of nutrient foramen was determined by using hypodermic needle No. 20 and 24. (Hidustan Syringes and Dispovan pvt. ltd.).

Large foramen – accepted the No. 20 needle;

Medium foramen – accepted only the No. 24 needle;

Small foramen – did not take No. 24 needle.

When more than one foramen was present, the larger one was considered Dominant (DF), and nutrient foramina smaller than a size 24 hypodermic needle were considered as being secondary nutrient foramina (SF)

Humerus: The distance between the superior aspect of the head and the most distal aspect of the trochlea.

Radius: The distance between the most proximal aspect of the head of radius and tip of the radial Styloid process.

Ulna: The distance between the most proximal aspect of the olecranon and the ulna Subdivisions of the position of the Foramina according to Foramen Index.

The position of the foramina was divided into three types according to the Foramen Index(FI) as follows:

Styloid process Type 1: FI up to 33.33, the foramen was in the proximal third of the bone;

Type 2: FI from 33.33 up to 66.66, the foramen was in the middle third of the bone;

Type 3: FI above 66.66 the foramen was in the distal third of the bone.

All measurements were taken to the nearest 0.1mm using a digital verniercaliper. The results were analyzed and tabulated using the Statistical Package for the Social Sciences (SPSS) 8.0 windows. The range, mean and standard deviation of Foramina Index were determined.

Results

Total 150 long bones of upper limb of right and left side of unknown age and sex were taken for the study. The parameters studied were depending on the number of nutrient foramina, direction of foramina and their distribution at various levels. The observations of the study are presented as tables.

Humerus: Out of 50 bones 26 humeri belong to right side and 24 to left. Total numbers of nutrient foramina were 60. Single foramina were found in 3. (72%), double nutrient foramina in 12 bones (24%) and no nutrient foramina in 2 bones (4%). The average length of the humeri was 315.1 mm and average distance of nutrient foramina from upper end was 169.68 mm. Most of the nutrient foramina were found in the middle 1/3rd i.e., 55 foramina (92%), rest of the foramina occupies 1/3rd i.e., 4 (6%) and only one foramina in upper 1/3rd (2%). All nutrient foramina are directed towards the elbow i.e., away from the growing end. Anatomical situation of the nutrient foramina on the shaft at large is on the anteromedial surface; out of 60 foramina 39 (67.2%) were on this surface, 11 (19%) of them were on posterior surface, 7 (12%) on medial border and 1.7% on the lateral surface.

Radius: Out of 50 bones 25 radii belong to right side and 25 radii belong to left side. Total number of nutrient foramina was 52. Single foramen were found in 46 bones (92%), double in 3 bones (6%) and absent in 1 bone (1%). The average length of the radius was 250.3 mm and average distance of nutrient foramina from the upper end was 85.7 mm. Most of the nutrient foramina were found in middle 1/3rd in 32 (61.5%), rest of the foramina occupies upper 1/3rd 29 (38.5%). Among 52 foramina only one is directed towards growing end and others away from the growing end. Anatomical situation of foramen on the shaft of radius at large is on the anterior surface; out of 52 foramina 37 (72.2%) were on this surface, 6 (11.5%) foramina were on the anterior border, 6 (11.5%) foramina were on the interosseous border and only 2 (4.8%) foramina were on posterior border.

Ulna: Out of 50 ulnae studied 25 ulnae belong to right side and 25 ulnae belong to left side. Total number of nutrient foramina was 50. Single foramen was observed in all 50 bones (100%). The average length of the radius was 264.7 mm and average distance of nutrient foramina from the upper end was 91.1 mm. Most of the nutrient foramina were found in upper 1/3rd in 29 (58%), 21 middle 1/3rd 29 (42%). One nutrient foramen is directed towards growing end and remaining 49 were directed away from the growing end i.e., towards the upper end (Elbow joint). Anatomical situation of foramen on the shaft of ulna mostly is on the anterior surface; out of 50 foramina 35 (70%) were on this surface, 10 (20%) foramina were on the anterior border and remaining 5 foramina were on interosseous border (10%). None of the ulna showed multiple foramina.

Discussion

Number of Nutrient Foramina

In the present study, a single nutrient foramen has a higher percentage (72%) in the humeral bones, compared to that of double (24%) and triple foramina (0%) and no nutrient foramina in 2 bones (4%) respectivelyis shown in (Table 1 and Figs. 1,2). Present result (Lutken, 1950)[9]; (Mysorekar, 1957): Forriol Campos et al., 1987).[4,10] Other studies

reported a higher percentage of a single nutrient foramen (80–88%) (Kizilkant et al., 2007).[3] The range of occurrence of double foramina varied from 13% to 42% (Mysorekar, 1967).[10] According to Kizilkant (2007), the percentage of occurrence of triple foramina in the humeri did not exceed (1–7%). The latter observations were in accordance to those reported in the present study. Moreover, Kizilkant et al., (2007)[3] reported the presence of four nutrient foramina in (1%) of the humeri studied. Such number was not observed in the present study. On the other hand, the absence of nutrient foramina in some humeri were also reported by other authors (Lutken, 1950; Patake et al., 1977; Kizilkant et al., 2007)[9,10,3] stated that in suchcases, the periosteal vessels were entirely responsible for the blood supply of the bone.

Table 1: Number of nutrient foramina observed in long bones of upper limb

Bone	Number of Bones	Number of Foramina	Percentages (%)
Humerus (n = 50)	36	01	72%
	12	02	24%
	02	00	04%
Radius (n = 50)	46	01	92%
	03	02	06%
	01	00	01%
Ulna (n = 50)	50	01	100%

Fig. 1: Single nutrient foramen

Fig. 2: Double nutrient foramina

In the present study, all the radii examined had (92%) single nutrient foramen, double nutrient foramen in (6%) of bones, and no nutrient foramen in (1%) bone. The samefinding was reported by Forriol Campos et al., (1987).[4] In otherstudies, the majority of radii (more than 90%) were found to possess a single nutrient foramen (Mysorekar, 1967; Kizilkant et al., 2007).[3] In such studies, radii possessing double nutrient foramina were also observed, and reported the absence of nutrient foramina in (1.2%) of radii examined.

In the present study, (100%) of ulnae examined had a single nutrient foramen. Who recorded a single nutrient foramen in all specimens examined, other authors reported a single nutrient foramen in more than 91% of ulnae (Mysorekar, 1967; Forriol Campos et al., 1987; Kizilkanat et al.).[10,4,3] Furthermore, observed three nutrient foramina in (1%) of ulnae examined, while Mysorekar (1967)[10] reported the absence of nutrient foramina in (0.6%) and (1.1%) of ulnae respectively.

Position of Nutrient Foramina

In this study, Table 2 shows 92% of the nutrient foramina were located along the whole middle third of the humerus, with the foramen index ranging between 33% and 68.68% of the bone length. In accordance with the present results, previous studies reported the position of the nutrient foramina within the middle third of the bone (Mysorekar, 1967; Forriol Campos et al., 1987 Kizilkant et al., 2007).[10,4,3] In this study, (67.2%) of all humeral nutrient foramina were observed on the anteromedial surface 19% of them were in the posterior surface (1.7%) on the lateral surface and 12% on the medial border of the bone. Similar findings had been reportedby Forriol Campos et al., (1987) and Kizilkant et al., (2007).[4,3] On the other hand, Mysorekar (1967)[10] reported an equal percentage of foramina on both the anteromedial surface and the medial border. The site of entrance of the main artery into the humerus makes it vulnerable to be damaged in cases of exposure and plating of the medial column in Supracondylar fractures of the humerus. So, it had been advocated to plating these fractures both medially and laterally with fixation extending up to the diaphysis.

In the present study, as shown in Fig. 3 and 4,61.5% of the total nutrient foramina were distributed most often in the middle third of the radius and 38.5% were in the proximal third, with the foramen index ranging between 27.82% and 48.57% of the bone length. The ratios of the present study were close to those reported by Mysorekar

Table 2: Position and number of Dominant Foramina (DF) and Secondary Nutrient Foramina (SF) observed in Humerus

Position	Total Number of Foramina	%	Number of Foramina					
			Single		Two		Three	
Anteromedial surface			DF	SF	DF	SF	DF	SFA
		67.2%	29		9	1	–	–
Posterior surface	11	19.0%	2		3	6	–	–
Lateral surface	01	1.7%	–	–		1	–	–
Medial border	07	12.1%	5	–		4	–	–

(1967)[10] who found 62% of foramina located in the middle third of the bone and 36% in the proximal end. On the other hand, some reports such as those of Shulman (1959), Forriol Campos et al. (1987)[4], Kizilkanat et al. (2007)[3] stated that the majority of nutrient foramina were located in the proximal third of the bone.

Fig. 3: Radius

Fig. 4: Ulna Bones

In the present study, 72.2% of all radial foramina were on the anterior surface, of the bone. Such results were in accordance with the previous studies (Mysorekar, 1967; Forriol Campos et al., 1987)[10,4] who stated that the majority of nutrient foramina were located on the anterior surface of the bone.

Regarding the ulna, the nutrient foramina (42%) were in the middle third while majority 58% were in the proximal third of the bone, with the foramen index ranging between 27 and 47.59% of the bone length. No nutrient foramina were detected in the distal third of the ulnae. Reviewing the literatures, some authors reported that the majority of nutrient foramina were located in the middle third (Mysorekar, 1967)[10] while others stated that most of foramina were in the proximal third. However, all authors agreed that there were no nutrient foramina in the distal third of the ulna.

In the present study, 70% of the nutrient foamina were located on the anterior surface of the ulnae. In all previous studies, and in accordance with the present results, the nutrient foramina were mostly observed on the anterior surface of the ulna (Kizilkanata et al., 2007; Forriol Campos et al., 1987)[3,4] The blood supply to the sites of muscle attachment to the proximal half of theradius and ulna is directly reinforced by the nutrient arteries. There are, however, no significant muscle attachments to the distal half of the radius and ulna, corresponding to a general lack of nutrient foramina. Delayed or nonunion in the middle or lower diaphysis following trauma may be directly related to the absence of the nutrient arteries entering the bones in these areas The posterior surface of both radius and ulna often lack nutrient foramina especially in the middle and dorsal diaphysis. That is why the dorsal localization for the plate is preferred during operative procedure.

Size of Nutrient Foramina

The present results showed that, Table 3 and 4 and Fig. 1, most of the foramina studied were dominant; all long bones of upper limb possessed a majority

Table 3: Position and number of Dominant Foramina (DF) and Secondary Nutrient Foramina (SF) observed in the Radius

Position	Total number of foramina	%	Number of Foramina					
			Single		Two		Three	
			DF	SF	DF	SF	DF	SF
Anterior surface	37	71.2%	34	–	3	–	–	–
Anterior border	06	11.5%	4	–	–	2	–	–
Posterior surface	02	03.8%	2	–	–	–	–	–
Posterior border	01	01.9%	1	–	–	–	–	–
Interosseous border	06	11.5%	5	–	–	1	–	–

Table 4: Position and number of Dominant Foramina (DF) and Secondary Nutrient Foramina (SF) observed in the ulna

Position	Total Number of Foramina	%	Number of Foramina					
			Single		Two		Three	
			DF	SF	DF	SF	DF	SF
Anterior surface	35	70%	35	–	–	–	–	–
Anterior border	10	20%	10	–	–	–	–	–
Interosseous border	05	10%	5	–	–	–	–	–

of secondary nutrient foramina. The present results contradicted with those of Kizilkanata et al. (2007)[3] who stated that most foramina were of the dominant type. They added that wherever a single nutrient foramen was observed, it was always dominant. This was not the case in the present study. Berard (1835)[2] stated that there was no femur without a dominant nutrient foramen.

Direction of Nutrient Foramina

In this study, all the nutrient foramina in humerus were directed distally (away from the growing ends). Similar observations were reported by Lutken (1950) who stated that all canals which were found in humerus were directed distally. In the radii examined, one foramen was directed towards the growing end and all others were away from the growing end. Similar observations were reported by Mysorekar (1967)[10] who stated that all nutrient foramina on the diaphysis of radius entered obliquely and were directed the elbow.

The nutrient foramina of all ulnae examined one had a proximal direction and remaining all were away from the growing end. Similar observation were reported by Craig et al., (2003)[1]who statedthat all nutrient foramina on the shaft of the ulna entered obliquely and all weredirected towards the elbow, (Table 5, Figs. 1 and 3).

Table 5: Position and direction of Nutrient Foramina in long bones of upper limb

Bone	Position		
	Type-1	Type-2	Type-3
Humerus	1 (1.7%)	55 (91.6%)	4 (6.7%)
Radius	20 (38.5%)	32 (61.5%)	0
Ulna	29 (58%)	21 (42%)	0

Obliquity of Nutrient Foramina

In all long bones of upper limbs examined, there were no changes in the obliquity of the foramen whether it was in the centre of the bone or nearer the ends. Such results were in agreement with those of Mysorekar (1967).[10]

Conclusion

The present study was undertaken to study the nutrient foramina of upper limb long bones. The study material consisted of 150 long bones; each bone was studied for the number, position, size, direction and obliquity of their nutrient foramina. In all bones nutrient foramina were single in number and were secondary in size. Most of the nutrient foramina were concentrated in the middle third of the bone. Nutrient foramina were mostly located on the anterior surface of the shaft of bones of the upper limb.

The direction of nutrient foramina followed the growing end theory. The results of the present study confirmed previous findings regarding the number and position of nutrient foramina of long bones of the limbs and provided clinical information concerning the nutrient foramina which could be useful as reference for surgical procedures. Accordingly, intimate understanding of the characteristic morphological features of the nutrient foramina by orthopedic surgeons is recommended. Exact position of the distribution of the nutrient foramina in bone diaphysis is important to avoid damage to the nutrient vessels duringsurgical procedure.

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Original Article

Indian Journal of Anatomy
Volume 9 Number 1, January – March 2020
DOI: http://dx.doi.org/10.21088/ija.2320.0022.9120.2

A Study of Patterns in the Dorsal Venous Plexus and Veins of Upper Limbs in Humans

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How to cite this article:
Fazal Mehmood Gahlot, Amarendra M Kabadi, Veereshkumar S Shirol. A Study of Patterns in the Dorsal Venous Plexus and Veins of Upper Limbs in Humans. Indian J Anat. 2020;9(1):17-22.

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Received 24.10.2019 | **Accepted** 28.11.2019

Abstract

Context: The study of veins of the upper limbs in living humans and also the study of dorsal venous arch pattern in the upper limbs are important.

Aim: To study the patterns in the dorsal venous arch and superficial veins of upper limbs in humans.

Settings and Design: Present cross-sectional study was carried out at JN Medical College, Belgaum.

Methods: Institution based cross sectional study was carried out among 100 study subjects of age 18–70 years in whom the superficial veins were prominently seen. Tourniquet, Pencil, Rubber, measuring tape, Thread, Camera were used. A tourniquet was tied obliquely to slightly abducted arm inferomedially at the level of lower border of teres major and superolaterally up to greater tubercle of humerus. The superficial veins of upper limb were made prominent by asking person to flex and extend elbow and wrist alternately for 2–3 times. Superficial veins of the arm, forearm and hand were studied and the parameters of the veins like Site of origin of the vein, Variations of vein, Course and length of vein up to the tourniquet were noted down.

Statistical Analysis: The data was described as mean values and difference was assessed by using *t* - test.

Results: We observed five different patterns in cubital fossa. 11 different patterns were observed in right hand and 10 in left hand. The mean length (cm) of cephalic vein, basilic vein, median cubital vein and median vein of forearm in left upper limb of females was 51.6, 50.8, 11.3, 18.1 respectively, in left upper limb of males was 53.2, 50.4, 11.6, 18.1 respectively, in right upper limbs of female was 51.3, 50.8, 12.7, 17.9 respectively, and in right upper limbs of male was 51.9, 50.4, 11.6, and 17.5 cm respectively. These differences were statistically not significant.

Conclusion: Five different patterns in cubital fossa. 11 different patterns were observed in right hand and 10 in left hand.

Keywords: Patterns; Dorsal venous arch; Veins; Upper limbs; Humans.

Introduction

The veins of the upper limb can be divided into superficial and deep groups. The superficial group of veins are variable in disposition and present in superficial fascia. The deep veins accompany the arteries as venae comitantes. The main superficial veins of the upper limb are cephalic vein, basilic vein, median vein of the forearm and the median cubital vein.[1] Similar to the dermatomoal pattern the logic for naming the main superficial veins of the upper limb cephalic (towards the head) and basilic (towards the base) become apparent when the limb is placed in the initial embryonic position.[2]

The superficial veins run away from pressure points and hence, they are absent in the palm, in the ulnar border of the forearm, in the back of the arm and trapezius region. The course of the veins is spiral from dorsal to ventral surface of the limb. The earlier a vein becomes deep it is better because

the venous return is associated by muscular compression. The load of the preaxial vein (cephalic) is greatly received by the more efficient postaxial vein (basilic) through a short-circuiting channel, the median cubital vein and partly by the deep veins through a perforator vein connecting the median cubital vein with the deep vein.[3]

The superficial veins of upper limb are accompanied by cutaneous nerves and superficial lymphatics and not by arteries. The superficial lymph nodes lie along the veins and the deep lymph nodes along the arteries.[3] The superficial and deep set of veins have valves but they are more in number in the deep veins than in the superficial veins.[2]

The study of veins of the upper limbs in living humans and also the study of dorsal arch pattern in the upper limbs are important. Hence present study was undertaken to study the patterns in the dorsal venous arch and veins of upper limbs in humans.

Materials and Methods

Institution based cross sectional study was carried out among 100 study subjects at the Anatomy Department of JN Medical College, Belgaum. Institution Ethics Committee approval was taken. The procedure of the study was explained in detail to the study participants and written informed consent was obtained from all the study participants for the present study.

Adults of age 18–70 years were included. Only those who were thin built and in whom the superficial veins could be seen prominently were included. Obese individuals were not included as the superficial veins could not be seen prominently.

Inclusion Criteria

1. All willing healthy adults
2. Both the sexes
3. Age 18–70 years
4. Thin built and muscular adults in whom the superficial veins could be seen prominently seen.

Exclusion Criteria

1. Not willing to participate in the present study
2. Age less than 18 years
3. Obese individuals
4. Not able to see the superficial veins prominently
5. Diseases of the upper limbs

Materials used

Following material was used:

1. Tourniquet
2. Pencil
3. Rubber
4. Measuring tape
5. Thread
6. Camera

Procedure adopted

In case of 100 study subjects consent form was given and consent was taken for the study. A tourniquet was tied obliquely to the slightly abducted arm infero-medially at the level of lower border of teres major and supero-laterally up to greater tubercle of humerus. The superficial veins of upper limb were made prominent by asking the person to flex and extend the elbow and the wrist alternately for 2–3 times. Superficial veins of the arm, forearm and hand were studied and the parameters of the veins were noted down.

Following findings were noted:

1. Site of origin of the vein
2. Variations of vein
3. Course and length of vein up to the tourniquet

After noting down all these parameters of the superficial veins of the upper limbs the results were obtained.

The length of the cephalic vein from radial end of dorsal venous network up to the tourniquet tied at the level of greater tubercle of humerus was noted. The length of basilic vein was noted from ulnar end of dorsal venous network up to tourniquet. Dorsalvenous network pattern was studied. We did not take the help of any reference for this. We only noted different patterns and named them as type 1, 2, 3… till we found a total of 11 patterns.

Statistical analysis

The data was analyzed using mean values and standard deviation. For comparison of the mean values between two variables, student t - test was used. p - value < 0.05 was considered as statistically significant.

Results

Table 1 shows comparison of the length of the veins in cm in right and left upper limbs observed in 100 living persons. The mean length of cephalic vein in the left upper limb was 52.2 cm and the right upper limb was 51.7 cm. The mean length of basilic vein in the left upper limb was 50.5 cm and the right upper limb was 50.4 cm. The mean length of Median cubital vein in the left upper limb was 11.5 cm and the right upper limb was 11.9 cm. The mean length of Median vein of forearm in the left upper limb was 18.1 cm and the right upper limb was 17.6 cm.

Table 2 shows comparison of length of veins in cm in right and left upper limbs among the male and female. The mean length of cephalic vein in females in left upper limb was 51.6 ± 5.1 and in the right upper limb was 51.3 ± 3.6 and the difference was not statistically significant. The mean length of basilic vein in females in left upper limb was 50.8 ± 3.9 and in the right upper limb was 50.6 ± 4.1 and the difference was not statistically significant. The mean length of median cubital vein in females in left upper limb was 11.3 ± 1.7 and in the right upper limb was 12.7 ± 2.9 and the difference was not statistically significant. The mean length of median vein of forearm in females in left upper limb was 18.1 ± 4.4 and in the right upper limb was 17.9 ± 2.9 and the difference was not statistically significant. The mean length of cephalic vein in males in left upper limb was 53.2 ± 5.4 and in the right upper limb was 51.9 ± 4.5 and the difference was not statistically significant. The mean length of basilic vein in males in left upper limb was 50.4 ± 4.9 and in the right upper limb was 50.4 ± 4.2 and the difference was not statistically significant. The mean length of median cubital vein in males in left upper limb was 11.6 ± 2.4 and in the right upper limb was 11.6 ± 2.7 and the difference was not statistically significant. The mean length of median vein of forearm in males in left upper limb was 18.1 ± 3.7 and in the right upper limb was 17.5 ± 3.7 and the difference was not statistically significant.

Table 3 shows comparison of dorsal venous network pattern in right upper limbs among males and females. Type III pattern was the most commonly seen and maximum cases were seen in males. Type I, II, III, IV, V, VIII, IX and XI was seen predominantly in males compared to females. While in females only Type VII, was seen which was only one case observed in males. Type VI and X were seen equally in males and females. Overall type I, II, III were found to be the most common types followed by type IV, V and VI.

Table 4 shows comparison of dorsal venous network pattern in left upper limbs among males

Table 1: Comparison of the length of the veins in cm in right and left upper limbs in 100 living persons

Limb	Vein	Mean length in cm	Standard deviation
Left upper limb	Cephalic vein	52.2	5.3
	Basilic vein	50.5	4.7
	Median cubital vein	11.5	2.2
	Median vein of forearm	18.1	3.9
Right upper limb	Cephalic vein	51.7	4.2
	Basilic vein	50.4	4.1
	Median cubital vein	11.9	2.9
	Median vein of forearm	17.6	3.5

Table 2: Comparison of length of veins in cm in right and left upper limbs among the male and female

Vein	Left upper limb		Right upper limb		*t* - value	*p* - value
	Min-max	Mean ± SD	Min-max	Mean ± SD		
Length in female in cm						
Cephalic vein	46.5-60.5	51.6+5.1	45.5-60.5	51.3+3.6	0.257	0.798
Basilic vein	47.5-60.5	50.8+3.9	35.5-64	50.6+4.1	0.204	0.839
Median cubital vein	6.5-14.5	11.3+1.7	7-16.5	12.7+2.9	0.660	0.511
Median vein of forearm	11-28.5	18.1+4.4	10-29.5	17.9+2.9	0.159	0.874
Length in male in cm						
Cephalic vein	35-64.5	53.2+5.4	43.5-64.5	51.9+4.5	1.573	0.117
Basilic vein	38.5-64.5	50.4+4.9	40.5-58	50.4+4.2	0.038	0.969
Median cubital vein	7.5-18.5	11.6+2.4	5.5-11.5	11.6+2.7	0.046	0.963
Median vein of forearm	10-27.5	18.1+3.7	12.5-28.5	17.5+3.7	0.931	0.353

Table 3: Comparison of dorsal venous network pattern in right upper limbs among males and females

Pattern	Male	Female	Total
Type I	14	7	21
Type II	14	5	19
Type III	22	6	28
Type IV	6	3	9
Type V	4	2	6
Type VI	2	2	4
Type VII	1	2	3
Type VIII	2	1	3
Type IX	2	1	3
Type X	1	1	2
Type XI	2	0	2

Table 4: Comparison of dorsal venous network pattern in left upper limbs among males and females

Pattern	Male	Female	Total
Type I	9	9	18
Type II	10	6	16
Type III	10	4	14
Type IV	8	4	12
Type V	7	2	9
Type VI	6	2	8
Type VII	6	2	8
Type VIII	10	1	11
Type IX	2	0	2
Type X	2	0	2

and females. It was found that type I was seen equally i.e., nine cases each in females and in males. Overall also it was the most common type. Type II also overall there were 16 cases out of which majority i.e., 10 were seen in males and 6 cases was seen in females. Type III there were 14 cases out of which 10 were in males and 4 was in female. Type IV there were 12 cases out of which 8 were in males and 4 was in female. Type V there were 9 cases out of which 7 were in males and 2 was in female. Type VI there were 8 cases out of which 6 was in males and 2 was in female. Type VII there were 8 cases out of which 6 was in males and 2 was in female. Type IX there was only 2 case which was seen in male. Type X there was only 2 case which was seen in male.

Discussion

In a study on 50 specimens fixed in formalin to define the vascular territory of the acromiothoracic axis and for vascular flaps in plastic surgery it was found that cephalic vein had less tributaries in the deltopectoral groove. The cephalic vein was absent in 4% of the specimen.[4]

But in the present study, we did not find any absent cephalic vein. The median vein of forearm will bifurcate into two vessels one going to the basilic vein which is called the median basilic vein and this is used for giving intravenous injections. The vein is crossed by the anterior branch of the medial cutaneous nerve of the forearm. The nerve may be damaged by the needle or by irrigating fluids which enter the subcutaneous tissue instead of the vein. This will produce so much irritation of the nerve as to cause a reflex spasm of the muscles resulting in acute flexion of the forearm.[5]

In a biostatistical study on the arrangement of the superficial veins of the cubital fossa in Iraqis on 300 students, variations were found. The communication between basilic and cephalic veins was through a horizontal venous connection between one of the tributaries of these two veins. The median vein of the forearm divides into median cephalic vein and median basilic vein. A vein from the front of the forearm drains into the median basilic vein.

In one study of the mid-arm approach to basilic and cephalic vein cannulation under ultrasound guidance, it was found that taking a longitudinal view of the vein will allow easy visualization. For advancing needle, catheter or guide wire the use of cephalic and basilic vein as an approach using

ultrasonography was done in patients of heroin abuse, hypertension, hepatitis C, cirrhosis where all other veins were not visible on feet and ankles.[7]

In one study using cephalic and basilic vein in cubital fossa for palpating and inserting central venous catheters using ultrasound they used a transverse view of the vessels.[7]

In a stud of use of arterial reconstruction using the basilic vein from the zone of injury in pediatric supra condylar humeral fractures they recommended the neglected basilic vein as a donor graft for brachial artery repair. Basilic vein is selected as it is thin walled and there is decreased chance of spasm. Such thin walled vein is least favorable for long-term survival.[8]

The cubital veins are also used for introduction of cardiac catheters and to take blood samples from great vessels and chambers of heart. The veins may also be used for cardiac angiography.[9]

A study was done on 90 adult upper extremities of human cadavers to observe the pattern of the subcutaneous veins on the dorsum of the hand. The distribution of veins was not symmetrical in the dorsum of the hand. In 83.3% of the cases, the veins were arranged in two groups corresponding to the proximal halves of the second metacarpal bone and the second inter metacarpal space and area over the third metacarpal bone might be called vein lacking area. Crossing branches of veins were found in all the cases. There were three crossing branches in each case with internal diameter of 0.9 ± 0.2 mm. This study established that subcutaneous veins are arranged in two layers. They anastomose freely with veins of palmar aspect through intermetacarpal spaces. The average number of perforating branches was 3.9 and their internal diameters were 1 ± 0.4 mm, the perforating branch in first inter metacarpal space was wide and constant. In 70% of the cases venous valves were found which prevent blood flowing from dorsum to the palm of this hand.[10]

Median veins have diameter up to 10 mm and large veins have diameter greater than 10 mm, the wall of vein is made up of three layers: tunica intima, tunica media, and tunica adventitia. The innermost layer is called the tunica intima. The tunica intima includes the endothelium and its basal lamina and reticular fibers. Sometimes an elastic network surrounds endothelium, but these elastic fibers do not form lamina characteristics of an internal elastic lamina. Outside the tunica intima there is tunica media that contains smooth muscle cells in a loosely organized layer interwoven with collagen fibers and fibroblasts.[11]

The earliest vasculature of the limb bud is derived from endothelial cells arising from segmental branches of aorta, carinal veins and from angioblasts endogenous to the limb bud mesoderm. Initially limb vasculature consists of fine capillary network but soon some are enlarged resulting in large central artery that supplies blood to limb bud. From central artery the blood is distributed *via* a mesh of capillaries to the periphery and then collected into a marginal sinus which is located beneath the apical ectodermal ridge. Blood from the marginal sinus drains into peripheral venous channels.[12]

Conclusion

5 different patterns in cubital fossa were found, 11 different patterns were observed in right hand and 10 in left hand. This study will be helpful to the clinicians in performing various operative, diagnostic and therapeutic procedures.

Key Messages

This study will be helpful to the clinicians in performing various operative, diagnostic and therapeutic procedures.

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Original Article

Indian Journal of Anatomy
Volume 9 Number 1, January – March 2020
DOI: http://dx.doi.org/10.21088/ija.2320.0022.9120.3

An Anatomical Study on Branching Pattern of Coronary Arteries: A Cadaveric Study

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How to cite this article:
Kalai Anbusudar, Dhivya Sengottuvel. An Anatomical Study on Branching Pattern of Coronary Arteries: A Cadaveric Study. Indian J Anat. 2020;9(1):23-26.

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Received 19.11.2019 | **Accepted** 01.01.2020

Abstract

Background and Aims: With the increasing advancement in the cardiac imaging techniques, it is mandatory to have a proper knowledge in the anatomy of coronary arteries. The present study is conducted to find out the normal and variations of the branching pattern of coronary arteries in human cadaveric hearts. Coronary dominance was also analyzed.

Materials and Methods: 50 human hearts preserved in 10% formalin were collected from our Department of Anatomy of our institution.

Observations: In this present study, 8% of specimens had third coronary artery, the posterior interventricular arteries were two in number in 22% of specimens. Left coronary artery trunk gave two branches in 80% of the specimens and three branches in 20% of specimens. Right coronary dominance was in 72% of specimens and left coronary dominance was in 28% of specimens. Myocardial bridges were present in 18% of specimens.

Conclusion: Studying the variations of coronary artery is helpful for the interventional cardiologist, radiologist and cardiovascular surgeons to interpret in diagnostic and therapeutic procedures.

Keywords: Right coronary artery; Left coronary artery; Third coronary artery; Coronary dominance.

Introduction

Heart is a vital organ that pumps the blood for the tissues in human body. The myocardium is supplied by coronary arteries. With the advances in the use of imaging techniques, it is essential to have a proper knowledge in the normal and variations in the branching pattern coronary arteries.

The right coronary artery arises from the anterior (right coronary) sinus. Usually, right conal artery is the first branch of right coronary artery. This vessel arises independently from the anterior aortic sinus in approximately one-third of hearts and is therefore, sometimes termed the 'third coronary artery'. On approaching the crux, the right coronary artery normally produces up to three posterior interventricular branches. The left coronary artery from the left posterior (left coronary) sinus of the ascending aorta. Reaching the atrioventricular groove, the left coronary artery divides into its main branches namely, the circumflex and anterior interventricular branches. The main arteries and major branches are usually subepicardial, but those in the atrioventricular and interventricular grooves are often deeply sited, and occasionally hidden by overlapping myocardium or embedded in it (myocardial bridging).[1]

The presence of myocardial bridges and their relationship to coronary artery dominance supplying the myocardium may be clinically significant. Myocardial bridges may compress the coronary vessel underneath and compromise myocardial blood supply. Cases of sudden cardiac death where myocardial bridging is the only postmortem finding have been reported.[2] The present study is undertaken to observe the variations in branching pattern coronary arteries.

Materials and Methods

The present study was conducted in 50 adult heart specimens that were used during routine dissection for MBBS students in the Department of Anatomy in our institution. After opening the thoracic cavity by reflecting the anterior thoracic wall, the heart was taken out from the pericardial cavity with the great vessels. The specimens were numbered and stored in 10% formaldehyde. The right and left coronary arteries were studied to observe their origin, branching pattern, coronary dominance and the presence of myocardial bridges.

Results

In this study, the right and left coronary arteries arose from the anterior and left posterior coronary sinus of ascending aorta respectively in all 50 specimens.

Variations found in right coronary artery

The right conus artery arose from the anterior aortic sinus of the ascending aorta directly in 4 specimens (8%) and is called third coronary artery (Fig. 1). In 11 specimens (22%) the number of posterior interventricular artery were two which arose from right coronary artery (Fig. 2).

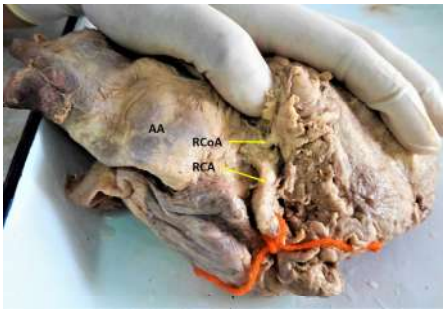

Fig. 1: Rt Conus artery coming directly from aorta

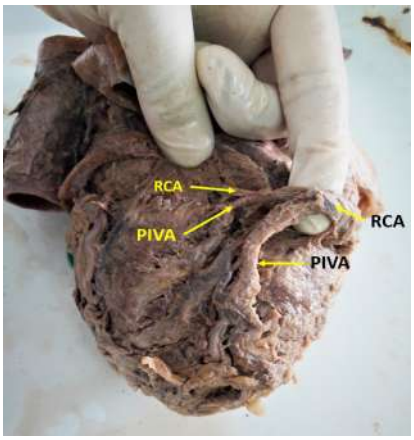

Fig. 2: Two PIVA from RCA

Variations observed in left coronary artery

Trifurcation of the trunk of left coronary artery was observed in 10 out of 50 specimens (20%). In these trifurcated specimens, left coronary artery branched as anterior interventricular artery, left median artery and left circumflex artery (Fig. 3). Table 1 shows the percentage of occurrence of branching pattern of left coronary trunk.

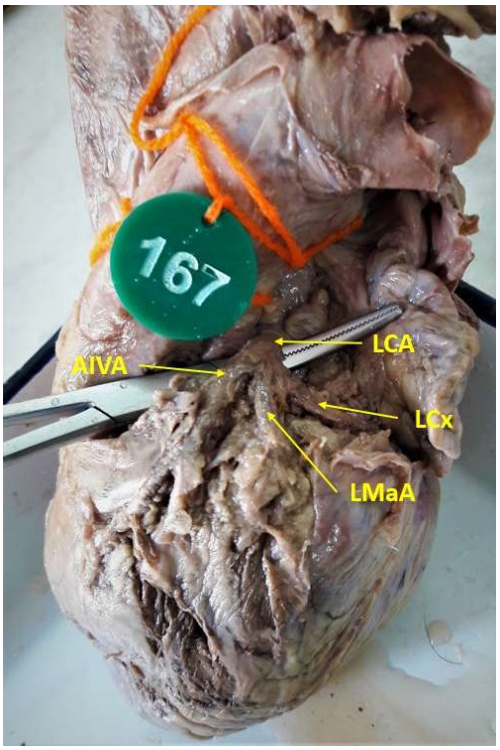

Fig. 3: Trifurcation of LCA as AIVA, median artery and LT circumflex artery

Table 1: Branching pattern of left coronary trunk

Branching pattern of left coronary trunk			
Bifurcation		Trifurcation	
No of Specimens	Percentages	No of Specimens	Percentages
40	80%	10	20%

Posterior interventricular artery arose from left circumflex artery in 14 specimens (28%) indicating the left coronary dominance. In the remaining 36 specimens (72%) the posterior interventricular artery arose from right coronary artery and indicating the right coronary dominance. No balanced pattern of coronary dominance was observed (Fig. 4). Table 2 explains the coronary dominance pattern.

In the present study, 9 specimens (18%) were found to have myocardial bridges. These myocardial bridges were present along the course of anterior interventricular artery in all 18% of specimens (Fig. 5).

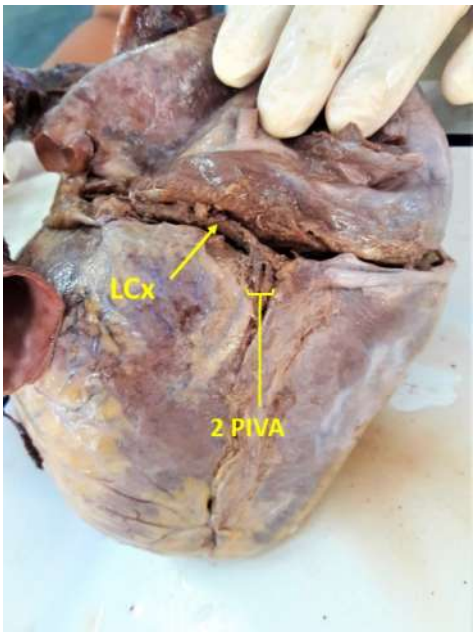

Fig. 4: PIVA from left coronary artery

Table 2: Coronary dominance pattern

Coronary dominance pattern			
Right coronary dominance		Left coronary dominance	
No of Specimens	Percentages	No of Specimens	Percentages
36	72%	14	28%

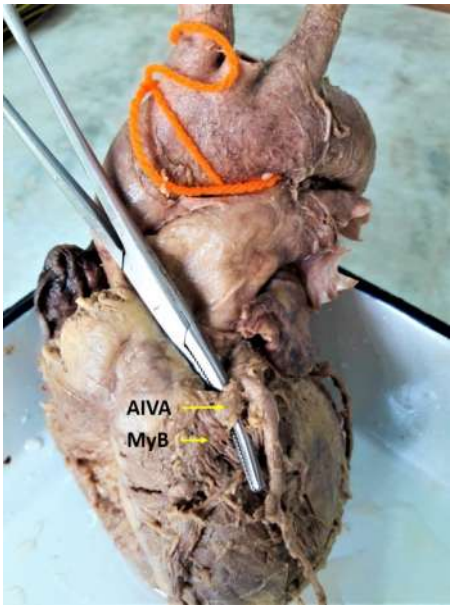

Fig. 5: Myocardial bridge

Abbreviations:

AA- Ascending Aorta

RCA- Right Coronary Artery

LCA- Left Coronary Artery

RCoA- Right Conus Artery

LCx- Left Circumflex Artery

AIVA- Anterior Interventricular Artery

PIVA- Posterior Interventricular Artery

LMaA- Left Median Artery

MyB- Myocardial Bridge

Discussion

Many studies are there on variations in branching pattern of coronary arteries.

Third coronary artery

Schlesinger MJ[3] (1949) discussed the presence of third coronary artery and J Reig Vilallonga[4] (2003) found an accessary orifice for the conal artery in the ascending aorta. Venkateshwar Reddy et al.[5] (2016) stated that right aortic sinus bifurcated as right coronary artery and conus artery in 30% of hearts. Anbumani et al.[6] (2016) observed in their study that 2% of specimens presented third coronary artery and in the present study it was found in 8% of specimens.

Number of posterior interventricular artery

Nordan DG et al.[7] (2012) studied that 2% of specimens had duplication of posterior interventricular artery. Venkateshwar et al. (2016) observed single posterior interventricular artery from right coronary artery in 80% of hearts and 2 or 3 posterior interventricular arteries from right coronary artery in 20% of hearts which correlates with the present study.

Branching pattern of left coronary artery

Banchi A[8] (1904) stated in their study that left coronary artery bifurcated as anterior interventricular artery and circumflex artery in 64%, trifurcation in 31% and left coronary artery gave 4 branches in 5%, Bosco GA et al.[9] (1935) in their study they found bifurcation of LCA (Left Coronary Artery) in 42%, trifurcation in 52% and there was no division of main LCA trunk in 2% of specimens. Mamatha Hosptna et al.[10] (2013) stated bifurcation of LCA in 93.3% of specimens and trifurcation of LCA in ANA6, 7% of specimens. Anbumani et al. (2016) observed bifurcation in 70% of specimens, trifurcation of LCA in 26% of specimens and quadrification in 4% of specimens. Vu Hoang Nguyen et al.[11] (2018) found bifurcation in 51.2%, trifurcation in 43.2% and quadrification in

5.6%, the present study correlates with Anbumani et al. (2016) with little difference in the percentage of occurrence as bifurcation in 80% of specimens and trifurcation in 20% of specimens.

Coronary dominance

Coronary dominance is determined by the arterial supply to the diaphragmatic surface whether it is by right coronary artery and left coronary artery.

In 1940, Schlesinger MJ[12] stated that right coronary dominance was present in 48%, left dominance was present in 18% and balanced type was present in 34%. Mamatha Hosptna et al. (2013) found in their study that in out of 30 specimens, 29 were right dominance and one specimen was left dominance. Cihan Altin et al.[13] (2015) study shows 81.6% right coronary dominance, 12.2% left dominance and 6.2% codominance. Anbumani et al. (2016) observed right dominance in 84%, left dominance in 16% and there was no balanced type. The present study differs a little from this study as 72% right coronary artery, 28% left coronary dominance and no balanced type.

Myocardial bridges

Loukas et al.[14] (2006) documented 34.5% of myocardial bridges in their study. Nordon DG et al. (2012) found muscular bridges in 4% of specimens, Cihan Altin et al. (2915) observed myocardial bridges in 1.1% and Vu Hoang Nguyen et al. (2018) stated the presence of myocardial bridges in anterior interventricular artery in 41.6%, in both anterior interventricular artery and posterior interventricular artery in 5.6% of specimens. Anbumani et al. (2016) observed myocardial bridges in 14% of specimens and this study correlates with our present study in which the myocardial bridges were found in 18% of specimens.

Conclusion

Thorough knowledge of branching pattern of coronary arteries essential for interventional cardiologist and radiologist for diagnosing and performing various procedures like coronary catheterization, coronary angioplasty and bypass graft surgeries. Studying the variations of coronary artery is also helpful to avoid the misinterpretations and complications during the above procedures. It is also mandatory for the anatomists to update the knowledge of the gross anatomy of coronary arteries to their students.

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Original Article

Indian Journal of Anatomy
Volume 9 Number 1, January – March 2020
DOI: http://dx.doi.org/10.21088/ija.2320.0022.9120.4

Incidence of Bifid Ureter and Its Clinical Significance: A Cadaveric Study

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How to cite this article:
Neelesh Kanasker, Preeti Sonje, P Vatsalaswmay. Incidence of Bifid Ureter and Its Clinical Significance: A Cadaveric Study. Indian J Anat. 2020;9(1):27-31.

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Received 04.10.2019 | **Accepted** 13.11.2019

Abstract

Introduction: Bifid ureter or incomplete type of double ureter is a rare congenital anomaly where separate pelvicalyceal system drain into separate ureter because of branching of ureteric bud, but they unite before draining into urinary bladder to open through single ureteric orifice. It's more common in females and on right side.

Objectives: The knowledge about the incidence of bifid ureter and its surgical and embryological significance is of immense value for urologist and renal transplant surgeon.

Methods: 25 cadavers embalmed in 10% formalin formed material of this study, identification of bilateral ureter and tracing of their course till urinary bladder was done, bifid ureter were seen on right side. After removal of intestine and mesentery, posterior abdominal wall was exposed, kidneys were cleaned by removing the fascia and meticulous dissection was done to trace ureters till pelvic cavity, number of bifid ureter were noted and photographs were taken.

Results: 2 cases showed presence of bifid ureter on right side where two ureters were descending down from the hilum posterior to renal vessels were seen, in one case they were uniting at a distance of 13.5 cm and in second case at a distance of 3.5 cm from the ureteric opening into urinary bladder. Course of ureter in pelvis was normal.

Conclusion: Review of literature suggests that duplication of ureter is seen very infrequently. It may be an accidental radiological finding in a patient or may be detected during autopsy. Therefore surgeons and clinicians should be aware of this anomaly to prevent iatrogenic injuries during surgeries and treating renal pathologies.

Keywords: Bifid ureter; Hilum of kidney; Urinary bladder; Renal surgeries.

Introduction

Ureter is a long muscular tubular structure having length of 25–30 cm and diameter of 3–4 mm. It extends from renal pelvis (superiorly) to lateral angle of base of bladder (inferiorly). It start from renal pelvis as posterior most structure at the hilum behind the renal vessels, descends down retroperitonealy in front of posas major muscle, crossed by genitofemoral nerve and gonadal vessels, further down it crosses pelvis brim anterior to common iliac vessels, descends down till it reaches opposite to ischial spine from where it turns anteromedially to enter base of bladder.[1]

The right and left ureters have different relations during their trajectory. The right ureter is related to the inferior vena cava, the descending portion of the duodenum, and it is crossed by the right colic and ileocolic vessels, while the left ureter is crossed by the left colic vessels, and passes posteriorly to the sigmoid colon and its mesocolon.[2]

Normally each kidney is drained by a single ureter, which conveys urine from the kidneys to the

urinary bladder. Single kidney drained by double, triple and quadruple ureters has been reported.[3]

Duplication of ureter is the most common congenital anomaly of urinary system. This anomaly might be complete or incomplete. Incomplete duplication of ureter is known as bifid ureter.[4]

Complication such as collecting system obstruction, urolithiasis, ureterocele, and vesicoureteral reflux[5,6] along with frequent urinary tract infections, ureteric stenosis, non-functioning of kidney units are associated with bifid ureter.[7]

Materials and Methods

Twenty-five cadavers fixed in 10% of formalin were procured from the Department of Anatomy, D. Y. Patil Medical College. Anterior abdominal wall and organs were dissected by 1st year MBBS students during routine dissection. Dissection of posterior abdominal wall was done as per steps of dissections given by Cunningham dissecting manual.[8] The steps were as follows:

1. After removal of stomach, intestine and mesentery, posterior abdominal wall was exposed.
2. Kidneys were cleaned by removing fascia and fat over it.
3. Hilums of the kidneys were dissected meticulously and ureters were traced down till pelvic cavity bilaterally.
4. Muscles of posterior abdominal wall were cleaned.

Incidence of bifid ureter were noted and photographed.

Results

Out of 25 cases two cases showed presence of bifid ureter. They were seen on right sided kidney in both the cases. Ureters were coming out from the hilum posterior to renal vessels, thus maintaining the relation with vessels at hilum. One coming from the upper end of hilum and other from lower end of hilum. Although level of union of two ureter were different in both the cases.

In first case they were joining 13.5 cm above their opening in urinary bladder (in abdominal cavity) as shown in Fig. 1, while in second case they were joining at 3.5 cm above their bladder opening (in pelvic cavity) as shown in Fig. 2, also in second case ureter crossed once each other. After joining, rest of their course was normal till their opening in urinary bladder.

No other associated anomalies like arterial variations were observed.

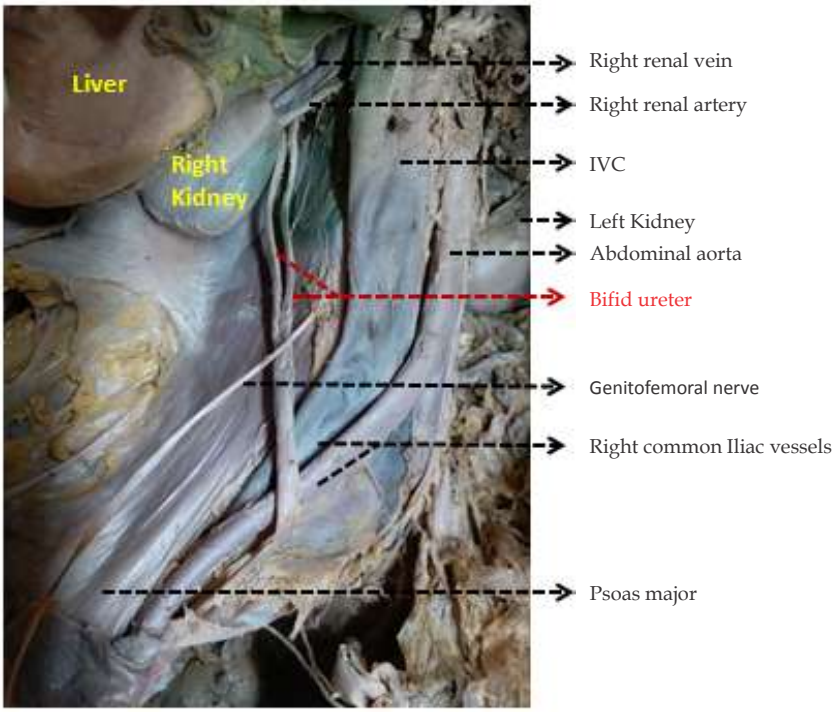

Fig. 1: Bifid ureter joining 13.5 cm above their opening in urinary bladder.

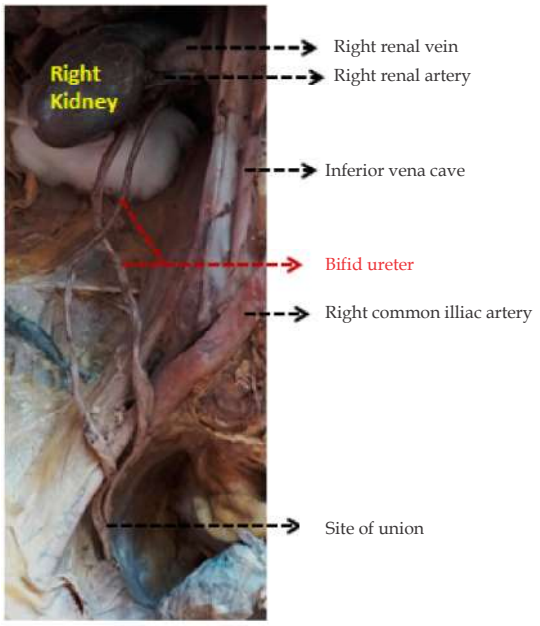

Fig. 2: Bifid ureter joining 3.5 cm above their opening in urinary bladder.

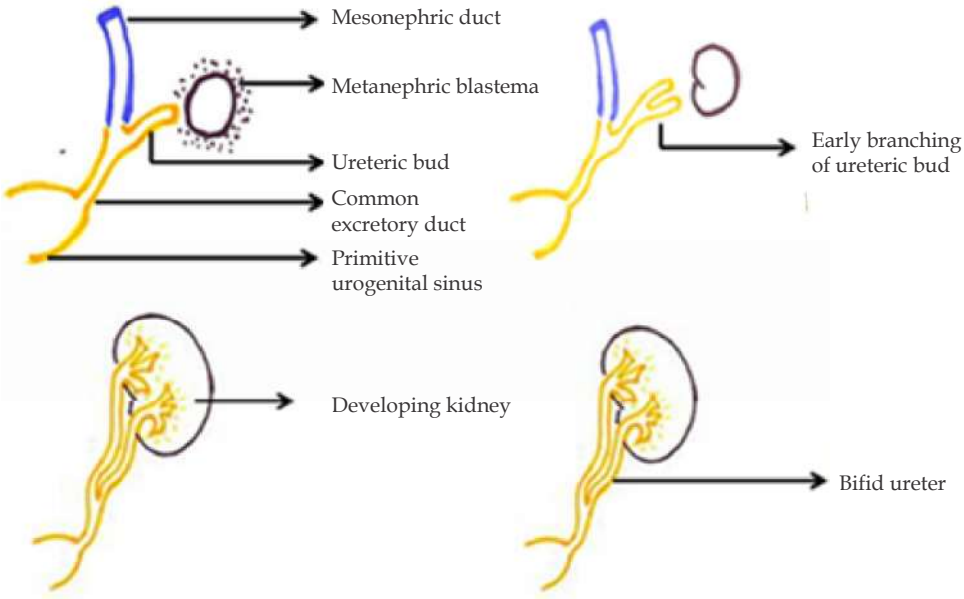

Fig. 3: Embryological basis of bifid ureter.

Discussion

The incomplete duplication is three times more common than complete duplication, with a frequency of one in 500 cases. Previous studies showed that the incidence of bifid ureteris 3% more in female than in males.[3]

Mandal et al.[6] and Rege VM et al.[9] reported cases of left sided bifid ureter in their studies with various renal and gonadal vessels abnormalities. In present study no renal vessels abnormalities were observed.

Other associated conditions with this anomaly are Goltz syndrome[10], (Also known as focal dermal hypoplasia, a multisystemic genetic disorder that principally involve skin, skeletal system, eye, and face, occasionally dental anomalies, abdominal wall defects and urinary system are also involved) High cephalad kidney[11], along with Ectopic ureter and L3 Hemivertebra.[12]

Anatomy textbooks emphasizes the three different areas in which the ureters suffer a constriction: First as it exits the renal pelvis (ureteropelvic junction), second when it crosses

the iliac vessels, third when it enters the urinary bladder. We believe that the incomplete bifid ureter presented here had a higher probability of constriction and subsequent calculi formation at the site of junction between both ureters, as it had an acute angle. Furthermore, it has been stated that once the ureters merge at different level and join the urinary bladder through one orifice (such as our case presented), an stenosis on the pyeloureteral transition or retrograde peristalsis could cause the YOYO-phenomenon saddle or seasaw reflex, where urine goes from one ureter to another, unable to move forward to the bladder, although this phenomenon is more common on blind end ureters.

Cystoscopy, ureteroscopy, computed tomography, magnetic resonance imaging, ultrasonography, and renal scintigraphy are useful to determine the presence of these anomalous ureters.[13-14-15] Symptomatic patients should be treated accordingly with the intensity of the symptoms, and no intervention should be performed in asymptomatic patients.[15]

Embryological Basis

Urinary system is formed from intermediate mesoderm during 4^{th} – 6^{th} week of intrauterine life. Initially there is formation of pronepheric tubules and duct, which regress almost completely apart from portion which continues as mesonephric tubules and duct, during 5^{th} week of intrauterine life ureteric bud arise from the distal end of mesonephric bud/wolffian duct (excretory part), at the same time metanephric tissue from metanephricblastema (secretory part), later on uretric bud grows to reach metanephric tissue to from calyceal system. Early or prior splitting of ureteric bud results in formation of complete or incomplete bifid ureter, as shown in Fig. 3 and metanephric tissue may also be divided into two parts each with its own pelvis and ureter.[16]

Molecular Explanantion

Actin Depolymerising Factors (ADF's), Cofilin 1 (Cfl1) and Destrin (Dstn) are required for ureteric bud branching morphogenesis. SatuKurre et al.[17] in his studies observed that lack of these genes arrests branching morphogenesis at an early stage, revealing considerable functional overlap between cofilin 1 and destrin. Thus, resulting faulty splitting of ureteric bud.

Conclusion

Bifid ureter may be an accidental radiological finding or may be detected during autopsy. Surgeons should be aware of this anomaly to prevent iatrogenic injuries during renal transplant surgeries while clinicians should take care for treating cases of nephrolithiasis as it is the most common pathological condition associated with bifid ureter.

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Original Article

Indian Journal of Anatomy
Volume 9 Number 1, January – March 2020
DOI: http://dx.doi.org/10.21088/ija.2320.0022.9120.5

Comparative Study of Formalin Solution and Saturated Salt Solution for Embalming Cadavers for Surgical Skills Training

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How to cite this article:
Rachna Gulati, Manish S Ahuja, Vijay Langer et al. Comparative Study of Formalin Solution and Saturated Salt Solution for Embalming Cadavers for Surgical Skills Training. Indian J Anat. 2020;9(1):33-37.

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Received 29.11.2019 | **Accepted** 01.01.2020

Abstract

Context: Surgical techniques have advanced rapidly over the years. Surgeons need to update themselves with these advances. Many surgeons also feel the need to hone their surgical skills so as to achieve best possible management of their patients. To facilitate this, Surgical Workshops (SWs) are organized in medical colleges. For these workshops to be effective, it is necessary that cadavers used in these workshops be embalmed in such a way that they resemble the body in natural state as far as possible.

Aims: To compare the two embalming methods–formal in solution and saturated salt solution in terms of (a) Sterility of body tissue/fluids achieved; (b) Range of motion in joints postembalming; (c) Ease of performing incision on abdomen.

Settings and Design: A total of 16 cadavers were taken for this study. These were all donated bodies between the age group 50–80 years.

Materials and Methods: These cadavers were divided into Two Groups: Group A and Group B. Each Group had four male and four female cadavers. Group A was embalmed using formalin solution and Group B was embalmed Saturated Salt Solution (SSS). Bacterial culture tests and measurement of ranges of motion were conducted for each cadaver. In addition, incision followed by suture were performed in the cadavers.

Statistical analysis used: Mann Whitney *U* test.

Results: The SSS method had a sufficient antibiotic effect and produced cadavers with flexible joints and a high tissue quality suitable for surgical workshops. The surgeons found the cadavers embalmed by the SSS method to have a higher range of mobility than those embalmed by the formalin method.

Conclusions: Cadavers embalmed by the SSS method are optimum for SWs. This method is simple, carries a low infectious risk, and is relatively of low cost, enabling a wider use of cadavers for training in surgical techniques.

Keywords: Cadaver; Embalmed; Formalin; Salt; Surgical; Workshop.

Introduction

Embalming of human body has been practiced since ancient times. Biblical texts refer to this practice, and Egyptians are known to have successfully embalmed bodies centuries ago.[1] Advances in surgical techniques and procedures necessitate that specialists in surgery and allied fields should train in the new techniques and try to master them.[2]

Various options are available to facilitate this training. These include use of live animals on whom surgical techniques can be practiced under anesthesia. This raises ethical issues which cannot be brushed aside. Also, anatomy of mammals may not exactly resemble that of humans. The other option is to use simulators and mannequins. These have limited utility for practicing surgical techniques, though they have proved effective in training of paramedical staff in procedures like cardiopulmonary resuscitation.[3–5]

Thus, the best resource for training of doctors in surgical techniques in specialties like surgery, orthopedics and ENT is the cadaver. Cadavers used for practicing and improving upon surgical techniques should mimic the living human body as far as possible. Proper preservation of cadavers is therefore very important.[6] Fresh or fresh frozen cadavers have been used for surgical workshops. They have advantages: Exhibit life-like color, retention of softness and good pliability. But they also have drawbacks: There is requirement of freezers for storage and they can be used for limited period of time due to put refaction that occurs on thawing. There is also the risk of contracting infection as these cadavers are not embalmed.[7]

Thus, the best resource for surgical skills workshop is the embalmed cadaver. Embalming fluids facilitate preservation of organs and tissues. An ideal embalming fluid should achieve the following: (a) Long-term preservation of the cadaver, (b) Prevent hardening of tissues, (c) Retain natural color and texture of tissues and organs, (d) Prevent excessive dessication and (e) Destroy bacteria and prevent their growth.[8]

Formalin Solution (FS) has been extensively used for embalming cadavers for more than a century now – either alone or in combination with other fluids. Formalin effectively coagulates tissue proteins, thus, preventing their degeneration. It is also effective as a bactericidal. But it also has drawbacks. It causes tissues and organs to become very rigid, thus, robbing the cadaver of pliability so, necessary for practicing surgical techniques.[9,10]

Keeping the drawbacks of formalin solution and the limitations of frozen cadavers in view, it is desirable that alternative methods of preserving cadavers be explored, especially for training in surgical techniques through dissection workshops.

Saturated Salt Solution (SSS) is one such material whose utility and effectiveness to preserve cadavers esp with regard to surgical workshops needs to be explored. It has been tried earlier, but only to preserve cadavers for dissection and teaching purpose.[11]

Objectives

To compare the two embalming methods in terms of (a) Range of motion in joints postembalming; (b) Sterility of body tissue/fluids achieved and (c) Ease of performing incision on abdomen.

Materials and Methods

A total of 16 cadavers were taken for this study. These were all donated bodies between the age group 50 and 80 years. These were divided into Two Groups: Group A and Group B. Each Group had four male and four female cadavers. Group A was embalmed using formalin solution and Group B was embalmed Saturated Salt Solution (SSS) methods. Bacterial culture tests and measurement of ranges of motion were conducted for each cadaver. In addition, incision followed by suture were performed in the cadavers.

The composition of these two solutions is as under:

(a) Formalin Solution (FS)

	Ingredient	Amount
(i)	40% Formaldehyde	6 L
(ii)	Ethyl Alcohol	0.4 L
(iii)	Glycerine	1 L
(iv)	Phenol	0.2 L
(v)	Water	12.4 L
	Total	20 L

(b) Saturated Salt Solution (SSS)

	Ingredient	Amount
(i)	Sodium chloride	7 kg
(ii)	40% Formaldehyde	0.5 L
(iii)	Ethyl Alcohol	0.4 L
(iv)	Glycerine	1 L
(v)	Phenol	0.2 L
(vi)	Water	Added to dissolve sodium chloride till solution becomes 20 litres
	Total	20 L

Embalming was done through the common carotid artery. An incision measuring 3 cm was made on anterior border of sternocleidomastoid (SCM) just below upper margin of thyroid cartilage. Around 5 L of embalming fluid was injected under pressure. The canula was left in place overnight and removed the next day. After this the common carotid artery was ligated and the incision was closed. Once embalming was completed, the cadaver was shifted back to a tank having phenoxyethanol as preservative.

Bacterial culture tests: These tests were conducted to see the level of sterility attained in the cadavers after embalming by the two methods. Samples were taken from:

(a) *Pharynx*: Through pharyngeal cotton swab.

(b) *Pleural fluid*: By opening up seventh intercostal space on both sides and taking swab.

(c) *Peritoneal fluid*: Incision was made in right iliac fossa and peritoneal swab taken.

The swabs used were sterile. The incisions for pleural and peritoneal fluid were made after sterilizing the skin over the region so that no infection is introduced. These samples were taken before embalming and again on 15 days after embalming.

Measurement of range of movement (ROM) of Joints: Orthopedic surgeon measured ROM of joints of both right and left side. Comparison was made between cadavers embalmed by FS *vs* those embalmed using SSS. A standard goniometer was used to test range of movement. Shoulder, elbow, hip and knee joints were tested.

Subjective assessment of each embalming method: This assessment was done by surgical specialist and orthopedic surgeon. This included:

(a) Paramedian incision on abdomen.

(b) Exposure of femoral vessels.

(c) Incision over gluteus maximus.

Results

1. *Bacterial culture tests*: The Formalin Solution (FS) embalmed cadavers revealed no bacterial growth after 15 days. Therefore, FS proved to be 100% effective in killing bacteria. The SSS embalmed cadavers revealed the following:

(a) In four out of eight cadavers there was no bacterial growth after 15 days.

(b) In one cadaver, there was one colony formation from pharyngeal swab culture.

(c) In one cadaver, one colony was formed from peritoneal fluid.

Thus, SSS was not as effective as FS in sterilizing the cadavers. However, only one colony each is grown from pharynx and peritoneal fluid in two cadavers.

2. *Range of Movement (ROM) at Joints*: The Mann Whitney *U* test was used to analyze the data obtained for Range of Motion (RoM). The RoM shows significant difference between Formalin Solution and Saturated Salt Solution. The data and results are summarized in Tables 1–4.

3. *Assessment by surgeons and orthopedic surgeons*:

Visual and tactile assessments by surgeons revealed that FS embalmed cadavers differed from living patients quite significantly: there was much more rigidity of tissues and skin. The SSS embalmed cadavers resembled the living patient much more in terms of pliability of tissue and flexibility of skin. The range of movement of joints was higher in SSS embalmed cadavers than in FS embalmed cadavers. The joints tested were shoulder, elbow, hip and knee.

Table 1: Range of Motion (RoM) at various joints in Formalin solution embalmed and Saturated Salt Solution embalmed cadavers. The legends are as per Table 2.

Group	Cadaver No	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12
A	1	38	32	84	72	106	104	46	38	38	32	46	38
A	2	36	30	88	68	102	100	48	44	36	34	48	44
A	3	34	36	82	66	108	106	50	46	40	36	50	46
A	4	40	28	84	70	110	102	46	40	32	32	44	44
A	5	32	26	80	74	104	100	52	48	34	34	46	42
A	6	42	34	78	68	108	104	54	54	38	34	48	44
A	7	36	36	86	74	98	98	48	46	38	32	48	48
A	8	40	26	88	66	104	100	50	48	36	34	44	40
B	1	52	46	96	88	118	112	56	52	48	42	54	48
B	2	54	52	100	96	110	102	54	48	44	38	50	50
B	3	50	48	96	96	106	100	60	58	42	38	52	46
B	4	56	48	98	94	112	112	62	56	46	40	54	48
B	5	52	46	100	94	108	106	58	50	44	36	56	48
B	6	48	44	106	98	116	110	60	52	46	40	48	42
B	7	54	52	104	98	108	100	64	60	40	36	56	48
B	8	52	50	104	100	110	104	62	54	38	34	54	50

Table 2: Legends for alphabets and figures used in Table 1

Group A	Cadavers embalmed by Formalin Solution (FS)
Group B	Cadavers embalmed by Saturated Salt Solution (SSS)
Cadaver number	Eight cadavers in Group A and eight in Group B. Numbered 1 to 8 in Each Group
V1	Flexion at shoulder joint (Rt)
V2	Flexion at shoulder joint (Lt)
V3	Abduction at shoulder joint (Rt)
V4	Abduction at shoulder joint (Lt)
V5	Flexion at elbow joint (Rt)
V6	Flexion at elbow joint (Lt)
V7	Flexion at hip joint (Rt)
V8	Flexion at hip joint (Lt)
V9	Abduction at hip joint (Rt)
V10	Abduction at hip joint (Lt)
V11	Flexion at knee joint (Rt)
V12	Flexion at knee joint (Lt)

Table 3: The mean, median and standard deviation of values V1 to V12

		V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12
Mean		44.75	39.63	92.13	82.63	108.00	103.75	54.38	49.63	40.00	35.75	49.88	45.38
Median		45.00	40.00	92.00	81.00	108.00	103.00	54.00	49.00	39.00	35.00	49.00	46.00
Std Deviation		8.258	9.556	9.366	13.716	4.953	4.435	6.076	6.120	4.619	3.088	4.031	3.557
Percentiles	25	36.50	30.50	84.00	68.50	104.50	100.00	48.50	46.00	36.50	34.00	46.50	42.50
	50	45.00	40.00	92.00	81.00	108.00	103.00	54.00	49.00	39.00	35.00	49.00	46.00
	75	52.00	48.00	100.00	96.00	110.00	106.00	60.00	54.00	44.00	38.00	54.00	48.00

Table 4: The results of Mann Whitney *U* test. All variables (Range of Motion) have shown significant difference between Formalin Solution and Saturated Salt Solution – *p* - value is less than 0.05.

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12
Mann-Whitney U	0.000	0.000	0.000	0.000	8.500	17.000	.500	5.500	3.000	4.000	3.000	9.000
Wilcoxon W	36.000	36.000	36.000	36.000	44.500	53.000	36.500	41.500	39.000	40.000	39.000	45.000
Z	-3.378	-3.373	-3.373	-3.376	-2.498	-1.608	-3.323	-2.797	-3.077	-3.008	-3.087	-2.465
Asymp Sig (2-tailed)	.001	.001	.001	.001	.013	.108	.001	.005	.002	.003	.002	.014
Exact Sig [2 (1-tailed Sig)]	.000b	.000b	.000b	.000b	.010b	.130b	.000b	.003b	.001b	.002b	.001b	.015b

Not corrected for ties.

All variables have significant difference as shown in the tables

Discussion

Embalming has been practised since ancient times to preserve the dead bodies. The Egyptians were probably the first to do so, – the mummies preserved in the pyramids are most well-known example.

In the present study, it has been seen that cadavers preserved in SSS had attained high level of sterility. Two of the four cadavers did show bacterial growth, but that was restricted to single colony.

One of the earliest anatomists to use salt solution for preserving cadavers was Ambrois Pare (1510–1590).[1] The use of formalin solution is known since the times of Henry Gray. Formalin became popular because of its ability to cause instant coagulative necrosis and also its remarkable sterilizing powers. The fact that it causes shrinkage of tissues – esp loose connective tissue is not much of hindrance in anatomical study and dissection for teaching purpose, but it prevents effective utilization of cadavers for training in surgical techniques.[12]

For utilizing cadavers for surgical workshops, it is desirable that cadavers be preserved in a way that they resemble the living patient as far as possible. The high level of formalin which is used in the conventional embalming technique does preserve the cadaver and achieves high level of sterility. But it adversely affects the quality of cadaveric tissues

and organs, esp of soft tissue. This in turn affects joint flexibility.[2,13]

Besides hardening cadavers, formalin has other disadvantages: It dehydrates tissues, constricts arterioles and capillaries, rapidly coagulates blood and discolors skin through formalin pigment formation and gives unpleasant odour.[3,9]

In our study, SSS was not as effective as FS in sterilizing the cadavers. However, since only one colony each is grown from pharynx and peritoneal fluid in two cadavers, the risk of infection through SSS embalmed cadavers is negligible. Moreover, specialists and surgeons practicing surgical techniques do observe precautions like use of gloves and hand hygiene through 70% alcohol and washing of hands and arms before and after practice of surgical techniques.

The SSS has definitely proved superior to FS in other spheres of cadaver preservation. This includes range of motion of joints and pliability of tissues and skin. There is minimal hardening of tissues and organs. The offensive odor of formaldehyde is also absent. Though saturated salt exerts osmotic load, the dehydration so, typical of FS is absent.

Conclusion

Saturated salt solution offers a viable alternative to formalin solution for embalming cadavers for surgical workshops. The advantages include absence, of hardening and dehydration, increased range of motion of joints, greater pliability of tissues and skin and absence of strong odor.

Acknowledgements

The authors duly acknowledge the help received from Shri DR Basannar, MSc, MPS, Scientist F, Govt of India for statistical analysis for this research article.

Key Messages

Cadavers embalmed by saturated salt solution are better suited for surgical workshops than those embalmed by formalin solution.

Prior publication: Nil

Support: Nil

Conflicts of interest: Nil

Permissions: Nil

Total number of photographs: Nil

Presentation at a meeting: Nil

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Original Article

Indian Journal of Anatomy
Volume 9 Number 1, January – March 2020
DOI: http://dx.doi.org/10.21088/ija.2320.0022.9120.6

Variations in the Origin and Draining Pattern of Gonadal Vessels with their Surgical Significance and Developmental Correlations

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How to cite this article:
Preeti Sonje, Neelesh Kanasker, P Vatsalaswamy. Variations in the Origin and Draining Pattern of Gonadal Vessels with their Surgical Significance and Developmental Correlations. Indian J Anat. 2020;9(1):39-43.

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Received 04.10.2019 | **Accepted** 06.12.2019

Abstract

Variations are very commonly found in different vessels of the body. Gonadal vessels also show numerous variations which are important in surgeries of posterior abdominal wall. Also, these vessels are closely related to renal vessels, so, variable origins of these vessels are of utmost importance in renal surgeries. Present study was undertaken to observe the variations in the gonadal vessels.

Materials and Methods: 30 cadavers (26 males and 4 females) embalmed in 10% formalin were procured from the Anatomy Department of, D Y Patil Medical College, Pune. So, sixty gonadal vessels were dissected for this study. The variable levels of origin of gonadal arteries from abdominal aorta as well as variable origins of the same were noted down. Also, the variable draining pattern of gonadal veins were noted. Photographs of all the variations were taken.

Results: Numerous variations in origin, level and source of origin of testicular arteries and ovarian arteries were found. Common variation found was their origin from accessory renal arteries. Gonadal veins also showed, variable draining patterns with sometimes duplication of veins.

Conclusion: Variant origin and draining pattern of gonadal vessels are important in the surgeries of posterior abdominal wall, renal surgeries like renal transplant, surgical excision of tumors of posterior abdominal wall, surgeries on abdominal aorta etc. Also, these variations are important for radiologists and also, for surgeries of varicocoele and testicular tumors.

Keywords: Abdominal aorta; Inferior vena cava; Gonadal arteries; Gonadal veins.

Introduction

The testicular arteries arise anteriorly from the abdominal aorta inferior to the origin of renal arteries. Then they pass under the parietal peritoneum on psoas major muscle. The right testicular artery passes in front of the inferior vena cava while the left testicular artery passes behind the inferior mesenteric vein. Each artery then runs anterior to the genitofemoral nerve, ureter and the lower part of external iliac artery and enters the deep inguinal ring as a content of spermatic cord, passes *via* the inguinal canal to reach the testis.

Pampiniform plexus emerge on the posterior aspect of testis. In inguinal canal pampiniform plexus fuse to form four veins which travel towards abdominal cavity through deep inguinal ring. Within the abdomen these veins coalease into two veins, which ascend on each side of the testicular artery, anterior to ureter, psoas major while behind the peritoneum. Left vein is crossed by the colic vein and right vein is crossed by the root of mesentry. These veins join to form single testicular veins, the right testicular vein drains into inferior vena cava at an acute angle just inferior to the level of renal veins while the left testicular vein opens into the left renal vein at a right angle. Ovarian arteries are the

branches of abdominal aorta and originates below renal ateries. Each descends behind peritoneum, crosses the external iliac artery and vein at the pelvic brim to enter the true pelvis.

Ovarian plexus present in the mesovarium and suspensory ligament give rise to ovarian veins. They usually merge to form a single vein which drains into the inferior vena cava on the right side and the renal vein on the left side.[1]

The purpose of the present study was to know the different types of variations in gonadal vessels. These variations are important for surgeons as well as for radiologists. They are important in surgeries of posterior abdominal wall, renal transplant surgeries, surgical excision of tumors of posterior abdominal wall, surgeries on abdominal aorta etc.

Materials and Methods

Thirty cadavers (26 males and 4 females) embalmed in 10% formalin were procured from the Department of Anatomy, D Y Patil Medical College, Pune. So, sixty gonadal vessels were dissected for this study. The level of origin of gonadal arteries as well as variations in their origin were noted down. Also, the variable draining pattern of gonadal veins were noted down and photographed.

Steps of dissection were followed as per Cunningham's manual of practical anatomy volume 2.[2]

The steps of dissection were as follows:

- All the specimen were labeled with number;
- Anterior abdominal wall was already dissected as cadavers were dissected by undergraduate students;
- Abdominal organs were removed to expose the posterior abdominal wall;
- Abdominal aorta and inferior vena cava were dissected meticulously and variant origin of gonadal arteries, along with draining pattern of corresponding veins were observed;
- All the variations were noted down;
- Photographs of the variations were taken.

Results

Following variations were noted in the gonadal vessels:

1. Circumaortic left renal vein was observed in four cases. Also, duplication of left testicular vein was seen in all the four cases of which one testicular vein was draining into left renal vein while the other was draining into circumaortic renal vein, shows (Fig. 1).
2. Accessory renal artery giving rise to accessory testicular artery on left side in 4 cases (Fig. 2), while in two cases it was seen bilaterally (Fig. 3).
3. Drainage of right testicular vein into right renal vein was seen in 3 cases (Fig. 4).
4. Level of origin of right testicular artery from abdominal aorta was seen at the level of origin of inferior mesenteric artery in 2 cases (Fig. 5).
5. Duplication of left ovarian vein with their drainage into left renal vein, while drainage of right ovarian vein was seen into right renal vein (Fig. 6). This was found in single case.

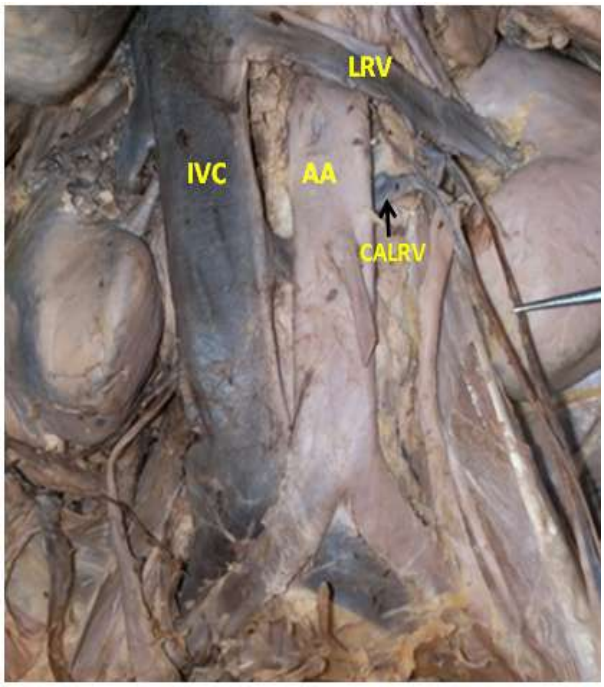

Fig. 1: Circumaortic left renal vein along with duplication of left testicular vein. One testicular vein was draining into left renal vein while the other testicular

Abbreviations

IVC - Inferior vena cava

AA - Abdominal aorta

LRV - Left renal vein

CALRV - Circumaortic left renal vein.

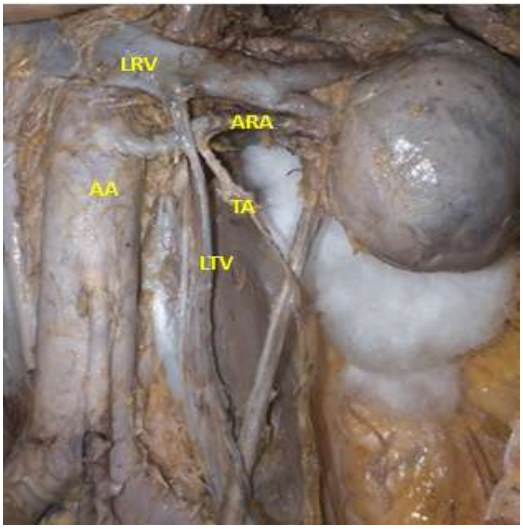

Fig. 2: Accessory renal artery giving rise to accessory testicular artery on left side

Abbreviations

ARA - Accessory renal artery

TA - Testicular artery

LTV - Left testicular vein

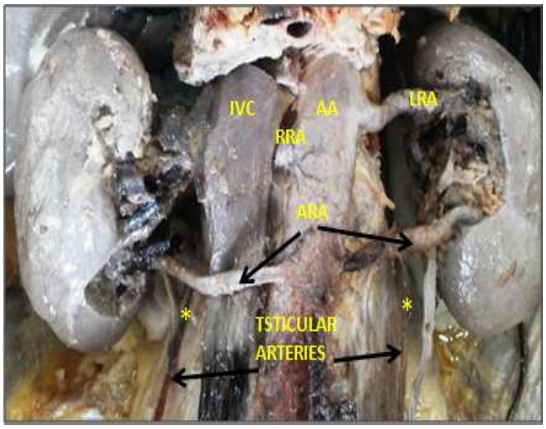

Fig. 3: Accessory renal artery giving rise to accessory testicular artery bilaterally

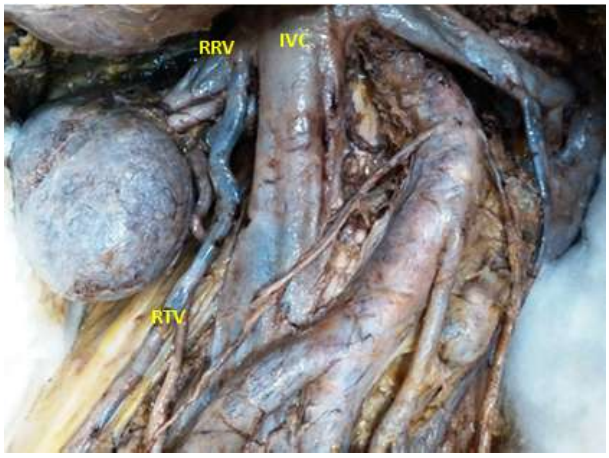

Fig. 4: Right testicular vein draining into right renal vein

Abbreviations

IVC - Inferior vena cava

RRV - Right renal vein

RTV - Right testicular vein

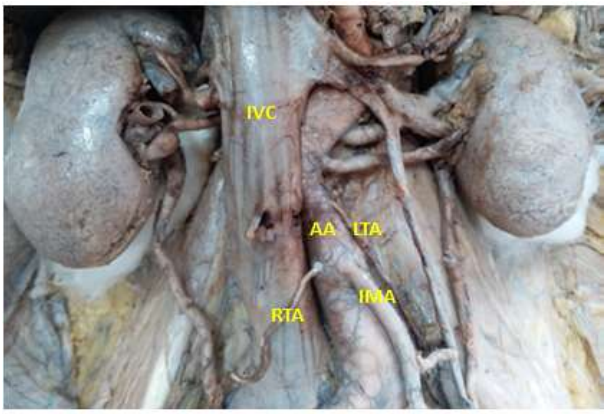

Fig. 5: Right testicular artery arising from abdominal aorta at the level of origin of inferior mesenteric artery

Abbreviations

IVC - Inferior vena cava

AA - Abdominal aorta

LTA - Left testicular artery

RTA - Right testicular artery

IMA - Inferior mesenteric artery

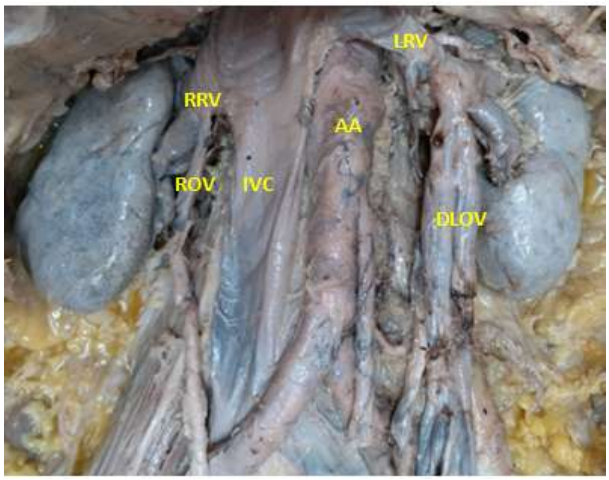

Fig. 6: Left ovarian vein was duplicated was draining into left renal vein, right ovarian vein was draining into right renal vein

Abbreviations

IVC - Inferior vena cava

AA - Abdominal aorta

RRV - Right renal vein

ROV - Right ovarian vein

LRV - Left renal vein

DLOV - Double left ovarian vein.

Discussion

Testicular vessels variations are not uncommon. As per previous studies testicular artery variations are more common on right side as compared to left side. Cicekcibai et al.[3] in his study mentioned 5.5% of cases showing the origin of the gonadal arteries from the renal arteries.

Rusu[4] and Mamatha et al.[5] observed high origin of testicular artery in their study. Kumar N[6] found variation of testicular vein in 21.3% of cases which were more common on the left side along with termination of the right testicular vein into right renal vein and accessory renal vein were also observed.

Knowledge of the origin and course of the testicular artery is surgically important as its ligature during operative procedures will lead to testicular atrophy. So, unusual course and origin of the testicular artery are surgically important and should not be neglected.[7] Sushma R Kotian et al.[8] classified the gonadal vessels according to their level and source of origin, as follows:

Type I: Origin of testicular artery from the abdominal aorta inferior to the renal artery (Normal pattern);

Type II: Origin of testicular artery from the abdominal aorta superior to the renal artery;

Type III: Testicular artery originating from the renal artery;

Type IV: Origin of testicular artery from the abdominal aorta at the level of origin of the inferior mesenteric artery. Normally testicular artery originates from the abdominal aorta inferior to the origin of renal artery but studies have also reported their origin posterior or superior to the renal artery.

Cases of the origin of right testicular artery from the renal artery have been reported. The testicular artery may originate from an accessory renal artery.[9] Rarely origin of the testicular artery may be seen from other arteries like suprarenal, phrenic, superior mesenteric, lumbar, common iliac, or internal iliac arteries.[10] In the present study, origin of the testicular artery was observed either from the renal artery or the accessory renal artery.

Arching of the testicular artery in front of the renal vein has been observed in previous studies which was named as the artery of Luschka.[2] Such arched artery may get compressed leading to testicular degeneration. Similar finding was observed in present study, where left testicular artery was arching over the left renal artery and the vein.

Because of advanced surgical techniques for the treatment of varicocoele and undescended testis the anatomy of gonadal arteries has assumed great importance. Unfamiliar anatomy of gonadal vessels during laparoscopic surgery of abdomen and pelvis may lead to vascular troubles of gonads.[11]

Variable arrangements of renal and gonadal veins are of immense surgical importance. The incidence of additional renal vein may contribute to the selection criteria adopted for a donor kidney suitable for transplantation.

Presence of additional renal vein may act as an alternate collateral route if the portion of inferior vena cava is interrupted between these veins. It has been also reported that the right renal vein rarely received tributaries, whereas left renal vein regularly had complex connections with other venous channels, which formed the basis of collateral pathways after caval interruption. Asala et al. (2001)[12] found 2 cases in which right gonadal vein was draining into right renal vein, out of 150 cadavers dissected while variations of gonadal veins were more frequent on the left side, as observed by him. In the present study, right testicular vein was seen draining into the right accessory renal vein.

Embryological Basis

During development of inferior vena cava, the "renal collar" forms a circular aortic venous ring, which is formed anteriorly by subcardinal veins and anastomosis between them, posteriorly by supracardinal veins and their anastomosis, while on each side it is formed by supracardinal-subcardinal anastomosis. Once the definitive position of metanephros is attained, permanent venous pattern begins to appear. At this time, bilaterally symmetrical cardinal venous system forms unilateral right-sided inferior vena cava. Inferior vena cava is thus formed in the right of aorta. At this stage, two renal veins are present on each side, one on the ventral plane while another dorsal to it. In the right side, one renal vein opens into the lateral portion of the renal collar and the other opens more dorsally towards cranial part of the supracardinal vein. During further development, there is confluence of the two tributaries forming a single vessel that connects with the lateral portion of renal collar. The persistence of these two veins will form the additional renal vein of right side.

Gonadal vein develops from caudal part of

subcardinal vein and drains into the supracardinal and subcardinal anastomosis. In the right side, this anastomosis and also a small portion of subcardinal vein are incorporated into the formation of inferior vena cava, resulting into the drainage of right gonadal vein into the inferior vena cava. If this fails part of right renal vein is formed by right supracardinal veins.[13]

Multiple renal veins are seen in about 14 percent of kidneys. The common anomaly of the left renal vein occurs when it divides and passes on both the sides of aorta to reach the inferior vena cava. The portion of the left renal vein associated with the aorta develops from anastomoses between the cardinal systems of the two sides, which is known usually known as the renal collar, with preaortic and retroaortic limbs. Commonly ventral pat of renal collar is retained, so, that the left renal vein passes anterior to the aorta; but if ventral part disappears and dorsal pat persists, it will form retro aortic left renal vein. In case if both the dorsal and ventral parts persists a circumaortic venous ring is formed [14] which is found in four cases in the present study.

Conclusion

The detailed knowledge of the variations in gonadal vessels is of utmost importance to the urologist, surgeons dealing with renal transplant surgeries, and radiologists for diagnostic procedures. While performing surgical procedures for the treatment of varicocele and undescended testes within abdominal cavity, anatomical knowledge of testicular artery is very essential in order to prevent testicular atrophy.[15]

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Original Article

Indian Journal of Anatomy
Volume 9 Number 1, January – March 2020
DOI: http://dx.doi.org/10.21088/ija.2320.0022.9120.7

Morphometric Study of Orbit in Skull Bones: Direct Measurement Study

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How to cite this article:
Chakka Sreekanth, Lattupalli Hema. Morphometric Study of Orbit in Skull Bones: Direct Measurement Study. Indian J Anat. 2020;9(1):45-53.

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Received 19.10.2019 | **Accepted** 13.11.2019

Abstract

The essential segments of the skeleton are the human skull and cranium which have received significant attention in forensic research especially in the analysis of ethno-racial relationship. The features within it (example orbit) may give further insight into the understanding of the craniofacial anthropometry. Understanding the structural disposition of the human body is aided by the advances in medical imaging techniques such as radiography, MRI, CT scan etc. But direct measurement on dry skulls is a more natural perspective in assessing the orbital cavities.

Conclusion: Periorbital and facial injuries are mainly caused by assaults and falls and at times may involve the forehead. Such injuries necessitate cranial and orbital reconstructions to correct both esthetic and functional deficits. Care must be taken to prevent damage to the neurovascular structures contained in the orbit or within its walls. In order to achieve this, the surgeon needs to have a proper understanding of the human orbital structure, its relationship with both intra- and extracranial structures, and associated key surgical and anatomical landmarks.

Keywords: Orbit; Shapes; Length; Orbital index.

Introduction

The two orbital cavities are situated on either side of the saggital plane of skull between the cranium and the skeleton of the face. Thus situated, they encroach about equally on these two regions. Each orbital cavity is essentially intended as a socket for the eyeball and also contains associated muscles, nerves, vessels and in essence lodges the visual apparatus. This is an anatomical region which is of clinical and surgical interest to many disciplines like ophthalmology, oral and maxillofacial surgery and neurosurgery.

In the adult human, the orbits are four sided pyramidal cavities: Its base opens into the face and has four borders, superior margin: frontal bone, Inferior margin: maxilla and zygomatic, Medial margin: frontal, lacrimal and maxilla, and Lateral margin: zygomatic and frontal. Its apex is pointing back into the head and lies near the medial end of superior orbital fissure and contains the optic canal which communicates with middle cranial fossa. Seven bones make up the bony orbit: Frontal (Pars orbitalis), Lacrimal bone, Ethmoid bone (Lamina papyracea), Zygomatic bone (Orbital process of the zygomatic bone), Maxillary bone (Orbital surface of the body of the maxilla), Palatine bone (Orbital process of palatine bone), and Sphenoid bone (Greater and lesser wings). The orbit is a bony pyramid with four walls: a roof, lateral wall, floor, and medial wall. The base of the pyramid is the orbital entrance, which is roughly rectangular. It measures 4 cm wide by 3.5 cm high and is rotated laterally. Because of this lateral rotation, the lateral orbital rim is approximately at the equator of the globe, making the globe relatively exposed laterally. The apex of the orbital pyramid is situated 44–50 mm posterior. The medial orbital

walls are parallel, approximately 2.5 cm apart and separated by paired ethmoid sinuses. The orbital volume is roughly 30 ml, of which 7 ml is occupied by the globe (Standring S, 2005).[8] Also, since the orbit is developed around the eye, it has a tendency towards being spheroidal in form, and its widest part is not at the orbital margin but about 1.5 cm, behind this. Patniak et al. (2001)[3] stated that in each orbital cavity, the width is usually greater than the height, the relation between the two is given by the orbital index, which varies in different races (Orbital Index = Orbital Height/Orbital Breadth). Taking the orbital index as the standard, three classes of orbit have been described.

CT has revolutionized the diagnosis and management of ocular and orbital diseases. The use of thin sections with multiplanar scanning and the possibility of 3-D reconstruction permits thorough evaluation. Quantification of eye and orbit anthropometric variation within the normal population is important for prediction and prevention of eye injury. With CT images, accurate measurements can be collected for bony structures of the orbit that surround and protect the eye. Accurate measurements of eye and orbit anthropometry are valuable in the design of eye protective equipment and modeling of facial impacts for injury prediction purposes. (Ashley A et al., 2010).[7]

Not many studies have been done pertaining to morphometry of orbit in Indian population especially in south Indian skulls. Hence, this study of morphometry of orbit in skulls becomes essential to develop a database to determine normal orbit values in South Indian population.

Aims and Objectives

This study is aimed at evaluating the morphology and morphometry of orbit related to gender and side wise in South Indian population and to get normative/baseline data regarding orbit.

1. To study the morphology and morphometry of orbit in the skulls that is segregated according to gender.
2. This study employs the use of direct measurement on dry skulls as it will present a different and a more natural perspective in assessing the orbital cavities.
3. The parameters taken for this study are shape of the orbit, perimeter, height, breadth, length of the lateral wall, medial wall, roof and floor. Intra orbital distance and extra orbital distance.
4. To compare this study with previous studies.

Materials and Methods

Osteometric study was done using 100 bones obtained from the Department of Anatomy, Narayana Medical College, Nellore and also Sri Padmavathi Medical College for Women (SVIMS) Tirupathi.

The materials required for the study were thread, metallic scale and vernier calipers. Two measurements were made for each parameter to get an average value The methods employed were according to (Mekhla D 2012):

1. In the case of shape both sides orbits were visualized assessed to determine whether square or round.
2. The Perimeter (Pm) of the orbit was measured by pressing a loop of thread along the outer margin of orbit. The thread was then measured on a metallic scale and the readings were noted.
3. The Height of the orbit (Ht) was measured as the distance between the midpoint of the upper and lower margins of orbital cavity.
4. Breadth (Br) of the orbit was measured as the distance between the midpoint of the medial and lateral margin of the orbit by using manual vernier calipers.
5. Orbital Index was measured by using the following formula:

Orbital Index = Orbital height/Orbital breadth × 100.

Taking the orbital index as standard, three classes of the orbit were recognized:

1. Megaseme (Large): The orbital index is 89 or over.
2. Messeme (Intermediate): Orbital index between 89.
3. Microseme (Small): Orbital index 83 or less.
4. Length of the lateral wall of the orbit was measured from the midpoint of the lateral margin of the orbit to the apex of the orbit using a thick strip of paper. The length of the paper was then measured using metallic scale and vernier calipers.
5. Length of the medial wall of the orbit was measured from the midpoint of medial wall of the orbit to the apex of the orbit.

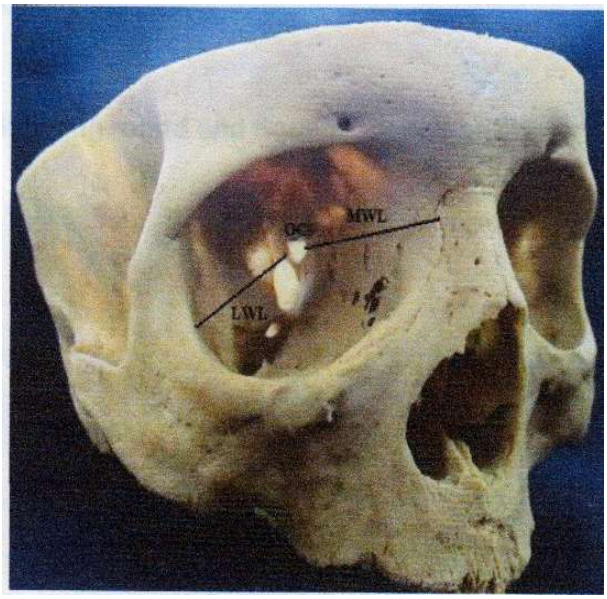
6. Roof length of the orbit was measured from the midpoint of the upper margin of the orbit to the apex of the orbit.[7] Floor Length of the orbit was measured from the midpoint of the lower margin of the orbit to the apex of the orbit.
7. Intra orbital distance was measured between the midpoints of medial margins of medial of two orbits.
8. Extra orbital distance was measured between the midpoints of lateral margins of two orbits.

Results and Discussion

The orbits are paired structures, located on the anterior part of the face and protected by the lids. Each orbit can be compared to a tiny jewel box that has very precious contents, all carefully wrapped in fatty tissue. Morphologically, each orbit is a four sided pyramid with a posterior apex and anterior base. Knowledge of the orbital osteology is paramount in adequately choosing and performing an orbital approach. Understanding the critical topographical elements in this area helps to classify an orbital lesion and provides a solid basis in choosing the most adequate intra orbital route for the treatment (Fig. 1).

Shape of the orbit

E Pretorious et al. (2006)[11] in their study found two shapes of the orbit namely square which was 73.33% in males and round which was 26.77%, in females the square shape was observed in 2% and the round shape was observed in 80%. A study done by Mekhala D (2014)[20] in her study also reported that the Orbit had two shapes round and square. In females the round percentage being 72% and square being 28%. In males square shape was seen in 80% and round shape was seen in 20% of the skulls. In the present study in males square shape was seen in 66.7% and round shape in 33.3%. In females square shape was seen in 30.2% and round shape in 69.8% respectively (Fig. 6, Table 1). There is a difference in the percentages in present and previous studies. These variations may be due to, interobserver variations or small sample size in the previous study or racial differences seen in South African population.



OC - Optic canal, LWL - Lateral wall length, MWL - Medial wall length

Table 1: Comparison of the shape of orbit in male and female skulls

Shape	Male		Female		Chi-square	*p*-value
	N	%	N	%		
Round	19	33.3%	30	69.8%	13.019	< 0.0001 (Sig.)
Square	38	66.7%	13	30.2%		
Total	57	100%	43	100%		

Table 2: Comparison of Gender between PMR and PML

	Gender	Mean	Std. Dev.	S.E. of Mean	Mean Difference	Z	*p*-value
PMR	Males	12.87	0.50	0.07	0.56	4.87	< 0.0001 (Sig.)
	Females	12.30	0.62	0.09			
PML	Males	12.88	0.48	0.06	0.57	5.08	< 0.0001 (Sig.)
	Females	12.32	0.60	0.09			

Fig. 1: Skulls

Fig. 2: Measurements of Pm, Ht and Br

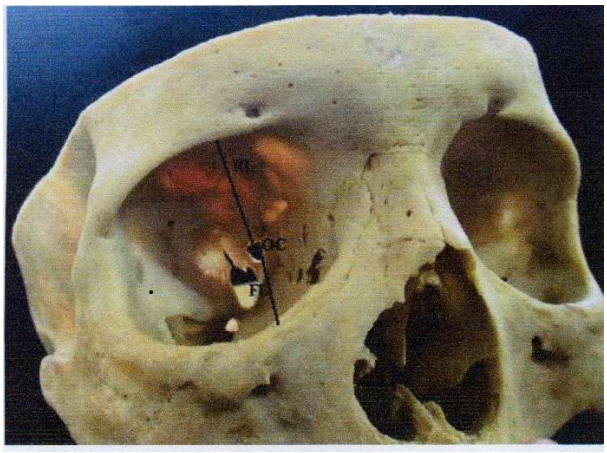


Fig. 3: Measurements of Roof Length (RL) and Floor Length (FL) OC - Optic Canal

Fig. 4: Measurements of Orbital Breath and Height

Orbital Dimensions

Perimeter of the Orbit

In the study done by Mekhala D (2014)[20] the mean value was 12.93 on right side and 12.91 on the left side the *p* - value was 0.543. In the present study, the mean value of perimeter in males on the right side is 12.87 and left side is 12.88 the *p* - value is < 0.0001. In females the mean value of the perimeter on right side is 12.30 and left side is 12.32 and the *p* - value is < 0.0001. When compared with previous authors the results of present study are more or less equal (Table 2 and Fig 2). Accurate measurement of perimeter of orbit is very important to design the eye protective equipment's.

Height of the orbit

In the work done by Sayee Rajangam et al., (2010)[13] the mean value of the height in males on the right side is 3.5 and left side is 3.37. In females the mean value of height was 3.2 on right side and 3.08 on the left side the *p* - value on right side was 0.397 and left side was 0.174. In a study done by Sanjai S et al., (2007)[14] the mean height value was 3.314 in males and 3.289 in females and the *p* - value being 0.255. In the work of Jaswinder Kaur et al., (2012)[12] 12 the mean value of height on right side is 3.19 and left side is 3.22. In the work of Mekhala D et al., (2014)[20] the mean value of height in males on the right side is 3.55 and left side is 3.53 and the *p* - value is 0.487. The same work totally in males is 3.62 and

Table 3: Comparison of Gender between HTR and HTL

	Gender	Mean	Std. Dev.	S.E. of Mean	Mean difference	z	*p*-value
HTR	Males	3.77	0.28	0.04	0.20	3.81	< 0.001 (Sig.)
	Females	3.56	0.24	0.04			
HTL	Males	3.75	0.28	0.04	0.19	3.54	< 0.001 (Sig.)
	Females	3.56	0.24	0.04			

Fig. 5: Measurements of IOD and EOD

Fig. 6: Showing round and Square shaped orbits

in females 3.45 and the *p* - value is < 0.001. In the present study, the mean value of height in males on the right side is 3.77 and females is 3.56. To the left side in males the mean value is 3.75 and females is 3.56. The *p* - value is < 0.001 significant. The values are high compared to the other authors (Figs. 4,5 and Table 3). These differences may be due to racial differences as seen from the population studied or due to variations in sample size.

Breadth of the orbit

In the study of Sayee Rajangam et al., (2012)[13] in males towards the right side the mean value of the breadth of the orbit is 4.17 and left side is 4.08. In females to the right side it is 3.72 and to the left it is 3.69. The *p* - value is 0.07 for males and 0.145 in females. In the study of sanjai Sangvisichien et al., (2007)[14] in male the mean value of the orbital breadth is 4.01 and in females it is 4.05 the *p* - value is < 0.001. In a study done by Mekhala D (2014)[20] in males the values were 4.29 and 4.05 in females and the *p* - value is < 0.001. In the present study the mean value of orbital breadth the value in males on the right side is 4.48 and left is 4.47 the *p* – value is < 0.001 which is significant. In females on the right it is 4.19 and left is 4.18. The *p* - value < 0.001 and is significant (Fig. 4 and Table 4). In the study of Ukoha U et al., (2011)[6] the mean orbit value is towards the right 3.603 and left 3.498 and the *p* - value is > 0.05. The study of Jaswinder Kaur et al., (2012)[12] in the right side it is 3.97 and left side it is 3.88 and the *p* - value is 0.823.

Orbital Index

In the present study, there is no significant difference observed in the orbital index, between the genders and also sides. According, to the standard classification, the mean orbital index of both genders in the present study belongs to Megaseme category. In the present study, the OI mean value in males is on the right 90.2 and left is 88.13 and the *p* - value is 0.02 which is significant. In females on the right it is 87.34 and left is 87.03

Table 4: Comparison of Gender between BR and BL

	Gender	Mean	Std. Dev.	S.E. of Mean	Mean difference	z	*p*-value
BR	Males	4.48	0.35	0.04	0.29	4.43	< 0.001 (Sig.)
	Females	4.19	0.31	0.05			
BL	Males	4.47	0.35	0.05	0.29	4.43	< 0.001 (Sig.)
	Females	4.18	0.29	0.04			

Table 5: Comparison of Gender between OIR & OIL

	Gender	Mean	Std. Dev.	S.E. of Mean	Mean difference	z	*p*-value
OIR	Males	90.2	6.22	0.83	2.86	2.29	0.02 (Sig.)
	Females	87.34	6.10	0.93			
OIL	Males	88.13	12.64	1.67	1.10	0.53	0.60 (Not Sig.)
	Females	87.03	6.15	0.94			

and the *p* - value is 0.60 which is not significant. In the present study, the values are more in males compared to females. The authors conclude that, the OI can be used as simplest and most efficient method to indicate racial differences and sexual differences. (Table 4).

In the study of Sayee Rajangam et al., (2007)[13] in Indian population the OI on the right side in males is 73.55 and left is 75.27. In females on right side is 66.79 and left side is 65.03 and the *p* - value is 0.003 in male. In females IOI is 66.79 on right side and 65.03 on left side and *p* - value is 0.028 and belongs to Microseme category. In the study of Sanjai Sangavicichien et al., (2012)[14] in Thais the OI mean value in males is 83.50 and females is 86.61. The *p* - value is 0.027 and belongs to Mesoseme category. The category is Microseme in males and Mesoseme in Females. In the study of Mekhala D (2012)[20] in Indians in males the OI was 84.62 and 85.46 in females and the *p* - value is 0.104 and the category is Mesoseme.

Normal values of orbital indices are vital measurements in the evaluation, and diagnosis of craniofacial syndromes and posttraumatic deformities, and knowledge of the normal values for a particular region or population can be used to treat abnormalities to produce the best esthetic and functional results Ebeye O et al., (2013).[15]

Length of lateral wall of orbit

Thanasil Huanmanop et al., (2007)[4] reported that there was no significant gender difference in the length of the lateral wall. And the length of the lateral wall was significantly larger on the left side compared to right side. He reported in males on the right side 4.68 and left side 4.78. In females the mean value in females to the right side is 4.64 and left side is 4.66 and the *p* - value is > 0.05 in males and > 0.05 in females. In the study of Mekhala D (2012)[20] in males the value is 4.70 and females 4.31 the *p* - value is < 0.001. The same study of Thanasil Huanmanop et al., (2007)[4] the right side mean value is 4.66 and the left side value is 4.72 and the *p* - value < 0.001. In the study of Mekhala D (2012)[20] the right side mean value 4.52 and left side is 4.51 and the *p* - value is 0.695. The lateral wall of the orbit continues to grow throughout the childhood, producing a wider adult orbit Song XING et al., (2012)[10].

In the present study, (Fig. 4 and Table 6) the mean value of the length of the lateral wall of the orbit in males on the right side is 4.86 and 4.87 on the left side, the *p* - value being < 0.001 which is significant. In female the values are 4.49 on right side and 4.50 on the left side the *p* - value being < 0.001 which is significant. The slight variations between the values may be due to racial variations.

Table 6: Comparison of Gender between LWLR and LWLL

	Gender	Mean	Std. Dev.	S.E. of Mean	Mean difference	z	*p*-value
LWLR	Males	4.86	0.34	0.04	0.37	5.57	< 0.0001 (Sig.)
	Females	4.49	0.32	0.05			
LWLL	Males	4.87	0.32	0.04	0.37	5.91	< 0.0001 (Sig.)
	Females	4.50	0.29	0.04			

Table 7: Comparison of Gender between MWLR and MWLL

	Gender	Mean	Std. Dev.	S.E. of Mean	Mean difference	z	*p*-value
MWLR	Males	4.83	0.39	0.05	0.44	5.44	< 0.0001 (Sig.)
	Females	4.39	0.43	0.06			
MWLL	Males	4.85	0.38	0.05	0.44	5.54	< 0.0001 (Sig.)
	Females	4.41	0.42	0.06			

Table 8: Comparison of Gender between RLR and RLL

	Gender	Mean	Std. Dev.	S.E. of Mean	Mean difference	z	*p*-value
RLR	Males	5.30	0.37	0.05	0.50	6.36	< 0.001 (Sig.)
	Females	4.80	0.41	0.06			
RLL	Males	5.28	0.34	0.05	0.46	6.27	< 0.001 (Sig.)
	Females	4.82	0.38	0.06			

Table 9. Comparison of Gender between FLR and FLL

	Gender	Mean	Std. Dev.	S.E. of Mean	Mean difference	z	*p*-value
FLR	Males	5.07	0.38	0.05	0.19	2.87	0.01 (Sig.)
	Females	4.88	0.29	0.04			
FLL	Males	5.07	0.37	0.05	0.18	2.73	0.01 (Sig.)
	Females	4.89	0.28	0.04			

Table 10: Comparison of Gender between IOD and EOD

	Gender	Mean	Std. Dev.	S.E. of Mean	Mean difference	z	*p*-value
IOD	Males	3.26	3.35	0.44	0.52	1.09	0.32 (Not Sig.)
	Females	2.74	0.22	0.03			
EOD	Males	11.21	0.66	0.09	0.20	1.52	0.13 (Not Sig.)
	Females	11.00	0.63	0.10			

The junction of this wall with the roof and floor of the orbit are smooth and rounded anteriorly but weakened for about half the distance by superior orbital fissure and for some two-thirds of the distance by the inferior orbital fissure Patnaik VVG et al., (2001)[3]

Length of Medial wall of orbit

In the study of Thanasil Huanmanop (2010)[4] the mean value of the medial wall of the orbit to the right side is 4.23 and to the left side is 4.18. In females it is 4.22 and 4.24 the *p* - value for males is > 0.05 and females is > 0.05. The same study to the right side showed 4.21 and left showed 4.23 the *p* - value is > 0.05. In the study of Mekala D (2012)[20] in males towards the right is 4.52 and left is 4.51 and in males is 4.53 and 4.22 in females. *p* - Value in male and female is < 0.001 and to the right and left is 0.695. Thanasil Huanmanop (2007)[4] have reported that there were no significant differences in the length of the medial wall of orbit betwen the genders and sides. In the present study, the length is significantly larger in males than females (Fig. 4 and Table 7).

In the present study, the mean value of medial wall of the orbit in males on right side is 4.83 and left side is 4.085 and the *p* - value is < 0.0001 which is significant. In females on the right it is 4.39 and left 4.41 and the *p* - value is < 0.0001 which is significant.

The differences could be due to racial or variations in the methodology or small sample size. Blow out fractures of the orbit occur frequently in the medial and inferior walls, the two thinnest area of the bony orbit. The medial wall is extremely fragile because of the presence of the adjacent ethmoid air cells and more anteriorly, the nasal cavity Patnaik VVG (20010)[3]. Medial wall trauma is strongly related with diplopia due to mechanical entrapment of medial rectus muscle B Dobrovat et al. (2011)[18]. The knowledge of the walls is most important during reconstruction surgeries.

Length of roof of orbit

In as side wise study of authors Jeremiah Munguti (2012)[5] the right side men value of the length of roof of orbit is 5.29 to the right and 5.31 on left side and the *p* - value is 0.927. Thanasil Huanmanop et al., (2007)[4] to the right side his vales were 4.45 and left side is 4.48 and the *p* - value is > 0.05. Thanasil Huanmanop et al., (2007)[4] in the gender wise study showed on the right side in males 4.52 and left side is 4.54. In females on the right side is 4.38 and left side is 4.43 and the *p* - value in males is < 0.05 and females > 0.05. In the study of Mekhala D (2012)[20] in males it is 5.15 and females it is 4.75 and the *p* - value is < 0.001. In the same study of Mekhala D (2012)[20] in the side wise towards the right side it is 5.24 and left side it is 4.23 and the *p* - value is 0.695.

In the present study, the mean value of the roof length of orbit in males on right side is 5.30 and left side is 5.28 and the *p* - value is < 0.001 which is significant. The roof length mean values in females to the right side it is 4.80 and left side is 4.82 and the *p* - value is < 0.001 which is significant (Fig. 3 and Table 8).

The roof of the orbit is very thin, but reinforced laterally by greater wing of Sphenoid and anteriorly by supra orbital margin. So, the fractures which involve frontal bone tend to pass towards the medial side. Chiarella S et al., (2009).[2]

Length of floor of orbit

In a gender wise study of the orbit Thanasil Huanmanop et al., (2007) 4 in males on the right

side the value was 4.69 on the right side and 4.65 on the left side and the *p* - value for the males is > 0.05 and in females to the right side it is 4.61 and left side is 4.53 and the *p* - value is > 0.05. In the study of Mekhala D (2012)[20] the values in males were 4.85 and in females 4.59 and the *p* - value is < 0.001. In the side wise study, Jeremiah Munguti (2012)[5] on the right it is 5.47 and left it is 5.48 and the *p* - value is 0.927. In the study of Thanasil Huanmanop et al., (2007)[4] on the right side it is 4.59 and 4.65 on the left side and the *p* - value is > 0.05. In the study of Mekhala D (2012)[20], in the right side it is 4.73 and left side is 4.72 and the *p* - value is 0.984.

In the present study, the floor length mean value in males on right is 5.07 and left side is 5.07 and the *p* - value is 0.01 which is significant. In females the right side is 4.88 and left side is 4.89 and the *p* - value is 0.001 which is significant (Fig. 3 and Table 9) Intra-orbital distance.

In the study of Jeremiah Munguti et al., (2012) the mean value of IOD in males is 1.891 and females is 1.826 and *p* - value is 0.331. In the study of Mekhala D (2012)[20] in males it is 2.66 and in females it is 2.44 and the *p* - value is > 0.001. In the present study, the IOD in females is 2.74 and males is 3.26 and *p* - *va*lue in both male and female is 0.32 which is not significant so, could not prepare statistic table (Fig. 5).

Extra-orbital distance

The present study showed the mean value of EOD as 11.21 in males and *p* - value being 0.13 which is not significant. In females it is 11.0 and the *p* – value is 0.13 which is also not significant. In the study of Jeremiah Munguti et al., (2012) in males EOD is 9.94 and females it is 9.64 and the *p* - value is < 0.001. In the study of Mekhala D (2012) the values in male was 10.97 and female was 10.33 and the *p* - value is < 0.001 (Fig. 5).

Conclusion

Normal values of orbital indices are vital measurements in the evaluation, and diagnosis of craniofacial syndromes and posttraumatic deformities, and knowledge of the normal values for a particular region or population can be used to treat abnormalities to produce the best esthetics and functional result. Accurate measurements of orbital dimensions are very important during plastic surgery, maxillofacial and neurosurgeries and also in the design of eye protective equipment. Also, these can be used during forensic and anthropological investigation of unknown individuals for determining gender, ethnicity, etc.

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Original Article

Indian Journal of Anatomy
Volume 9 Number 1, January – March 2020
DOI: http://dx.doi.org/10.21088/ija.2320.0022.9120.8

Case Based learning in Neuroanatomy in Small Groups for First MBBS Students

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How to cite this article:
Shaifaly Madan Rustagi, Suraj Prakash, Vandana Dave et al. Case Based learning in Neuroanatomy in Small Groups for First MBBS Students. Indian J Anat. 2020;9(1):55-60.

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Received 11.11.2019 | **Accepted** 07.12.2019

Abstract

Background: Competency Based Medical Education (CBME) requires that we shift from didactic lectures to small group teaching method and provide early clinical exposure to students to make them more competent and skilled Indian Medical Graduates. Case Based Learning (CBL) is an interactive, student-centered and instructor-led learning method that promotes learning for competence and provides opportunities for integrated teaching.

Aims and Objectives:

1. To introduce CBL as a Teaching–Learning Method for teaching Neuroanatomy.
2. To obtain feedback from students and faculty about their perception and experience of CBL as a teaching learning method.

Methodology:

1. Hundred (100) students were given five CBL sessions on neuroanatomy (ascending and descending tracts) by dividing them into five groups comprising of 20 students each.
2. Prior to CBL sessions the students were taught ascending and descending tracts in the same small groups in rotation by 5 faculty members.
3. After the CBL sessions in small groups the students were assessed on the basis of an MCQ test on their knowledge of ascending and descending tracts.
4. Post sessions anonymous Google Based Questionnaire was given to students and faculty to assess their perceptions of this teaching learning method.

Findings: Seventy-eight (78) students responded to the feedback questionnaires out of which 95% students agreed that CBL in small groups was an effective learning tool and 95% felt that clinical case scenarios helped in meaningful progression of learning.

Conclusions: CBL was perceived as an effective teaching and learning method. It was practically relevant and added the clinical aspect to the theoretical concepts. It induced the students to think and apply their knowledge to solve the clinical cases scenarios given.

Active learning was achieved as students interacted in small groups as compared to didactic lectures. Small groups discussions and interaction with faculty led to better understanding of the concepts.

Keywords: Small group teaching method; Case based learning; Neuroanatomy; Interactive teaching method; CBME.

Introduction

Competency Based Medical Education (CBME) requires that we shift from didactic lectures to small group teaching method and give early clinical exposure to students to make them more competent and skilled Indian Medical Graduates. Further, the new CBME emphasizes on a student - centered active approach to learning where the learners become responsible for their learning.

The ascending and descending tracts in neuroanatomy are a must know area for

undergraduate students. The anatomy, course, functions and applied anatomy of these tracts been classically taught as didactic lectures to first year MBBS students. They do not comprehend the clinical relevance of the tracts and levels of lesions when actual clinical cases are given.

CBL is an interactive, student-centred and instructor-led learning method. Clinical case scenarios are written as problems that provide the students with the history, relevant symptoms and signs and diagnostic investigations of a patient. By discussing a clinical case related to the topic taught, students evaluated their own understanding of the concept using a high order of cognition. This process encourages active learning and produces a more productive outcome.[1]

This type of learning has been shown to enhance clinical knowledge, improve teamwork, improve clinical skills, improve practical behavior, and improve patient outcomes. CBL advantages include providing relevance to the adult learner, allowing the teacher more input into the direction of learning, and inducing learning on a deeper level. CBL imparts relevance to medical and related curricula, is shown to tie theory to practice, and induce deeper learning. CBL is practical and efficient as a mode of teaching for adult learners.[2]

CBL is found to increase interactive learning for the student.[3] Integrated and case-based teaching was found to be useful in imparting knowledge and better retention of the gained knowledge was inferred statistically.[4] CBL (guided enquiry) was preferred over PBL by both students and faculty as a Teaching Learning Method.[5]

We conducted this educational project to introduce CBL as a teaching–Learning method for teaching neuroanatomy in small groups and to obtain feedback from students and faculty regarding their perception and experience CBL as a teaching learning method.

Materials and Methods

Our study was a cross-sectional observational study conducted on 100 students of First MBBS (2018–2019 batch) at Army College of Medical Sciences, Delhi. The duration of study was 5 months and for which permission was obtained from the Institutional Ethics committee.

The faculty and students were introduced and sensitized to the introduction of CBL in small groups as a teaching-learning tool. Google forms/ Questionnaire for faculty and students were prepared and validated with the help of faculty of Department of Anatomy and MEU of ACMS. After the sensitization of students, their email id and phone numbers were collected for posting of feedback forms.

Five important tracts of neuroanatomy (4 ascending and 1 descending) were selected and 5 clinical case scenarios based on their applied anatomy were drafted.

Hundred students of first MBBS were divided into 5 groups comprising of 20 students each. Five faculty members were assigned to teach one tract each.

Step I

(a) Each teacher taught 04 ascending + 01 descending tract in rotation to all 5 Groups. For e.g., spinothalamic tract was taught by one teacher to all 5 Groups in rotation (½ an hrs per group).

(b) After this a draw of lots was done of 5 cases (one per tract) and Each Group got a clinical case based on a tract.

Step II

All 5 Groups of 20 students were given relevant teaching/learning material of their clinical case and tract to read and discuss for next 48 hours.

Step III

(a) All students gathered in groups and discussed clinical cases with the respective anatomy faculty.

(b) Each Group presented their topic (by Group Leader) for 15 minutes each followed by 5 minutes of summarization by the faculty.

(c) All teams heard the cases of all groups and summarizations.

(d) A post session-Google Questionnaire for faculty and students on Effectiveness of CBL.

(e) MCQ Test on Tracts in Neuroanatomy.

The *Google Questionnaire on Students perception of CBL* had 4 sections:

a. *Section I* had eight close ended questions with 5 point Likert Scale response.

   Strongly disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree = 5.

b. *Section II* dealt with close ended questions on role of facilitator.

c. *Section III* was on effectiveness of orientation session.

d. *Section IV* dealt with suggestions to make CBL in small groups a more effective method.

The Faculty feedback was taken after the CBL sessions. *The Google Questionnaire for faculty perception of CBL had* ten closed-ended questions with 5-point Likert scale response.

Statistical analysis

The google forms inbuilt statistical analysis was used to analyze the responses. The response to close ended questions was expressed as percentage. Open ended questions were analyzed by thematic grouping of qualitative responses.

Results

Section I

Of the hundred students included in the study 78% participated in the analysis. 95% students agreed that CBL in small groups was an effective learning tool (Table 1). 92% students preferred this method to the traditional method of learning. 87.2% students thought that CBL in small groups helped in improving communication skills (Table 1). 95%

Table 1: Student Google Questionnaire responses of section I (n = 78)

S No	Question	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1.	Case Based Learning (CBL) in small groups was an effective learning tool for me	0	4 (5.1%)	0	22 (28.2%)	52 (66.7%)
2.	CBL in small groups was better than traditional method of learning	0	2 (2.6%)	4 (5.1%)	34 (43.6%)	38 (48.7%)
3.	CBL in small groups helped me in better understanding of anatomy of tracts	0	0	8 (10.2%)	23 (29.5%)	47 (60.2%)
4.	CBL sensitized me towards clinical case solving in neuroanatomy	0	0	2 (2.6%)	26 (33.3%)	50(64.1%)
5.	Clinical case scenarios helped in meaningful progression of learning	0	2 (2.6%)	2 (2.6%)	28 (35.9%)	46 (58.9%)
6.	CBL in small groups promotes peer discussions and peer communication	0	2 (2.6%)	7 (8.9%)	10 (12.8%)	59 (75.6%)
7.	CBL helps in improving communication skills	0	2 (2.6%)	8 (10.2%)	18 (23%)	50 (64.1%)

Table 2: Thematic Aggregation of Qualitative responses by students about CBL

Appreciation	No and presentation of cases	Time	Other advantages
It should be held at regular intervals	Adding more questions per case that everyone gets to present the answer.	Longer time required	Overall
Should be done on regular basis	Presentation of cases can be little different	Timing and coordination should be better	Apart from improving communication skills and increasing interest in clinical application, it will also be helpful in academic performance
Everything was perfect according to me	More clinical cases should be discussed	Audio video aids could be effective to better understand the topic	
More topics included under this method. Helps in practical application	More no of cases should be provided	There should be different difficulty level of cases so that we could compare how the disease progresses	Overall the CBL method of teaching is an excellent idea as it involves more from the student side and I think it improves our thinking ability about clinics
More equally important topics like abdomen and pelvis along with their clinical based questions should also be taught using this method	The number of cases should be more so, as the students think in more than a single direction for cases in order to understand the topic better	Although it was very effective and innovative but it was very time consuming too. (May be because it was held in 1st term) Its efficiency could have been increased by managing the time being taken by each group to solve a particular case. So, that student's solve it more seriously and quickly which will enhance their clinical outlook and ability to reach any clinical conclusion more quickly with preciseness. Otherwise we liked it	I found CBL is best for understanding neuroanatomy
	A Mike should be provided to the students so that, we can hear them clearly and this thing can be done in other subjects too		

Table 3: Faculty Google Questionnaire about perceptions of CBL (n = 5)

S No	Questions	Strongly disagree	Disagre	Neutral	Agree	Strongl Agree
1	CBL stimulates students' desire to learn	0	0	0	1	4
2	Students felt confident to apply theoretical knowledge of tracts to solve clinical cases	0	0		3	2
3	CBL is a good method to practice integration of knowledge and skills	0	0	0	1	4
4	CBL preparation requires a lot of effort	0	0	0	3	2
5	CBL is time consuming and hinders the normal speed of the class	0	0	1	3	1
6	It is feasible to conduct CBL sessions	0	0	0	2	3
7	CBL helps towards SDL (Self-directed learning) in students	0	0	0	1	4
8	I am satisfied with the CBL approach to teaching	0	0	0	2	3
9	Other topics in Anatomy should also be taught by CBL	0	0	0	1	4
10	CBL be used as a TLM for future batches	0	0	0	3	2

students were of the opinion that clinical case scenarios helped in meaningful progression of learning (Table 1). 90% students agreed that this method helped them in better understanding of anatomy of tracts (Table 1). 100% students felt that group discussion was useful in clinical case solving.

Section II and III

Ninety-seven percent students felt that the role of facilitator/faculty was important. 100% students felt that the faculty understood their queries and answered them effectively. 74% students found the orientation/sensitization before the CBL session effective. 95% liked the method so much that they wanted to be taught other topics in Anatomy by CBL method.

Section IV

Suggestions by students to make CBL in small groups a more effective method are given in (Table 2).

In the multiple choice based questionnaire, which followed the CBL session, the students showed satisfactory response. 76% of the students could answer all the questions correctly.

Data from faculty feedback questionnaires also favored CBL as a teaching method. Five faculty members participated in the CBL sessions and all agreed that CBL is a good method to practice integration of knowledge and skills and promoted self-directed learning (Table 3). Four faculty members found it to be time consuming and hindered the normal speed of the class (Table 3). All faculty found this as a feasible TLM and wanted to teach other topics in anatomy by same method (Table 3).

Discussion

The new curriculum based on CBME requires that interactive methods of teaching should be employed to make it student centric and promote self-directed learning. CBL is a form of learning which imparts practical relevance to theoretical concepts and develops a deep level of understanding of the subject and promotes analytical thinking.

Kassebaum[6], Singhal[7], Tayem Yi[8] and Joshi[9] have found CBL an interesting and useful learning method for teaching undergraduates in Dentistry, Microbiology and Pharmacology & Biochemistry respectively. Their findings remonstrate that CBL was embraced by majority of students. The students' clinical reasoning and logical thinking were improved. Our study also, demonstrates that 95% students found that clinical case scenarios helped in meaningful progression of learning and 90% students agreed that this method helped them in better understanding of anatomy of tracts.

Tayem Yi found that 82% found CBL an effective tool in teaching pharmacology and 80% students felt that CBL improved their collaborative skills and ability to work within a team (79%). Our results are in concordance with 95% students agreeing that CBL in small groups was an effective learning tool and 87.2% students thought that CBL in small groups helped in improving communication skills.

On the contrary, Nordquist et al.[10] observed

that implementation of CBL was not satisfactory due to inadequate implementation process and devised a checklist for its implementation in a surgical curriculum.

Singhal divided his class of 100 students into two groups and compared between didactic lectures and CBL sessions as methods of teaching and then did a crossover. A post-test MCQ questions was conducted immediately and after 6 weeks to see effectiveness of CBL and the post 6 week test favored CBL. We did not do a crossover and all 100 students were offered the CBL module.

Massonetto et al.[11] also introduced small group discussion of cases in an Obstetrics and Gyne teaching programme of 4th year undergraduates and the group taught by the new method gave higher rating of clarity of concepts. In our study group also, 90% students agreed that this method helped them in better understanding of anatomy of tracts.

Ghosh S[12] have tried a combined approach of teaching physiology by adding CBL tutorials to didactic lectures and found that 84% students preferred this combined approach.

Hasamnis et al.[13] used CBL sessions for clinical pharmacology to enhance learning and used the DREEM (Dundee Ready Education Environment Measure). Questionnaire of 50 items to assess case based learning on clinical pharmacology. However, we used pre-validated Google Questionnaires for analyzing our study.

Dubey et al.[14] observed that of the Eighty-one students who participated in CBL sessions in pathology 95.06% expressed a desire for more such sessions in all topics of pathology. These results were similar to ours where 95% students liked the method so much that they wanted to be taught other topics in Anatomy by CBL method.

It is evident from students' and teachers' questionnaires that CBL helps in internalization of concepts and stimulates the desire to learn. The students feel confident to apply the theoretical knowledge of anatomy imparted to solve clinical cases. Thus, CBL imparts practical relevance to theoretical knowledge.

Our faculty admitted that the whole experience was quite interesting. The faculty received this method with enthusiasm and gave constructive suggestions for drafting case scenarios, validation of google questionnaires and conduct of sessions.

Students found the methods a welcome change from the mundane lectures and felt it should have been initiated earlier in the academic year to enhance their interest in the subject.

Conclusion

CBL was perceived as an effective method of teaching and learning which was practically relevant and added the clinical aspect to the theoretical basis. It induced the students to think and apply their knowledge to solve the clinical cases scenarios given.

Active learning was achieved as students interacted in small groups as compared to didactic lectures. Small group discussions and interaction with faculty led to better understanding of the concepts. CBL though requires more efforts both from faculty and students but the concept and application were found to be feasible and relevant to the new curriculum.

Limitations

The students were busy in preparations for their prelims exams and so 22% did not participate in the study. Paper case scenarios were given. These could have could have been designed more elaborately with audio and visual aids.

Acknowledgements

I take this opportunity to wholeheartedly thank my faculty who supported me in planning and execution of the project. I also thank the students who took part in the project enthusiastically.

Conflict of Interest: None

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Original Article

Indian Journal of Anatomy
Volume 9 Number 1, January – March 2020
DOI: http://dx.doi.org/10.21088/ija.2320.0022.9120.9

Correlation of Foot Dimensions with Body Mass Index: A Study in Young Population of Central India

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How to cite this article:

Sundip Hemant Charmode, Dinanath Keshavbhat Pujari, Kadlimatti Huchchesha Shivappa et al. Correlation of Foot Dimensions with Body Mass Index: A Study in Young Population of Central India. Indian J Anat. 2020;9(1):61-68.

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Received 02.11.2019 | **Accepted** 21.12.2019

Abstract

Background and Objectives: Identifying a human individual through scientific means is a key component of forensic investigation. Anatomists, forensic scientists, anthropologists, physicians, podiatrists, and numerous other groups all over the world have studied human foot in different ways. In developing countries like India, people tend to walk barefooted for various reasons like spiritual thoughts, religious reasons, during socio-cultural events, climatic condition, in rural areas and due to socio-economic reasons. This increases the importance of foot impression for forensic investigation. Human foot morphology is greatly influenced by the combined effects of heredity and living style. The present study was proposed to correlate the foot dimensions with body mass index of an individual.

Methodology: This cross-sectional study was conducted amongst 1000 participants (500 male and 500 female) of ESIC Institute Gulbarga over a period of 14 months. Foot length, foot breadth along with stature and weight was measured.

Results: Mean stature was 161.88. Mean weight (male) was 58.21 kg and female was 50.14 kg. No statistically significant correlation was observed between BMI and Foot length of both sides; whereas BMI and foot breadth on both sides had significant correlation. Linear regression equation was calculated.

Interpretation and Conclusion: Statistically significant correlation wasn't observed between BMI and Foot length of both sides; whereas BMI and foot breadth on both sides observed statistically significant correlation, $r = 0.124$ (right), $r = 0.125$ (left). This data would be useful for forensic investigations for the purpose of inclusion, exclusion of a suspect.

Keywords: Correlation; Foot length; Foot breadth; Body mass index; Linear regression Coefficient; Crime; Bare foot.

Introduction

Identifying a human individual through scientific means is a key component of forensic investigation. Every human body part is unique in itself. There is a relationship between each part of the body and the whole body.[1] Anatomists, forensic scientists, anthropologists, physicians, podiatrists, and numerous other groups all over the world have studied human foot in various ways.[2] Foot-impression is one of the commonest physical evidence foundin crime scenes that can help to link the crime and criminal.

In developing countries like India, people tend to walk barefooted for various reasons like spiritual thoughts, religious reasons, during socio-cultural events, climatic condition, in rural areas

and due to socio-economic reasons. This increases the importance of foot impression for forensic investigations. Human foot morphology is greatly influenced by the combined effects of heredity and living style determinants that make the size and shape data of the feet/footprints unique to establish a human identity.[1] Foot-outline is defined as the line tracing around the outer margins of the fleshed foot. Both footprints and foot-outlines can provide promising information to establish the identity of suspect or perpetrator.[3]

Human height and weight has also been studied in many forensic and medical domains. Foot-impression is likely to correlate with weight as feet bear body weight. The utility of foot-impression as an indicator of body mass has been less explored.[4] In forensic perspective, the researchers have conducted population standard body weight determination from footprint for use in crime scene investigation.[5–8] But unfortunately, the literature review shows feeble number of studies recorded correlating foot-outline with living human body mass index.[9,10] The present study, aims to correlate the body mass index and foot-outline measurements in young population of Central India.

Aim

To study the relationship between foot dimensions with Body Mass Index.

Materials and Methods

Study design: Descriptive cross sectional study.

Setting: Anthropometric section of Department of Anatomy, ESIC Medical College and Hospital, Gulbarga, Karnataka.

Duration of study: 14 months; From 31 October 2017 to 31 December 2018.

Sample size: 1000 participants which includes Medical, Dental and Nursing students aged between 18 and 21 years of age in ESIC Institute, Gulbarga.

Sampling technique

Inclusion criteria

Medical, Dental and Nursing students aged between 18 and 21 years in ESIC Medical College, Gulbarga.

Exclusion criteria

Students of NRI quota and students those with poorly defined wrist creases, deformities of vertebral column and limbs, contractures, missing limbs, history of trauma to hand and foot, with features suggestive of dysmorphic syndromes, chronic illness, hormonal therapy were excluded from the study.[11,12]

Sample selection

Simple random sampling method[13] as we selected 1000 participants out of total 3000 Medical, Dental and Nursing students in our institute satisfying the inclusion criteria. As subjects belonged to 1st to 3rd year, they were easily accessible and also represented the young adult age group.

Data collection procedure

Foot Length

Each subject will stand on a Calibrated Foot Board with his/her back against the wall in such a manner that the posterior most point of the heel will gently touch the wall. A vertical stop was placed against the anterior most point of the foot. The distance between the posterior most point of the heel and the anterior most point of the foot was measured as the foot length[14] (Fig 3).

Foot Breadth

It will be measured as distance between Metatarsal tibiale (point projecting most medially on the head of the 1st metatarsal bone) and Metatarsal Fibulare (point projecting most laterally on the head of the 5th metatarsal bone)[15] (Fig 2).

Height

Standing height will be measured to the nearest centimeters (cm) using a Stadiometer with subject standing erect on a horizontal resting plane bare footed having the palms of the hands turned in ward and the finger pointing downwards. The height will be measured from the sole of the feet to the vertex of the head as recommended by International Biological Program[16] (Fig 1).

Body weight

It will be taken using the Mechanical Weighing Balance to the nearest kg according to the standard

procedures A. Ibegbu, David et al.[16] (2013).[16]

Body Mass Index

It will be calculated by dividing weight by height squared (weight/height squared (kg/mt^2)) AIbegbu, David et al.[16] (2013).

Data collection tools

Vernier slide calipers, calibrated foot board, stadiometer, regular weight machine, questionnaire for collection of personal details, academic scores, lead pencils, stationary etc.

Data collected were tabulated, graphically represented and statistically analyzed.

Results

Table 1: Correlation of Foot length and Body Mass Index and its graphical representation as shown in Fig 4. There was no statistically significant

Fig. 1: Measurement of stature

Fig. 2: Measurement of foot breadth

Fig. 3: Measurement of foot length

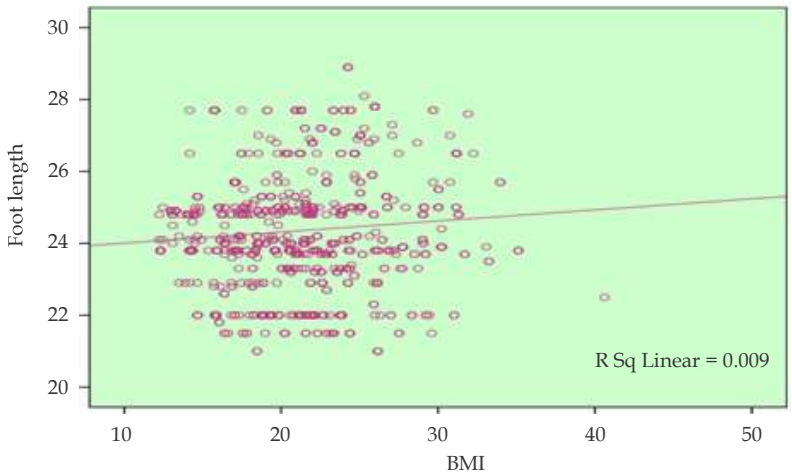

Fig. 4: Graphical representation of foot length and body mass index

correlation between BMI and Foot length of right and left ($p > 0.05$), so, linear regression equation couldn't be derived.

Table 2: Correlation of Foot breadth and Body Mass Index and its graphical representation as shown in Fig 5. There was a statistically significant correlation between BMI and Foot breadth of right and left ($p < 0.01$). Study reveals that, foot breadth of both sides was significantly more in those who had higher body mass index.

Table 3: Gender wise comparison of parameters and its graphical representation as shown in Fig 6. There was statistically very highly significant difference in Foot length on right and left, Foot breadth right and left, Height and weight among males and females ($p < 0.001$). The Foot length right and left, Foot breadth right and left, Height and weight were significantly more in males as

Table 1: Correlation of Foot length and Body Mass Index

Variables	Minimum	Maximum	Range	Mean	SD	n	Correlation r	*p* - value
Body Mass Index	12.22	40.61	28.39	20.97	4.66	1000	–	–
Foot length right	21.0	28.9	7.9	24.34	1.54	1000	r = 0.073	$p > 0.05$ NS
Foot length left	21.5	29.0	7.5	24.32	1.50	1000	r = 0.024	$p > 0.05$ NS

Table 2: Correlation of Foot breadth and Body Mass Index

Variables	Minimum	Maximum	Range	Mean	SD	n	Correlation r	*p* - value
Body Mass Index	12.22	40.61	28.39	20.97	4.66	1000	–	–
Foot breadth right	7.5	10.9	3.4	8.95	0.78	1000	r = 0.124	$p < 0.05$ S
Foot breadth left	7.7	11.5	3.8	8.96	0.68	1000	r = 0.115	$p < 0.05$ S
Linear Regression Equation	BMI = 19.306 + 0.168 (Foot breadth right)							
Linear Regression Equation	BMI = 17.214 + 0382 (Foot breadth left)							

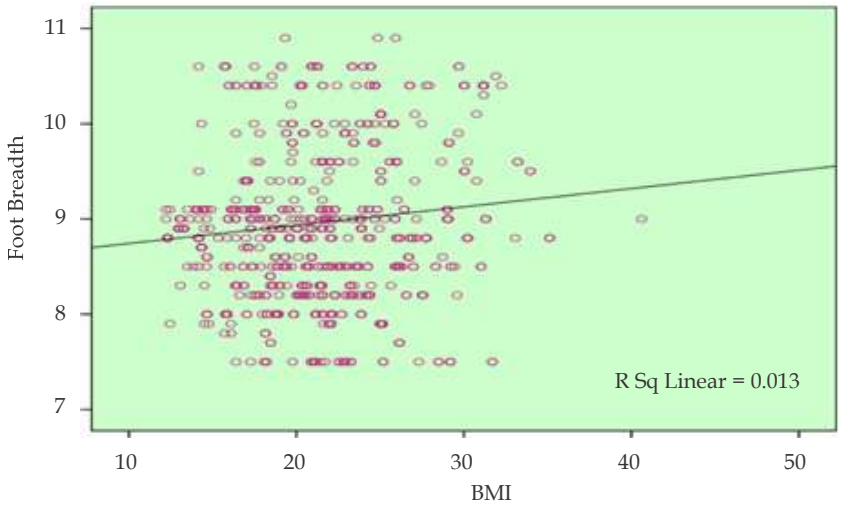

Fig. 5: Graphical representation of foot breadth and body mass index

Table 3: Gender wise comparison of parameters

Variables	Male (n = 500) Mean ± SD	Female (n = 500) Mean ± SD	Z test value	*p* - value and significance
Foot length right	25.18 ± 1.32	23.39 ± 1.19	Z = 30.07	p<0.001, VHS
Foot length left	25.31 ± 1.16	23.19 ± 0.96	Z = 31.19	p<0.001, VHS
Foot breadth right	9.39 ± 0.71	8.45 ± 0.52	Z = 22.97	p<0.001, VHS
Foot breadth left	9.35 ± 0.59	8.52 ± 0.47	Z = 23.21	p<0.001, VHS
Height	169.28 ± 11.75	153.42 ± 9.75	Z = 22.26	p<0.001, VHS
Weight	58.21 ± 11.91	50.14 ± 9.85	Z = 11.21	p<0.001, VHS
BMI	20.58 ± 4.94	21.41 ± 4.27	Z = 2.53	p<0.05, S

NS= not significant, S=significant, HS=highly significant, VHS=very highly significant

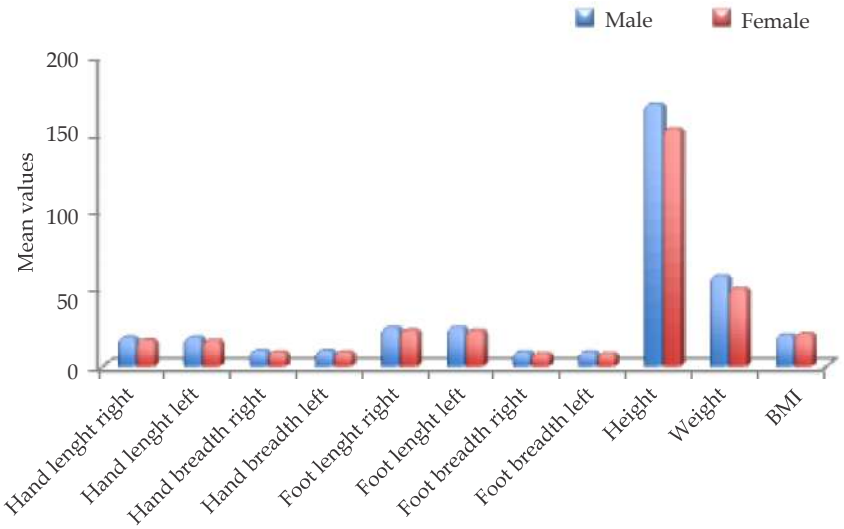

Fig. 6: Graphical representation of gender wise comparison of parameters

Table 4: Comparison of present study with previous studies

Sl No	Study/Author/Year	Sample size	Parameters studied	Observations				
				Mean height M/F	Mean foot length		Mean foot breadth	
					Right M/F	Left M/F	Right M/F	Left M/F
1	Anitha Oommen et al.[14](2005)	100	HL, FL	NA	26.21/23.75	26.0/23.68	NM	NM
2	B Danborno, AElukpo et al.[25] (2007)	400	H, HL, HB, FL, FB	173.7/160.0	28.39/24.52	26.42/24.70	9.02/8.23	9.09/8.11
3	Patel SM, Shah GV et al.[24] 2007	502	H, FL	170.9/156.14	Male- 24.44	Female- 2.34	NM	NM
4	Chikhalkar BG et al.[23] (2008)	300	H, W, FAL, HL, HB, FL, FB	167.26	24.008 with SD 1.420		8.895 with SD 0.703	
5	Krishna K, Kanchan T et al.[28] (2011)	246	HL, HB, FL, FB	NA	NA	NA	NA	NA
6	Patel PN, Tanna JA et al.[21] (2012)	273	H, FL, FB, HL, HB, AS	164.59	24.178 with SD 1.809		9.28 with SD 0.865	
7	A. Ibegbu, David et al.[16] (2013)	600 children	H, HL	NC	NC	NC	NC	NC
8	Prakash M Mohite et al.[22] (2015)	230	H, HL, HB, FL	165.02	Male- 25.86, Female- 22.67		NM	NM
9	Uhrova P, Benus R et al.[29] (2015) -Slovakadults	250	H, HL, HB, FL, FB	NA	NA	NA	NA	NA
10	Rati Tandon et al.[15](2016)	497	H, HL, HB, FL, FB, DL	172.7/157.1	Male - 26.22, Female - 23.35		Male- 9.95, Female - 8.89	
11	Kim W, Kim YM et al.[30] (2018)	5195	H, HL, HB, FL, FB	NM	NA	NA	NA	NA
12	Present study (2018–19)	1000	H, FL, FB	161.88	25.18/23.39	25.31/23.19	9.39/8.45	9.35/8.52

H= Height, HL = Hand length, HB = Hand breadth, FL = Foot length, FB = Foot breadth, PL = Palm length, DL = Digit/finger length, AS-Arm span, FAL = Forearm length, NM = Not measured NC = Not comparable, NA = Not available.

compare females, whereas BMI was significantly more in females as compare to males.

Table 4: Comparison of present study with previous studies

Fig. 1: Measurement of Height (cm) from the sole of the feet to the vertex of the head using Stadiometer

Fig. 2: Measured as distance between Metatarsal

tibiale (point projecting most medially on the head of the 1st metatarsal bone) and Metatarsal Fibulare (point projecting most laterally on the head of the 5th metatarsal bone).

Fig. 3: Foot length measured as the distance between the posterior most point of the heel and the anterior most point of the foot was measured as the foot length.

Fig. 4: Graphical representation of correlation between Foot length and BMI

Fig. 5: Graphical representation of correlation between Foot breadth and BMI

Fig. 6: Multiple bar diagram represents gender wise comparison of variables

Discussion

The study participants were of age group between 18 and 21 years, as the participants were students from 1st to 3rd medical, dental, nursing and ayurvedic streams of ESIC Institute. The age of 18 years has been accepted as adult and foot grows to adult size by age of 16 years.[17-20]

In present study, human stature ranged from 135.2 cm to 195.2 cm mean stature was 161.88 cm with SD of 13.45. These findings correspond closely with studies done on Indian population like that of Patel et al.[21](164.59 cm) and Mohite et al.[22] (165.02 cm) and Chikhalkar et al.[23] (167.2 cm), shown in (Table 4). Mean human weight was observed as 58.21 kg in male and 50.14 kg in females. Mean foot length on right side was 25.18 cm in male, 23.39 cm in female. Mean foot length on left side was 25.31 cm in male, 23.19 cm in female, (Table 3) and Fig 6. These findings correspond with studies of Anitha Oommen et al.[14], Rati Tandon et al.[15], Patel SM, Shah GV et al.[24] 2007, Prakash M Mohite et al.[22] (2015), shown in (Table 4). Foot breadth on right side was 9.39 cm in male, 8.45 cm in female. Foot breadth on left side was 9.35 cm in male, 8.52 cm in female, (Table 3) and Fig 6. These findings correspond with studies of B Danborno, AElukpo et al.[25] (2007), Rati Tandon et al.[15], Patel PN, Tanna JA et al.[21] (2012), Chikhalkar BG et al.[23] (2008), shown in (Table 4). Gender wise correlation revealed statistically highly significant difference between males and females ($p < 0.001$) in foot dimensions on both sides and also in height, (Table 3, Fig. 6) and were higher in males as compared to females. These findings matched with studies of Chikhalkar BG, Mangaonkar AA et al.[23] (2008), Kavyashree AN et al.[26] (2015) and Prakash M Mohite et al.[22] (2015), shown in (Table 4).

Body mass index was calculated from stature and weight as weight (kg)/height (mt^2) as 20.58 in male and 21.41 in female. BMI was observed significantly more in female as compared to male,(Table 3 and Fig 6). Based on foot dimensions and living body weight measurements, regression equations have been developed. Regression is a statistical tool, with the help of which we can estimate the unknown values of one variable from known values of another variable.[27] In present study, linear regression coefficient couldn't be calculated between BMI and foot length, but regression coefficient equation was successfully calculated between BMI and foot breadth as BMI = 19.306 + 0.168 *Foot breadth right and BMI = 17.214 + 0382 *Foot breadth left.

There was a statistically significant correlation between BMI and Foot breadth of right side, r = 0.124 and left side, r = 0.115. Whereas, statistically significant correlation between BMI and foot length couldn't be observed neither on right side, $r = 0.073$, nor on left side, $r = 0.024$. That proved that, foot breadth of both sides was significantly more in those who had higher body mass index.

Conclusion

1. Highly statistically significant difference was observed in mean foot length and breadth on both sides in both sexes.
2. Body mass index was observed significantly higher in females as compared to males.
3. Statistically significant correlation was observed between body mass index and foot breadth.
4. Statistically non-significant correlation was observed between body mass index and foot length.
5. The linear regression formula derived can be used for population between 17 and 20 years but it might be of limited use for children and older people.
6. Equation derived from present study can be used to estimate body mass index from foot width and *vice versa* among the Central Indian population.
7. It would be unwise to use the same equations for body mass index estimation for different Indian populations.
8. The data collected should be useful for forensic investigations in cases of crime in Kalaburagiregion.

Limitations

1. In the present study, age range of only 17 to 20 years was considered.
2. Only healthy individuals were included in the study. Hence, the data may not be applicable students those with deformities of foot, vertebral column and limbs, contractures, those with h/o of trauma to foot, those with features suggestive of dysmorphic disorder, pregnant females.
3. Applicability of anthropometric measurements in living and deceased individuals may practically differ.
4. The present study is a preliminary one and would be followed up by other studies to address the above limitations.

Compliance with ethical standards

1. *Conflict of interest*: All authors hereby disclose that there is no financial and personal relationships with other people or organizations that could inappropriately influence (bias) this work. A document declaring this has been attached.
2. *Animal subjects research:* The present study had no involvementof animal subjects in any form or manner.
3. *Human subjects research*:
    a. The present study was conducted on human subjects. The present studyhas received the approval of Institutional Ethical Committee of ESIC Medical College, Gulbarga. IEC comes under the Rajiv Gandhi University of Health Sciences, Bangalore.
    b. The present study, being approved by the Institutional Ethics Committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and all subsequent revisions.
    c. Informed consent was taken from each and every human participant and the records have been kept with Anthropometry section of Department of Anatomy of ESIC MC, Gulbarga.
    d. The scan copy of Ethical Committee Approval letter has been attached along with the manuscript.

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Original Article

Indian Journal of Anatomy
Volume 9 Number 1, January – March 2020
DOI: http://dx.doi.org/10.21088/ija.2320.0022.9120.10

A Study of Vermiform Appendix and Its Various Position in Adults

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How to cite this article:

Syed Nazeer Ahmed, Mohammed Khaleel Ahmed. A Study of Vermiform Appendix and Its Various Position in Adults. Indian J Anat. 2020;9(1):69-72.

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Received 09.11.2019 | **Accepted** 02.12.2019

Abstract

Introduction: Aim of our present study was to observe variations of position of vermiform appendix in local population primarily in adults. Totally 50 adult cadavers were dissected during last 5 years for under graduates in the Department of Anatomy, Khaja Banda Nawaz institute of medical sciences, Kalaburagi, Karnataka. Length and breadth, extent of mesoappendix, position of appendix and arterial supply of appendix were studied. In our study most common position was retrocecal, least common was preileal and postileal position. Retrocecal position was seen in 66%, pelvic position was in 26%, subcecal in 4%, preileal 2%, postileal 2% and paracecal position was not observed in any cadaver. In males average length of appendix was 77.20 mm, breadth was 12.42 mm, where as in females length was 69.33 mm, breadth was 10.80 mm. In 34% cases mesoappendix extended up till tip and in 66% cases mesoappendix failed to reach the tip of appendix. In 70% cases single appendicular artery was observed and in 30% cases two appendicular arteries were present. Morphological and positional variations of vermiform appendix is a very important information, to be remembered before planning orduring any surgical procedures to prevent postoperative complications.

Materials and Methods: The present study is of 50 adult vermiform appendix obtained from Department of Anatomy, Khaja Banda Nawaz Institute Medical Sciences, Kalaburagi, Karnataka. The vermiform appendix was observed in cadavers after routine dissection.

Results: In 35 adult male specimens the length of appendix ranged from 30 mm–120 mm with an average being 77.2 mm. Breadth of the appendix at the base ranged from 7 mm–22 mm with an average being 12.42 mm. Mesoappendix in 17 adults specimens (34%) extended upto the tip and in 33 adults specimens (66%) the mesoappendix failed to reach the tip In 35 (70%), adult cadavers single appendicular artery was observed and in 15 (30%), cadavers double appendicular arteries were observed.

Conclusion: High incidence of retrocecal position and incomplete mesoappendix in our population explains that - diagnosis of acute appendicitis is difficult. A clear cut picture of size, shape and position of appendix is very important to diagnose, based on only clinical presentation of a patient with appendicitis. The area of tenderness in appendicitis will depend upon the position of the appendix, length, part of the appendix with inflammation, direction of the appendix.

Keywords: Retrocecal; Preileal; Postileal; Pelvic; Mesoappendix.

Introduction

As per the universally accepted standard text book, Grey's text book of anatomy, vermiform appendix is worm like tubular, narrowest part of large intestine at structure arising from posteromedial wall of cecum just below the ileocecal junction. Vermiform appendix is present mainly in humans and few arthropod apes. Mesoappendixis a peritoneal fold which suspends the appendix and contains blood

vessels, lymphatics and nerves. Appendix is the only part of large intestine which is devoid of taenia coli, sacculations and appendices epiploicae. Length of vermiform appendix is 2–20 cm, with average being 9 cm. The average diameter at the base is 6 mm. The vermiform appendix is described ashaving 3 parts: they are base, body and tip. According to Wakeley[1], Sandhyasathyavan[2] retrocolic and retrocecal position of appendix were seen in 65.28%, 70% of cases respectively. While Delic J[3], Ravi Kumar[4] reported retrocecal position in 38% and 35.8% of and in present study with 26%. This may be due to the increase in length, thickness and function of the appendix due to the presence of extensive mesoappendix.

Materials and Methods

The present study is of 50 adult vermiform appendix obtained from Department of Anatomy, Khaja Banda Nawaz institute of medical sciences, Kalaburagi, Karnataka. The vermiform Appendix was observed in cadavers after routine dissection by the medical student. The length, width, mesoappendix, position of appendix, blood supply of appendix were observed. We observed a few variations which were more regional and such information is essential for all Surgeons. Instruments required are – scale (plastic), divider and other dissection instruments (Fig. 1).

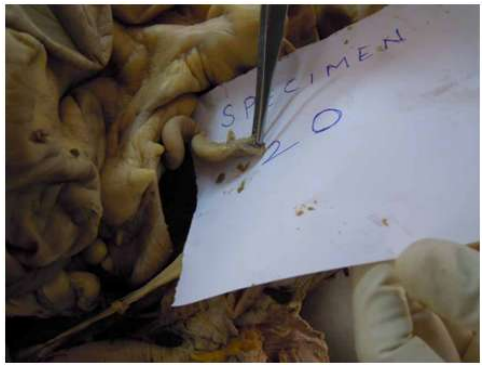

Fig. 1: *In situ*: Vermiform appendix
(LA = Length of appendix, BA = Breadth of appendix)

Results

Length and Breadth of Appendix

In 35 adult male specimens the length of appendix ranged from 30 mm–120 mm with an average being 77.2 mm. breadth of the appendix at the base ranged from 7mm–22 mm with an average being 12.42 mm (Table 1).

Mesoappendix

Mesoappendix in 17 adults specimens (34%) extended up to the tip and in 33 adults specimens (66%) the mesoappendix failed to reach the tip (Table 2).

Table 1: Showing measurements of vermiform appendix in adults

Adult male specimen no	Length in mm	Breadth in mm	Adult female specimen no	Length in mm	Breadth in mm
Total: 35 (70%)	Range: 30 mm–120 mm Average: 77.2 mm	Range: 7 mm–22 mm Average: 12.42 mm	Total No 15 (30%)	Range: 30 mm–100 mm Average: 69.33 mm	Range: 5 mm–20 mm Average; 10.8 mm

Table 2: Showing mesoappendix in adults

Adult specimen No.	Meso appendix extends up to tip	Meso appendix failed to reach the tip
Total No 50	17 (34%)	33 (66%)

Table 3: Showing positions of vermiform appendix

Adult specimens	Preileal	Postileal	Pelvic	Retro Cecal	Sub Cecal	Para Cecal
50	1	1	13	33	2	Nil
Percentage	2	2	26	66	4	Nil

Table 4: Showing arterial supply of appendix

No of cadavers	One appendicular artery	Double appendicular artery
50	35	15
Percentage	70%	30%

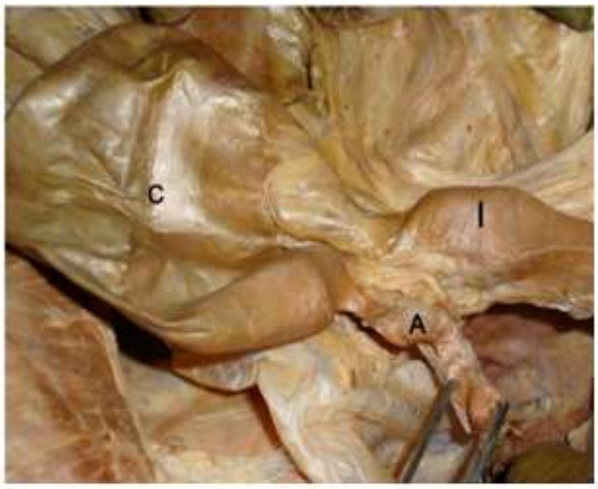

Fig. 2: Vermiform appendix in preileal position

Fig. 5: Vermiform appendix in retrececal position

Fig. 3: Vermiform appendix in postileal position

Fig. 6: Showing single appendicular artery

Fig. 4: Vermiform appendix in subcecal position

Fig. 7: Showing double appendicular artery

Discussion

In our present study, retrocecal position was observed in 66% of cases respectively. Retrocecal position was the common in our study and least common position was preileal and postileal position. Paracecal position was not observed in any case. The percentage of pelvic position seems to be high in north Karnataka. In our study, the length of the appendix was longer in Males than Females. Length of appendix in adult males was 9.2 cm and in adult females was 9.12 cm but average length was 7.72 cm.[5] Breadth of the appendix was 5 mm and 6.7 mm respectively. But in present study, breadth was in the range of 6–12 mm. The increased thickness of appendix in our local population may be related to their dietary habits.[6,7] Observed one appendicular artery in 39.8% & 39% of cases respectively. In our present study, one appendicular artery was present in 70% of cases and 2 arteries were observed in 30% of cases.[8–10] As per Datta AK, described the positions as subcecal, paracolic, retrocecal, retrocolic, splenic, promonteric, pelvic and miclinguinal.[11]

The meso appendix is a triangular peritoneal fold, enclosing the appendicular artery and appendix. This extends to a variable length. As per AK Datta[11] and Keith L More.[13] The mesoappendix is extending upto the tip of the appendix, whereas, as per Hollinshead[12] and Last the mesoappendix extends to a variable length.

Conclusion

The relations, measurements, positions and arterial supply are studied by gross dissection in 50 specimens (50 adults) from the population of North Karnataka, Kalaburagi.

- It is observed that the relations of the appendix are same in all specimens, irrespective of adults.
- In adult males the length of the appendix varied from 4.5 cms to 5.5 cms and in the females from 4.5 cms to 6 cms. 4.5 cms to 5.5 cms and in the females from 4.5 cms to 6 cms longer than in males in adults.
- Retrocecal positions are more common, being 52% in adults.
- The extent of the mesoappendix is variable and in the present study both complete and incomplete types are observed.
- In all the specimens, the lumen of appendix is not obliterated.
- High incidence of Retrocecal position and incomplete mesoappendix in our population explains that diagnosis of acute appendicitis is difficult.

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Original Article

Indian Journal of Anatomy
Volume 9 Number 1, January – March 2020
DOI: http://dx.doi.org/10.21088/ija.2320.0022.9120.11

Variations of Coronary Venous Anatomy with Implications for Cardiac Interventions

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How to cite this article:

Vandana Dave, Simmi Mehra, Ram Prakash Busar, et al. Variations of Coronary Venous Anatomy with Implications for Cardiac Interventions. Indian J Anat. 2020;9(1):73-78.

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Received 25.10.2019 | **Accepted** 28.11.2019

Abstract

Introduction: The Coronary veins are used as a conduit in various invasive cardiological procedures for arrhythmias and heart failure. The present study aims to study variations in anatomy of coronary sinus and its tributaries.

Materials and Methods: The study was conducted on 110 formalin fixed cadaveric hearts. The coronary sinus was observed for its length, formation, tributaries, Thebesian valve and Vieussens valve. The transverse and craniocaudal diameter of coronary sinus ostium were measured.

Results: The Coronary Sinus (CS) was classified into five types according to the formation by joining of tributaries. Type I CS was most common and observed in 52 (47.3%) specimens, which was formed by joining of great cardiac vein (GCV) and Oblique vein of left atrium (OBV). The mean length of CS was found as 26.09 ± 9.25 mm with range of 10.52 – 49.02 mm. In the first four types of CS, Type III CS presented maximum length of 29.94 ± 9.29 mm. The mean transverse and mean craniocaudal diameter of CSO were observed as 8.26 ± 3.13 mm and 10.18 ± 4.30 mm respectively. The Vieussens valve and Thebesian valve were present in 59 (53.63%) and 91 (82.72%) heart specimens. GCV and middle cardiac vein were present in all specimens with no variation in their course and drainage.

Conclusion: Knowledge of variations in the CS and its tributaries are helpful in biventricular pacing and various invasive cardiac procedures.

Keywords: Coronary sinus; Coronary sinus ostium; Thebesian valve; Vieussens valve.

Introduction

The coronary venous system has become more important with the recent advances in the electrophysiology and invasive cardiac procedures. The coronary sinus is clinically important through its role in providing access for different cardiac procedures like mapping and ablation of atrioventricular accessory pathways, the retrograde perfusion of thrombolysis[1,2], bypass coronary artery stenosis[3], and delivery of stem cells to infarcted myocardium.[4] Transvenous implantation of a pacing lead in an appropriate coronary vein on the left ventricle is done through the coronary sinus.[5,6] Hence, knowledge of the normal anatomy and variations of coronary venous system is imperative for successful outcome of invasive cardiac surgeries.

Coronary Sinus (CS) is the largest vein of heart. The CS lies in the posterior part of atrioventricular groove and has a length of about 2–3 cm. It drains most of the venous return of heart and opens into the right atrium. The Coronary Sinus Ostium (CSO) is covered by an endocardial fold known as Thebesian Valve (TV). CS receives major tributaries of heart. These are great cardiac vein (GCV), oblique vein of left atrium (OBV), posterior vein of left ventricle

(PVL), middle cardiac vein (MCV) and small cardiac vein (SMV).[7] The valve present at the termination of GCV is known as Vieussens valve (Vv).

The studies on coronary venous system are scarce than the coronary arterial system as coronary venous system has not been given much importance in comparison to the coronary arteries. CS is used for retro perfusion in patients in whom the coronary arterial system is not acquiescent for revascularization. Variations in the coronary venous system are common cause of difficulty in accessing the suitable tributary for the biventricular lead placement.[8] Knowledge of the variations of coronary veins is helpful for the selection of patient suitable for invasive cardiac procedure and to avoid complications which can improve the treatment outcome. Therefore, the present study was aimed to study the normal anatomy and variations of coronary venous system.

Materials and Methods

This study was conducted on 110 formalin fixed adult human cadaveric hearts of both sexes from age of 22 to 87 years. The study was conducted in the Department of Anatomy, Mahatma Gandhi Medical College, Jaipur. The approval from the institute ethics committee was obtained before start of the study. Hearts with any pathology or macroscopic anomalies were excluded from the study.

The coronary sinus and its tributaries were traced by removing the epicardium and subepicardial fat. Variations in these tributaries were noted. The CS was opened longitudinally along its free wall to note the presence of Vieussens valve which is located at the termination of GCV. The formation of CS was noted according to the tributaries draining into the left end of CS. The right atrium was opened along the sulcus terminalis and thoroughly washed to remove blood clots. The length of CS was measured from its beginning point at the formation of CS which also marks the termination of GCV to the CS ostium. The presence or absence of Thebesian valve was noted. The transverse and craniocaudal diameter of CS ostium were measured. All the measurements were done by using the digital vernier callipers with 0.1 mm precision. These observations were tabulated. All qualitative data were expressed as numbers and percentage. Mean, range and standard deviation of all quantitative data were calculated.

Results

Formation of coronary sinus

A total of 110 hearts were studied. The tributaries forming CS were observed. According to the formation, five types of coronary sinus were noted, (Fig. 1 and 2). The Type I CS was most common and observed in 52 (47.3%) heart specimens, followed by Type III CS which was seen in 41 (37.3%) hearts. The Type V CS was observed only in one (0.9%) heart specimen, (Table 1).

Fig. 1: Heart specimens showing formatio of coronary sinus (CS). Type I GCV (great cardiac vein) with OBV (Oblique vein of left atrium), Type II - GCV with PVL (posterior vein of left ventricle), Type III - GCV with LMV (left marginal vein); MCV - Middle cardiac vein; SMV - Small cardiac vein.

Length of coronary sinus

The length of CS was measured. The mean length was found as 26.09 ± 9.25 mm with range of 10.52–49.02 mm. Type V CS was observed in only one heart, it presented a length of 39.2 mm. The mean length was also noted for different types of CS with range, (Table 2).

Table 1: Formation of coronary sinus

Sl. No.	Type of CS	Veins forming CS	No. of heart specimens	(%)
1.	Type I	GCV with OBV	52	47.3%
2.	Type II	GCV with PVL	10	9%
3.	Type III	GCV with LMV	41	37.3%
4.	Type IV	GCV with OBV and PVL	6	5.4%
5.	Type V	GCV with PLSVC	1	0.9%

CS = Coronary sinus; GCV = Great cardiac vein; OBV = Oblique vein of left atrium; PVL = Posterior vein of left ventricle; LMV = Left marginal vein; PLSVC = Persistent left superior vena cava.

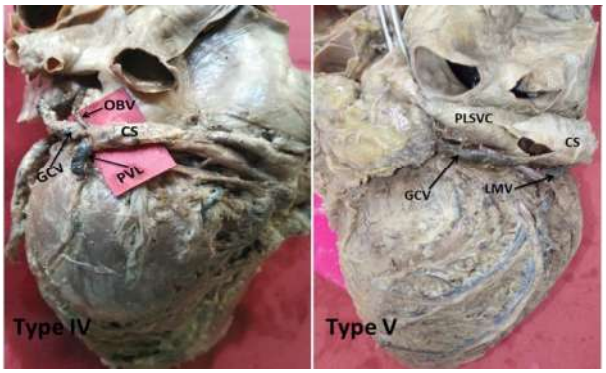

Fig. 2: Heart specimens showing formation of coronary sinus (CS). Type IV - GCV (Great cardiac vein) with OBV (oblique vein of left atrium and PVI, (Posterior vein of left ventricle), Type V = GCV with persistent left superior vena cave (PLSVC); LMV = Left marginal; vein

Diameter of coronary sinus ostium

The average transverse diameter of CSO was measured as 8.26 ± 3.13 mm (range 2.59 – 15.60 mm) and the average craniocaudal diameter of CSO was 10.18 ± 4.3 mm (range 3.10 – 18.9 mm). The average transverse and craniocaudal diameter of CSO were also measured for different types of CS, (Table 3).

Vieussens valve and Thebesian valve

Thebesian valve was observed in 91 (82.72%) heart specimens and Vieussens valve was present in 59 (53.63%) heart specimens. The presence or absence of Thebesian and Vieussens valve were also noted for different types of CS, (Table 3).

Tributaries of coronary sinus

The great cardiac vein and middle cardiac vein were observed as most common tributaries of coronary sinus and were present in all heart specimens. The small cardiac vein and middle cardiac vein formed a common channel just before draining into the coronary sinus in 12 heart specimens. Posterior vein of left ventricle (PVL) was observed as most variable tributary. PVL was present in 59 hearts. One PVL was seen in 20 heart specimens. Two and three PVL were observed in 16 and 13 hearts respectively and four and six PVL (Fig. 3) were observed in 9 and 1 hearts respectively. All the tributaries presented a normal course and drainage (Table 4).

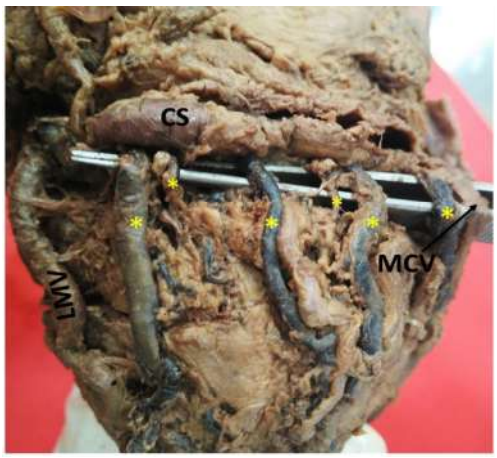

Fig. 3: Posterior surface of heart showing six posterior vein of left ventricle (*) draining into coronary sinus (CS). LMV = Left marginal vein; MCV = Middle cardiac vein.

Table 2: Length of coronary sinus

Sl. No.	Type of CS	Mean length of CS with standard deviation (mm)	Range (mm)
1.	Type I (GCV with OBV)	24.06 ± 8.22	11.91 – 45.9
2.	Type II (GCV with PVL)	19.15 ± 7.66	10.52 – 31.74
3.	Type III (GCV with LMV)	29.94 ± 9.29	13.89 – 49.02
4.	Type IV (GCV with OBV and PVL)	26.78 ± 9.18	20.6 – 45.01
5.	Type V (GCV with PLSVC)	39.2 mm	–

CS = Coronary sinus; GCV = Great cardiac vein; OBV = Oblique vein of left atrium; PVL = Posterior vein of left ventricle; LMV = Left marginal vein; PLSVC = Persistent left superior vena cava.

Table 3: Diameter of coronary sinus ostium (CSO) and presence or absence of Thebesian valve (TV) and Vieussens valve (Vv) in different type of coronary sinus (CS)

Sl. No.	Type of CS	Diameter of CSO (mm)		Number of hearts with TV present	Number of hearts with Vv present
		Transverse	Craniocaudal		
1.	Type I (GCV with OBV)	8.17 ± 2.83	10.54 ± 4.04	47	29
2.	Type II (GCV with PVL)	8.05 ± 3.10	9.15 ± 5.4	7	6
3.	Type III (GCV with LMV)	8.12 ± 3.50	10.14 ± 4.55	33	20
4.	Type IV (GCV with OBV and PVL)	9.26 ± 2.54	8.33 ± 2.81	4	4
5.	Type V (GCV with PLSVC)	14.79	14.38	0	0

GCV = Great cardiac vein; OBV = Oblique vein of left atrium; PVL = Posterior vein of left ventricle; LMV = Left marginal vein; PLSVC = Persistent left superior vena cava.

Table 4: Tributaries of coronary sinus (CS)

Sl. No	Tributary of CS	Present in number of heart specimens	Percentage (%)
1.	Great cardiac vein	110	100
2.	Middle cardiac vein	110	100
3.	Oblique vein of left atrium	68	61.81
4.	Small cardiac vein	58	52.72
5.	Left marginal vein	77	70
6.	Posterior vein of left ventricle	59	53.63

Table 5: Comparison of occurrence of Thebesian valve and Vieussens valve

Sl. No	Authors	Number of total hearts	Number of hearts with TV present (%)	Number of hearts with Vv present (%)
1.	Mak et al.[24]	75	73	-
2.	Karaca et al.[21]	52	67	75
3.	Maasarany et al.[25]	40	87.5	100
4.	Randhawa et al.[17]	50	64	60
6.	Present study	110	82.72	53.63

TV = Thebesian valve; Vv = Vieussens valve.

Table 6: Comparison of frequency of coronary veins

Authors	Mlynarski et al.[29]	Malago et al.[30]	Berhan et al.[9]	Ortale et al.[11]	Sharma et al.[28]	Mazur et al.[31]	Present study
Study method	64-slice CT	64-slice CT	Dual source CT	Cadaveric	Cadaveric	Cadaveric	Cadaveric
Sample size	199	301	339	32	30	200	110
CS	100%	100%	100%	100%	100%	100%	100%
GCV	-	100%	100%	100%	100%	100%	100%
MCV	100%	100%	100%	100%	100%	100%	100%
OBV	-	10.9%	10.6%	43%	30%	71%	61.81%
PVL	62.3%	82%	87%	100%	90%	63.5%	53.63%
SMV	-	18.9%	20%	54%	60%	74%	52.72%
LMV	80.4%	84%	87.9%	97%	100%	39.5%	70%

CS = Coronary sinus; GCV = Great cardiac vein; MCV = Middle cardiac vein; OBV = Oblique vein of left atrium; PVL = Posterior vein of left ventricle; SMV = Small cardiac vein; LMV = Left marginal vein.

Discussion

The Coronary Sinus (CS) and its tributaries are commonly used in treatment modalities for heart failure and arrhythmias.[1] The cardiac resynchronization therapy is a technique which restores the synchronization between right and left ventricle by implantation of a pacing lead in one of the tributaries of CS.[9] The knowledge of coronary venous anatomy is important to increase the success rate and treatment outcome of these procedures. Failure rate of these invasive cardiac procedures has been documented as 5–12% even with experienced hand.[10]

Formation of Coronary sinus

The CS is commonly observed to be formed by joining of GCV and OBV.[11,12] Samoon et al.[13] reported two types of formation of CS by union of GCV with LMV in 93% and union of GCV with PVL in about 7% subjects in the angiographic study of 150 patients. Manoranjitham et al.[14] noted the formation of CS in 30 human cadaveric hearts. They observed three types of CS on basis of its formation. These were formed by union of GCV with LMV in 93.33%, GCV with OBV in 3.33% and GCV with PVL in 3.33%. The present study has reported Five Types of CS which were formed by union of GCV with OBV (47.3%), GCV with PVL (9%), GCV with LMV (37.3%), GCV with both OBV and PVL (5.4%) and GCV with persistent left superior vena cava (0.9%). A previous study has reported different type of CS which was not formed as a continuation of GCV, the GCV was observed as directly draining into the right atrium or anterior cardiac vein.[15,16]

Length of Coronary sinus

The length of CS according to its formation has been documented in very few studies.[13,14,17] The mean length of CS in present study was revealed as 24.06 ± 8.22 mm (GCV + OBV), 19.15 ±7.66 mm (GCV + PVL), 29.94 ± 9.29 mm (GCV + LMV) and 26.78 ± 9.18 mm (GCV + OBV + PVL). The persistent left superior vena cava was observed in only one heart, in which the length of CS was 39.2 mm. Samoon et al.[13] noticed the length of CS as 71.70 ± 9.71 mm (GCV + LMV) and 70.18 ± 14.98 mm (GCV + PVL), which is different from our observations. Manoranjitham et al.[14] reported the mean length of CS as 54.98 ± 12.2 mm (GCV + LMV), 53.06 mm (GCV + PVL) and 34.52 mm (GCV + OBV). We also observed maximum mean length in CS formed by union of GCV with LMV. Randhawa et al.[17] observed the mean length of CS as 30.2 ± 3.1 mm (GCV + OBV) and 31.7 ± 5.9 mm (GCV + PVL). Ankoleker et al.[18] revealed the mean length of CS as 28 mm and an autopsy study by Bellesteros et al.[19] reported the length as 25.96 mm. These results correspond with our study. Variations in the length of CS may be caused by different size of hearts.

Diameter of Coronary sinus ostium

In the present study, the mean transverse and craniocaudal diameter of CS ostium was observed as 8.26 ± 3.13 mm and 10.18 ± 4.30 mm respectively. Zhivadinovic et al.[20] reported the mean transverse and craniocaudal diameter as 7.67 ± 1.72 mm and 8.1 ± 1.51 mm respectively which is similar to our observation. The mean diameter of CS ostium was ranged from about 8 to 12 mm in different studies.[21,22,23]

Thebesian valve and Vieussens valve

The TV was noticed in 91 specimens which is similar to the previous studies.[21,24,25]A considerable difference was observed in results of cadaveric studies and studies by using different type of imaging techniques. Anh et al.[26] reported TV in 54% hearts studied by using fiberoptic endocardial visualization catheter. The technical limitations in visualization of smaller valves could be a cause of lower prevalence of the valve. Corcoran et al.[27] studied the Vieussens valve in 50 cadaveric hearts and found obstructive Vieussens valve in 46% cases, (Table 5).

Tributaries of Coronary sinus

The GCV and MCV were observed as most consistent tributaries of CS and was present in all specimens, similar to the other studies.[9,11,28,29,30,31] The present study reported 0 to 6 PVL, similar variation in number of PVL was reported by previous studies.[21,32] Gilard et al.[32] observed 0 to 3 PVL and Karaca et al.[21] observed 2 to 6 PVL. Karaca et al.[21] noticed 2 PVL in 11%, 3 PVL in 38%, 4 PVL in 37%, 5 PVL in 11% and 6 PVL in 2% cases. In the present study, 6 PVL were noticed only in one heart specimen, (Table 6).

Conclusion

Invasive cardiac surgeries for cardiac ailments are becoming more common with advancement in electrophysiology. Coronary venous system is commonly used as an access route to the heart. The anatomy and variations of coronary veins described in the present study might be helpful for biventricular pacing, radio frequency ablation and other cardiac interventions. The presence of Vieussens valve, smaller coronary sinus ostium with large Thebesian valve and variable anatomy of inconstant tributaries of coronary sinus need to be negotiated before selection of any interventional cardiac procedure. Stem cell transplantation through the retrograde perfusion and mechanical induction of angiogenesis through coronary veins are the currently investigated research fields which require an accurate knowledge of coronary venous anatomy and its variations.

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Original Article

Indian Journal of Anatomy
Volume 9 Number 1, January – March 2020
DOI: http://dx.doi.org/10.21088/ija.2320.0022.9120.12

A Study of Variations in the Superficial Veins of Cadavers of Human Upper Limbs in North Karnataka

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How to cite this article:

Amarendra M Kabadi, Fazal Mehmood Gahlot, Veereshkumar S Shirol. A Study of Variations in the Superficial Veins of Cadavers of Human Upper Limbs in North Karnataka. Indian J Anat. 2020;9(1):79-84.

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Received 24.10.2019 | **Accepted** 03.01.2020

Abstract

Context: Superficial veins of upper limbs play an important role in vascular surgeries and in diagnostic and therapeutic procedures. These veins are clinically important for venipuncture, transfusion and cardiac catheterization.

Aim: To study variations in the superficial veins of cadavers of human upper limbs.

Settings and design: Institution based cross sectional study was carried out at Anatomy Department, JN Medical College, Belgaum.

Methods: The findings observed among 25 cadavers were site of origin of the vein, course of the vein, termination of the vein, variations of the vein and length of the vein. Appropriate procedures were followed and due respect was given to all cadavers.

Statistical analysis: The data analyzed using mean, standard deviations. Students t test was used to test the differences in the mean values.

Results: Average length of veins in left upper limbs of female and male cadavers for cephalic was 52.7 and 50.9 cm, basilic vein 51.1 and 49.8 cm, median cubital vein 8.9 and 9.4 cm and median vein of forearm 13.9 and 17.4 cm respectively. Average length of veins in right upper limbs of female and male cadavers for cephalic was 53.9 and 52.1 cm, basilic vein 48.7 and 49.6 cm, median cubital vein 8.6 and 9.8 cm and median vein of forearm 18.2 and 17.4 cm respectively. All these differences were statistically not significant.

Conclusion: Mean length veins in right and left upper limbs were similar for both males and females. Type III Dorsal venous pattern was the most commonly seen and all cases were seen only in males.

Keywords: variations, superficial veins, cadavers, human, upper limbs

Introduction

The superficial veins of the upper limbs play an important role in vascular surgeries and in diagnostic and therapeutic procedures. These veins are clinically important for venipuncture, transfusion and cardiac catheterization.[1]

The cephalic vein is useful in preparation for the construction of an arteriovenous fistula at the wrist.[2] An approach y cephalic vein is helpful in pacemaker and intra-cardiac defibrillator implantation.[3]

The median cubital vein is used for blood sampling, blood transfusion and intravenous injections.[4]

For central venous catheterization basilic vein or median basilic vein are chosen because basilic vein progressively increases in size as it runs through the arm and is in direct line with the axillary vein. [5]

The median cephalic vein and median basilic vein are used to obtain blood and for giving intravenous injections.[6]

There is a lot of variation in the origin, course and pattern of superficial veins of upper limbs. A good knowledge of variations of these superficial veins is very helpful to the clinicians. In a study, done on 96 cadavers, the origin, branches and anastomoses of nutrient vessels of the cutaneous nerves and superficial veins of the forearm were observed. Their relationship with the blood supply of adjacent muscle, bone and skin were assessed. The results suggested that nutrient vessels of the cutaneous nerves and superficial veins of the forearm have the same origin as those of the nutrient vessels of adjacent muscles and skin of the forearm.[7]

In a study done on 20 cadavers, arms were dissected. Cephalic and basilic veins were examined for size, distribution of valves and to determine optimal incisions for obtaining a suitable valve containing segment of the vein which was used for transplantation to a lower extremity vein. The result showed that a medial incision along middle one third of the arm exposing a basilic vein is recommended as optimal approach for vein harvesting in vein valve transplantation.[8]

Present study is an attempt to know more about the course, patterns and variations of superficial veins of the upper limbs in the cadavers.

Materials and Methods

Study design: Institution based cross sectional study.

Settings: The material for the study was about 25 cadavers obtained from the Anatomy Department of J. N. Medical College, Belgaum.

Sample size: During the study period of two years, it was possible to include 25 cadavers. Thus, a total of 50 upper limbs (25 left upper limbs and 25 right upper limbs) of 25 cadavers.

Ethical considerations: Initially the protocol was submitted to the Institution Ethics Committee and after approval, the study was initiated. But before that, permission from the Head of the Department of Anatomy, J.N. Medical College was obtained. Due respect was given to the cadavers while conducting the study.

Inclusion criteria

1. All cadavers available for the study during the study period

Exclusion criteria

1. Deformed limbs
2. Traumatized limbs

Materials used

The scalpel, blunt and toothed forceps, painting material, painting brush, Indian ink, and camera were used as materials for carrying out the present study.

Procedure adopted

In cadavers, incisions were taken on the thorax and on the upper limb. The skin, superficial fascia was dissected and reflected. The deep fascia in the deltopectoral groove was dissected to uncover the cephalic vein. The cephalic vein was traced above and below by separating carefully the fascia attached to it. The cephalic vein was traced down till it originated from lateralend of dorsal venous network in the anatomical snuff box.

The elbow the cephalic vein was connected to basilic vein through median cubital vein. The median cubital vein was dissected and traced. The basilic vein was dissected in the arm above until it formed the axillary vein and below where it would originate from the medial end of dorsal venous network.

The median vein of forearm was dissected and traced. On the dorsum of the hand the skin was reflected to note the dorsal metacarpal veins which form the dorsal venous network.

The findings observed were site of origin of the vein, course of the vein, termination of the vein, variations of the vein and length of the vein.

Statistical analysis

The data was entered in the Microsoft Excel Worksheet and analyzed using mean and standard deviations. Students t test was used to test the differences in the mean values. p value of less than 0.05 was taken as statistically significant.

Results

Table 1 shows comparison of the length of the veins in cm in right and left upper limbs observed in 25 cadavers. The mean length of cephalic vein in the left upper limb was 51.44 cm and the right upper limb was 52.63 cm. The mean length of basilic vein in the left upper limb was 50.21 cm and the right upper limb was 49.36 cm. The mean length of Median cubital vein in the left upper limb was 9.25 cm and the right upper limb was 9.5 cm. The mean length of Median vein of forearm in the left upper limb was 16.4 cm and the right upper limb was 17.66 cm.

Table 2 shows comparison of length of veins in cm in right and left upper limbs among the male and female cadavers. The mean length of cephalic vein in female cadavers in left upper limb was 52.7 ± 2.8 and in the right upper limb was 53.9 ± 3.9 and the difference was not statistically significant. The mean length of basilic vein in female cadavers in left upper limb was 51.1 ± 5.6 and in the right upper limb was 48.7 ± 2.1 and the difference was not statistically significant. The mean length of median cubital vein in female cadavers in left upper limb was 8.9 ± 3.3 and in the right upper limb was 8.6 ± 3.1 and the difference was not statistically significant. The mean length of median vein of forearm in female cadavers in left upper limb was 13.9 ± 5.1 and in the right upper limb was 18.2 ± 6.3 and the difference was not statistically significant. The mean length of cephalic vein in male cadavers in left upper limb was 50.9 ± 3.5 and in the right upper limb was 52.1 ± 5.1 and the difference was not statistically significant. The mean length of basilic vein in male cadavers in left upper limb was 49.9 ± 4.6 and in the right upper limb was 49.6 ± 4.6 and the difference was not statistically significant. The mean length of median cubital vein in male cadavers in left upper limb was 9.4 ± 2.1 and in the right upper limb was 9.8 ± 1.8 and the difference was not statistically significant. The mean length of median vein of forearm in female cadavers in left upper limb was 17.4 ± 5.7 and in the right upper limb was 17.4 ± 6.9 and the difference was not statistically significant.

Table 3 shows comparison of dorsal venous network pattern in cadavers in right upper limbs among males and females. Type III pattern was the most commonly seen and all cases were seen

Table 1: Comparison of the length of the veins in cm in right and left upper limbs observed in 25 cadavers

Limb	Vein	Mean length in cm	Standard deviation
Left upper limb	Cephalic vein	51.44	3.7
	Basilic vein	50.21	4.79
	Median cubital vein	9.25	2.41
	Median vein of forearm	16.40	5.59
Right upper limb	Cephalic vein	52.63	4.76
	Basilic vein	49.36	4.01
	Median cubital vein	9.5	2.23
	Median vein of forearm	17.66	6.64

Table 2: Comparison of length of veins in cm in right and left upper limbs among the male and female cadavers

Vein	Left upper limb		Right upper limb		T value	*p* value
	Min-max	Mean+SD	Min-max	Mean+SD		
Length in female cadavers in cm						
Cephalic vein	49.6-56.5	52.7+2.8	48.5-60.5	53.9+3.9	1.297	0.219
Basilic vein	44-60	51.1+5.6	46.5-53.4	48.7+2.2	2.013	0.067
Median cubital vein	5.6-15.5	8.9+3.3	5.5-13.4	8.6+3.1	0.321	0.761
Median vein of forearm	8.5-15.5	13.9+5.1	8.5-26.6	18.1+6.3	1.304	0.218
Length in male cadavers in cm						
Cephalic vein	38.8-56.5	50.9+3.5	35.5-58.5	52.1+5.1	1.101	0.278
Basilic vein	41.5-61.5	49.9+4.6	39.5-55	49.6+4.6	0.151	0.881
Median cubital vein	5.5-15.5	9.4+2.1	5-11.5	9.8+1.8	0.693	0.493
Median vein of forearm	8.5-26.5	17.4+5.7	8-28.5	17.4+6.9	0.004	0.996

Table 3: Comparison of dorsal venous network pattern in cadavers in right upper limbs among males and females

Pattern	Male	Female	Total
Type I	3	1	4
Type II	3	1	4
Type III	6	0	6
Type IV	1	1	2
Type V	2	0	2
Type VI	1	1	2
Type VII	0	1	1
Type VIII	1	0	1
Type IX	0	1	1
Type X	0	1	1
Type XI	1	0	1

Table 4: Comparison of dorsal venous network pattern in cadavers in left upper limbs among males and females

Pattern	Male	Female	Total
Type I	4	0	4
Type II	3	1	4
Type III	2	1	3
Type IV	2	1	3
Type V	3	0	3
Type VI	1	1	2
Type VII	2	0	2
Type VIII	1	1	2
Type IX	0	1	1
Type X	0	1	1

only in males. Type I, II, III, V, VIII and XI was seen predominantly in males compared to females. While in females Type VII, IX and X were seen which was not observed in males. Type IV, and VI were seen equally in males and females. Overall type I, II, III were found to be the most common types followed by type IV, V and VI.

Table 4 shows comparison of dorsal venous network pattern in cadavers in left upper limbs among males and females. It was found that type I was seen only in males and overall also it was the most common type. It was not seen in females. Type II also overall there were four cases out of which majority i.e. three were seen in males and only one case was seen in females. Type III there were three cases out of which two were in males and one was in female. Type IV there were three cases out of which two were in males and one was in female. Type V there were three cases out of which two were in males and one was in female. Type VI there were two cases out of which one was in males and one was in female. Type VII there were two cases out of which both were in males. Type IX there was only one case which was seen in female. Type X there was only one case which was seen in female.

Discussion

The frequency of variations in the arrangement of vessels in any part of the limb is well known. Most of the embryonic veins arise from these capillary plexuses which increase by sprouting and anastomoses and then fuse and enlarge forming fewer and larger channels. Genetic and hydrodynamic factors play an important role in final pattern of arrangement of veins which present maximum variations. [9]

In a study done on 300 persons on arrangement of superficial veins in cubital fossa in Indian subjects they found that in 51% of the cases the cephalic vein and the basilic vein were connected to the median vein of the forearm by a median basilic vein and median cephalic vein. In 10.5% of the cases the median cephalic vein did not join the cephalic vein. The median basilic vein did not join the basilic vein in 3% of the cases. In another 3% of the cases there was double Y shaped arrangement present. Inverted Y shaped arrangement was observed in 1.5% of the cases. In 1% of the cases one of the two limbs of Y joining either the basilic vein or the cephalic vein was found to be double. Thus, the median vein of forearm was present in one form or the other in 70% of the cases in this study.[9]

In another study done on patterns of superficial veins in cubital fossa in 300 Nigerian subjects, they found that median vein of forearm dividing into two and joining the basilic and cephalic vein. [10]

In our study superficial veins were studied in 25 cadavers.

In the study done on 300 persons on arrangement of superficial veins in cubital fossa in Indian subjects they found that cephalic and basilic veins were connected by the median cubital vein in H shaped pattern in 16.5% of the cases. Single median cubital vein was present in 12% of the total cases. Double median cubital vein was present in 4.5% of total cases. In two cases a venous arch was connecting the basilic and cephalic veins above the bend of the elbow.[9]

In a study done on 170 males and 96 females on arrangement of superficial veins in cubital fossa in Malays there was presence of two median cubital veins (in one male only).[11]

In our study the cephalic vein was connected to the basilic vein by median cubital vein in majority of the cases. In one case of cadaver the median cubital vein was observed. No other variations were observed.

In a study done on 300 persons on arrangement of superficial veins in cubital fossa in Indian subjects they found that in 10% of the cases there was no

cross connection between the cephalic and basilic vein i.e. absence of median cubital vein.[9]

In a stud done on 170 males and 96 females on arrangement of superficial veins in cubital fossa in Malay, there was absence of communication between the basilic and cephalic veins (in 7.3% of females and 8.8% of the males).[11]

In our study such observation was made in 2% of the cases.

In a study done on 300 persons on arrangement of superficial veins in cubital fossa in Indian subjects they found that in 3% of the cases cephalic vein was absent and veins in the fossa ran medially and joined the basilic vein.[9]

In another study done on cephalic vein, absence of cephalic vein was seen in two specimens (5%) of 40 shoulders in deltopectoral groove.[12]

In our study absence of cephalic vein was not seen.

In a study done on 300 persons on arrangement of superficial veins in cubital fossa in Indian subjects they found that in 0.5% of the cases basilic vein was absent and veins in the fossa ran laterally and joined the cephalic vein.[9]

In our study absence of basilic vein was not seen.

In another study done on 536 Indian subjects on superficial venous patterns in cubital region, they observe that more than one median vein of forearm. These either ended as such or joined one or more loops attached to the median cubital vein.[13]

In our study no such variations were observed.

In another study done on 536 Indian subjects on superficial venous patterns in cubital region, they observe that the cephalic vein itself turned medially to join the basilic vein. The brachial portion of cephalic vein was either absent (15 cases), rudimentary (11 cases) or taken by an accessory cephalic vein (78 cases). In one dissection a deep vein pierced the deep fascia in front of the elbow joint and extended upwards.[13]

Conclusion

The mean length of the cephalic vein, basilic vein, median cubital vein and the median vein of the forearm in right and left upper limbs were similar or statistically not significantly different for both males and females. Type III Dorsal venous pattern was the most commonly seen and all cases were seen only in males. Type I, II, III, V, VIII and XI was seen predominantly in males while in females Type VII, IX and X were seen. Type I & II Dorsal venous pattern was the most commonly seen and all cases were seen only in males.

Key messages

This data plays an important role as a guide or tool to the surgeons and anesthetist who are directly benefitted from this.

Prior publication: Nil

Support: Nil

Conflicts of interest: Nil

Permissions: All necessary permissions have been taken

Source(s) of support: Nil

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Original Article

Indian Journal of Anatomy
Volume 9 Number 1, January – March 2020
DOI: http://dx.doi.org/10.21088/ija.2320.0022.9120.13

Morphometric Study on Mastoid Process for Determination of Sex by Using 3D CT Scan

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How to cite this article:

MY Dofe, KS Nemade, NY kamadi. Morphometric Study on Mastoid Process for Determination of Sex by Using 3D CT Scan. Indian J Anat. 2020;9(1):85-89.

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Received 28.11.2019 | **Accepted** 03.01.2020

Abstract

Objective: The purpose of this study was to evaluate the accuracy of sex determination from the measurement of the area formed by 3 craniometric points related to the mastoid process i.e the porion, asterion, and mastoidale points in 3D reconstructed computed tomography of skull and comparison of its finding with the studies done by other authors where morphomertric analysis of mastoid process is done by manual method using vernier caliper or xerographic copies of skull or from CT Scan.

Method: For the study, 200 3D reconstructed CT scan images of skull were analysed, 100 were males and 100 were females. The three craniometric points were marked to demarcate a triangle on both side of 3D skull and measurement was done by using Radiant Dicom software.

Results: We observed that the mean of all mastoid parameters was more in male than in female. Even the surface area of mastoid process was higher in male than female. Results of present study compared with studies done by different workers in different regions. Each study showed that all the mastoid variables i.e distance from Porion to Mastoidale, Asterion to Mastoidale, Asterion to Porion and surface area of mastoid process were more in males than in females which correlates with our study.

Conclusion: Knowledge of above dimensions of mastoid process and comparision of its findings with various methods of measurement increases the accuracy of sex determination.

Keywords: Mastoid process; Sex determination.

Introduction

Determination of sex in fragmented bone is often a difficult task. The highest accuracy in sex determination is achieved when complete skeleton is available.[1]

Sex classification is more precise in pelvic remains than the skull but whole and complete pelvis is not always available for analysis.[2] Several studies have shown that cranium is also best indicator for sexual dimorphism by morphologic and morphometric analysis. Skull is probably the second best region of the skeleton to determine sex.[3] Dimorphism in skull is based on its size and robustness. The mastoid region is favorable for sex determination, as it is the most protected region and resistant to damage, due to its anatomical position at the base of skull.[4]

Sex determination from mastoid process is done metrically and non-metrically. Broca's (1875) and Hoshi (1921) have suggested that when the skull were placed on flat surface the male skull rests on mastoid process while female skull rests on occipital condyles.[5] Subsequentely trends changed to morphometric and statistical methods. Mastoid process is examined metrically by various authors. Suazo et al. (2008) determine the sex on Brazlian skull by taking triangular area formed by the points

porion, mastoidale, and asterion with the help of statistical analysis and discriminant functional analysis.[6] Some authors used some variable like mastoid length, breadth and width of mastoid process to determine the sex.

Determination of sex using mastoid variables was done by various methods like manual method using vernier caliper, xerographic copies and CT images. Most of the studies used manual method. very few studies are done using CT scans. So, the present study is undertaken to determine the sex from morphometric measurement of mastoid process by using 3(D) CT scans of skull and it's findings were compared with previous studies. So the aim of this study is also to find out any discrimination in sexing of skull by using CT scans and other method.

Materials and Methods

The present study is conducted in the Department of Anatomy, Government Medical College, Nagpur. Computerised tomographic images of 100 males and 100 females of age above 25 years were obtained from Radiology department. From this data 3D images of skull were reconstructed by using Radiant Dicom software. These 3D images were studied to determine the accuracy of mastoid process in sex determination. For mastoid measurement, three craniometric points were used. These are porion, asterion and mastoidale. Porion is superior point of external acoustic meatus. Asterion is the meeting point of lamboid, occiptiomastoid and parietomastoid sutures. Mastoidale is the tip of mastoid process.

These three points were located and marked The following readings were taken in cm. i.e shown in Figure 1.

- Porion to Mastoidale
- Asterion to Mastoidale
- Porion to Asterion

Figure 1. Showing demarcation of three craniometric point.

For better comparsion with previous studies readings in cm were converted in millimeter. The area of mastoid triangle was calculated by means of Herons formula.

All the mastoid variables were analysed by using software. The mean, standard deviation and *p* value were calculated and if ″P″ value less than 0.05 were consider to be stastastically significant difference between sexes.

Results

Total 200 CT images of skull were taken (100 male, 100 female). The univariate analysis shown in Table 1, Table 2, Table 3 and Table 4. Table 1 showed analysis of male skulls of right and left side where all the mastoid variables were insignificant except the distance from Asterion to Mastoidale (*p* valve less than 0.05).

Table 2 showed analysis of female skull of right and left side where all the mastoid variables shows significant differences wih *p* value less than 0.05 except the distance from Porion to Mastoidale.

Table 3 showed comparision of right sided mastoid parameters between male and female and Table 4. Showed comparision of left sided parameters between male and female. All the differences were highly significant with *p* valve less than 0.001 when male right side compared with female right side as well as when male left side compared with female left side which indicate that the measurement of these mastoid variables can be used for sex determination.

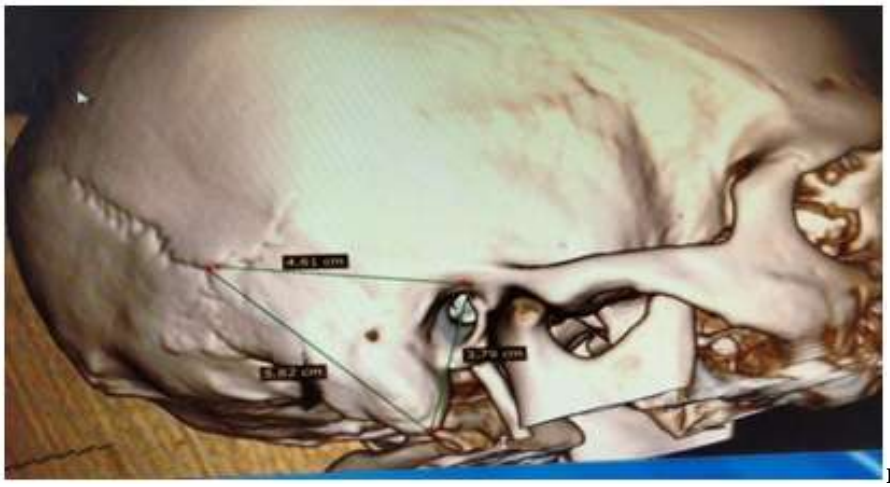

Fig. 1:

Table 1: Measurements of Mastoid variables in Male

Sr. No	Mastoid variable		Mean	SD	T test	*p*
1	Porion - Mastoidale	Right	31.04 mm	3.28	1.2072	0.2302
		Left	30.71 mm	3.78		
2	Asterion - Mastoidale	Right	47.04 mm	6.29	5.7028	<0.001*
		Left	45.10 mm	6.14		
3	Porion - Asterion	Right	42.98 mm	4.92	1.6378	0.1046
		Left	42.45 mm	4.78		
4	Surface area	Right	645.49 mm^2	123.07	1.4210	0.1585
		Left	631.45 mm^2	145.92		

Table 2: Measurements of Mastoid variable in Female

Sr. No	Mastoid variable		Female Mean	SD	T test	*p*
1	Porion - Mastoidale	Right	27.38 mm	4.57	0.760	0.445
		Left	27.14 mm	3.23		
2	Asterion - Mastoidale	Right	40.53 mm	7.48	3.894	0.0002*
		Left	38.7 mm	6.84		
3	Porion - Asterion	Right	39.02 mm	5.56	2.9078	0.0045*
		Left	37.96 mm	4.63		
4	Surface area	Right	505.75 mm^2	132.41	3.905	0.001*
		Left	477.78 mm^2	97.25		

Table 3: Showing comparsion of mastoid variables in male and female of right side

Sr. No	Mastoid variable		Mean	SD	T test	*p*
1	Porion - Mastoidale	Male	31.04 mm	3.28	6.503	<0.001**
		Female	27.38 mm	4.57		
2	Asterion - Mastoidale	Male	47.04 mm	6.29	6.6496	<0.001**
		Female	40.53 mm	7.48		
3	Porion - Asterion	Male	42.98 mm	4.92	5.3371	<0.001**
		Female	39.02 mm	5.56		
4	Surface area	Male	645.49 mm^2	123.07	7.729	<0.001**
		Female	505.75 mm^2	132.41		

Table 4: Showing comparsion of mastoid variables in male and female of left side

Sr. No	Mastoid variable		Mean	SD	T test	*p*
1	Porion - Mastoidale	Male	30.71 mm	3.78	7.1679	<0.001**
		Female	27.14 mm	3.23		
2	Asterion - Mastoidale	Male	45.10 mm	6.14	6.9593	<0.001**
		Female	38.7 mm	6.84		
3	Porion - Asterion	Male	42.45 mm	4.78	6.6379	<0.001**
		Female	37.96 mm	4.63		
4	Surface area	Male	631.45 mm^2	145.92	8.7628	<0.001**
		Female	477.78 mm^2	97.25		

*--significant

**--Highly significant

Discussion

Present study was undertaken on morphometric measurement of mastoid process by using CT images and its findings were compared with the studies done by other authors using various methods. We found that the mean value of all mastoid variables i.e Porion to mastoidale; Asterion to mastoidale; Porion to Asterion and surface area of mastoid process was higher in males than in females on both right and left side of skulls which correlates with other studies.

In the present study we also found that the mean value of mastoid variabies of right side was higher than left side in both male and female.

Table 5 shows the findings of study of various mastoid parameters done by different workers in different regions. Each study showed that all the mastoid variables were higher in male.

In 2003, Saaveedra de Paiva and Segre[4] affirmed that the value of mastoid triangular areas defined by three distinct craniometric landmarks (Porion, Asterion and mastoidale) were useful in sexing the skull. They used xerographic copies of skulls and they found significant difference in the area between mastoid triangle while comparing male and female skull. Because of asymmetrical measurements of mastoid triangle on right and left sides they recommended that the value of the total area (adding right and left sides) should be used for the inference. When this area was higher or equal to 1444.40 mm^2, the skull was reconganised as male and when total area was lower than or equal to 1260.36 mm^2 skull was reconganised as female.

In present study, in CT images of male, surface area of mastoid triangle of right side is 645 mm^2 and 631 mm^2 on left side and the value of total area (adding of right and left sides) is 1276 mm^2 while in female surface area of mastoid triangle on right side is 505 mm^2 and on left side is 477 mm^2 and total area (adding right and left sides) is 982 mm^2. This also shows that surface area was higher in male than in female.

Kemkes and Gobel[12] have hypothesized that population specific variability of the asterion

Table 5: Comparison between present study and studies conducted by previous workers for measurement (Porion to mastoidale; Asterion to mastoidale; Porion to Asterion and surface area).

Authors Manual Method	Population studied	No of skull	Po-Ms	AST-Ms	AST-Po	Surface area
Vineeta Saini et al. (2012)[7]	North India	M-104 F-34	M = 31.77 + 3.07 F = 27.98 + 3.47	M = 47.83 + 4.06 F = 43.0 + 4.32	M = 47.89 + 3.17 F = 44.69 + 3.75	
Nidugala H (2013)[8]	South India	M = 40 F = 40	M = 29.52 + 3.3 F = 24.26 + 3.7	M = 50.11 + 4.54 F = 46.51 + 4.12	M = 44.48 + 4.14 F = 42.87 + 3.08	
Albin Babu M Wilson (2013)[9]	South India	M = 40 F = 40				M=805.87 mm^2 F=620.56 mm^2
SB sukare et al. (2017)[10]	Marathwada (Maharashtra)	M = 80 F = 52	M = 29.86 + 0.41 F = 25.17 + 0.69	M = 48.33 + 0.64 F = 42.59 + 1.12	M = 44.96 + 0.57 F = 40.46 + 1.03	
PR Chavan, SL Sarda et al. (2018)[11]	Marathwada (Maharashtra)	M = 80	R-30.32	R-48.92	R-45.82	586.05 mm^2
			L-29.40	L-47.75	L-44.10	565.30 mm^2
		F = 52	R-27.12	R-45.38	R-43.30	508.47 mm^2
			L-23.23	L-39.80	L-37.61	436.37 mm^2
Authors Xerographic Copy Pavia and Segre (2003)[4]						M=1447.40 mm^2 F=1260.36 mm^2 Surface area of addition of both side
Author 3(D) CT scan						
Albin Babu M Wilson (2013)[9]	South India	M = 40 F = 40				M=828.53 mm^2 F=578.24 mm^2 Readings of one side. side not determined
Present study	Central India	M = 100	R-31.04 mm	R-47.04 mm	R-42.98 mm	R-645 mm^2
			L-30.71 mm	L-45.10 mm	L-42.45 mm	L-631 mm^2
		F = 100	R-27.38 mm	R-40.53 mm	R-39.02 mm	R-505 mm^2
			L-27.14 mm	L-38.7 mm	L-37.96 mm	L-477 mm^2

location undermine the value of the mastoid triangle as a sex determinant.

In 2003 Albin Babu M wislson et al.[9] did the comparsion between 3(D) CT scan and manual method of area measurement of mastoid process in sex determination of south Indian population to find out any significant difference between CT scan method measurement and manual method measurement of mastoid process in sex determination in south Indian Population. They found that on CT measurement, the area of single side in male is 828.53 ± 18.54 mm^2 and in female 578.24 ± 71.53 mm^2 while the area measured by manual method is 805.87 ± 90.99 mm^2 in male and 620.56 ± 90.63 mm^2 in female on single side. The side of measurement were not mentioned and they found that there was no significant difference in measurements taken by CT scan and manual method.

In present study, measurements of mastoid triangle were taken of both right and left side on CT images and mean of surface area was more on right side than left in both male and female.

Conclusion

Very few works were done on mastoid process by using 3D CT films to sex the skull. So the present study has provided a baseline data for sex determination of mastoid process of skull and on comparision with other studies, we found there is no discrimination in sexing of skull by using any method. The range of value for sexing the skull may be varies due racial difference or population based position of asterion.

More research on same parameters using various method of measurement increases the accuracy of sex determination.

Conclusion of the study knowledge of above dimensions of mastoid process and comparison its finding with various methods of measurements increases the accuracy of sex determination.

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Case Report

Indian Journal of Anatomy
Volume 9 Number 1, January – March 2020
DOI: http://dx.doi.org/10.21088/ija.2320.0022.9120.14

Rectus Sternalis: A Part of Syndrome of Musculoskeletal and Renovascular Anomalies?

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How to cite this article:

Manisha B. Sinha, Dharmendra Kumar, Prasenjit Bose. Rectus Sternalis: A Part of Syndrome of Musculoskeletal and Renovascular Anomalies?. Indian J Anat. 2020;9(1):90-92.

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Received 04.10.2019 | **Accepted** 07.12.2019

Abstract

Rectus sternalis is a strap muscle occasionally present in anterior thoracic wall. Rectus sternalis if present, can be used in breast reconstruction surgeries after mastectomy in association with pectorals and also in head and neck reconstructive surgery. During routine dissection for the undergraduates on the anterior thoracic wall, unilateral presence of rectus sternalis muscle was found on right side of the chest. The muscle was extending from 5^{th} rib on the right side (3.6 cm away from sternum) to sternum (at the level of manubriosternal junction). The muscle was 7.2 cm long and 0.8 cm broad in the middle part of the muscle. Both attachments were tendinous. This strap like muscle was seen running between superficial fascia and pectoral fascia of the chest. It may cause confusion as tumor mass or desmoids in anterior chest wall. In this case, rectus sternalis was seen associated with renovascular and other musculoskeletal anomalies. Accidental finding of rectus sternalis might be a predictor for renovascular anomaly for surgeons and radiologist.

Keywords: Rectus sternalis; Pectoralis minor; Tumor; Mastectomy.

Introduction

Among anterior chest wall muscles, the muscle rectus sternalis is a rare feature in the human beings. This muscle as the name suggests, is attached to the sternum at one end while the other end is either attached to pectoralis major or aponeurosis of rectus abdominis. The appearance of Rectus Sternalis (RS) creates lots of confusion while doing mammography and other imaging investigations because of its similarity to various pathologies such as breast carcinoma, extra – abdominal desmoid tumors, granular cell tumours, diabetic mastopathy, abscesses, hematomas, sclerosing adenositis, lymphadenitis, fat necrosis, and surgical scars[1] (Anjamrooz SH, 2013). It often leads to misdiagnosis of recurrence of breast cancer after treatment. As it is a small muscle in the chest, breast tissue may go deep and hence, may be left during mastectomy. It may create a difference in the depth of internal mammary lymph nodes causing problems during radiotherapy of breast carcinoma. Though function of RS is not known, this muscle is useful in breast reconstructive surgery[2] and in head and neck graft.[3,4] Here, we report a case of right sided rectus sternalis with left sided higher origin of pectoralis minor muscle in chest.

Incidence of this muscle has been described in both sexes equally. In Indian population, it has been reported in 4-8%.[5] But its association with variation in origin of pectoralis minor and renovascular anomlies have not been reported ever in India. Our case is unique because of its association with muscular and renovascular variation.

Case Report

During routine dissection for the undergraduates on the anterior thoracic wall of a 65 year old Indian male cadaver at All India Institute of Medical Sciences, Raipur, we found a rectus sternalis muscle on right side of the chest. The muscle was extending from 5th rib on the right side (3.6 cm away from sternum) to sternum (at the level of manubriosternal junction). The muscle was 7.2 cm long and 0.8 cm broad. Both attachments are tendinous (Fig. 1). This muscle was strap like, present between superficial fascia and pectoral fascia of the chest. Inferior extent of its tendon was attached to external oblique aponeurosis. In association with it, the left pectoralis minor was found originating from 2nd, 3rd, 4th costochondral junction. Right pectoralis minor and both pectoralis major were normal. Also anomalies of mal-ascent and mal-rotation of left kidney and its vascular supply were also present in the same cadaver.

Fig. 1: Photograph showing tendinous attachment of right side Rectus Sternalis to sternum and external oblique muscle and higher origin of left pectoralis minor in anterior chest wall. RS Rectus Sternalis, RA Rectus Abdominis, PM Pectoralis Major, Pm Pectoralis Minor.

Abbreviations

RS - Rectus Sternalis

RA - Rectus Abdominis

PM - Pectoralis Major

Pm - Pectoralis minor

Discussion

As we found in this case, rectus sternalis is a part of syndrome of musculoskeletal and renovascular anomalies. According to embryologist, nerve supply depends on development of the muscle and it is either from pectoral nerve or intercostal nerve. Sadler explained ventral longitudinal column of muscle arising from ventral tip of hypomeres.[6] Larsen WJ[7], 1997 described a rectus column which is restricted up to abdomen; occasionally it develops parasternally as sternalis muscle.

Unilateral rectus sternalis has been more commonly illustrated. Right sided uniceps sternalis was the presentation of our case. Anjamrooz SH[1], 2013 found biceps sternalis, a Y- shaped muscle on anterior chest wall lacking sternal attachment. Uniceps sternalis, was first described by Bradley et al.,[8] 1996 in six women during mammographic imaging. Left sided recteus stenalis was illustrated by Arraez-Aybar et al., 2003[3] and Deepali et al., 2010[9]. Unilateral three right rectus sternalis was described by Ramachandran and Kothandaraman, (2010).[10] A bilateral case of sternalis was observed by Shen et al., 1992 and Kumar et al., 2009.[11,12]

In this study, mal-ascended and mal-rotated left kidney with double arterial supply was found. Vascular variant of right kidney, suprarenal gland and testis along with biceps sternalis has been previously reported.[13,14]Association with anencephaly and anomalies of the adrenal gland has also been found earlier.[15]

It looks like syndromic presentation with rectus sternalis, as musculoskeletal, urogenital and vascular involvement.

Few muscles which are used for breast reconstructive surgery are latissimus dorsi, rectus sternalis.[16] Common flap of pectoralis and rectus sternalis as tissue expander is also an option to the surgeons.[3]

Conclusion

So in incidental finding of rectus sternalis, surgeons and radiologist should be cautious about other adrenal and renovascular anomalies. This muscle may be considered as an anticipation of musculoskeletal and renovascular anomalies for clinician.

Conflict of interest: Authors have no conflict of interest.

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[1] Flink H, Tegelberg Å, Thörn M, Lagerlöf F. Effect of oral iron supplementation on unstimulated salivary flow rate: A randomized, double-blind, placebo-controlled trial. J Oral Pathol Med 2006; 35: 540-7.

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Corporate (collective) author

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