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GENERAL INFORMATION

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LETTERS TO EDITOR

Medical Research and Publication: Concerns and Way Forward

Research and development is the cornerstone of any field in STEM (science, technology, engineering, and mathematics). Research in the field of medicine has done wonders, hence it is not only fascinating but transcending as well. An example of this can be attributed to the rapid development of the COVID-19 vaccine. The young medical graduates mostly strive towards becoming good "clinicians" but some of them want to be part of a bigger field of "research" in medicine. Research is a field of its own niche and has to be pursued with full and utmost dedication for it to result in something meaningful. Nowadays, biomedical research has been made an essential prerequisite for making curricula but most of the medical colleges do not prioritize medical research[1] believing that it may affect teaching and patient care.

In India, currently, there are no mandatory guidelines from any of the regulatory agencies governing health sciences for mandatory research training of undergraduates or to promote and facilitate some other mode of scholarly activity. Only the Indian Council of Medical Research (ICMR) encourages undergraduates in medicine for research by providing monetary help to do ICMR short-term summer projects.[2]

In our opinion, undergraduate medical students should be exposed to common medical and surgical problems (early clinical exposure) instead of involving them in active research early in the 1st year MBBS as they are already overburdened with an extensive syllabus.

New PostGraduate medical education draft regulations dictate the publication/submission of a research article in scientific journals or the presentation of the paper at the national conference of the concerned society, training in research methodology (basic course in biomedical research), medical ethics, and medico-legal aspects mandatory[3] which may be highly appreciable since the inception of these at this stage will sow a foundation for the same. Postgraduate thesis or dissertation should not be just an eligibility criteria for appearing in the summative examination, but it should also be given some weightage in either internal or summative assessment.

There should be a larger emphasis on faculty development rather than just mandatory publications for regular promotions toward a change of cadre. Although mandatory publications have been thought out for a positive outcome, it has resulted in quite contradictory outcomes by way of a larger section of research being redundant and repetitive. Further, there is huge rise in predatory journals by several commercial enterprises to take an advantage.[4] As a result, quality has taken a backseat in this rush to publish.[5]

To pile on to the difficult problem of writing and publishing research articles some colleges and NMC inspectors expect these to be published, in a subject-specific journal which also should be considered. The premise of publishing an article in a subject-specific journal is redundant when we are proceeding towards furthering the concept of interdisciplinary research. Articles published in a journal whose scope aligns with the objectives of the said article, should be considered valid for the promotion. NMC and publication committees of medical colleges should take note of this. The articles published in e-journals with a valid indexation should also be considered as valid since most of the journals are shifting to an e-platform lately. The problem of "research waste" is not indigenous to our setup but other countries as well.[6] A few suggestions to relieve the anxiety and streamline the process of publishing a research article:

- Mandatory research should not be the only criteria for promotion of faculty rather a scholarship activity-based (innovative teaching-learning methods, administrative duties, extracurricular activities and giving opinions in various committees) should be implemented.[2,7] This is in view of the hard fact that most of the new medical institutions do not have even the basic research facilities, say in the form sufficient number of bones, cadavers and properly functioning laboratories essential for biomedical research. Further, there is acute shortage of faculty, not only that, the faculty strength is palpably disproportionate to the number of teaching hours in anatomy, physiology and biochemistry. We are amazed how this goes on unnoticed till date by NMC inspectors and National Assessment and Accreditation Council members
- As a number of medical colleges are being established and subsequent increase in student number, faculty strength has to increase and teacher-student ratio (at least 1:10) should be maintained for medical education to be more proactive and to decrease the burden and stress on faculty
- Publication of a research article should be assisted by an in-house expert who should be a part of the central research facility of the medical college to write and articulate a research paper in terms of language, grammar, and interpretation. This will especially be helpful since we are non-native English speakers and such hand-holding in the initial stages of career will boost and encourage faculty to move forward in the right direction

- Medical education i.e., the ability to teach and evaluate students should not suffer nor a clinician's ability to attend and treat patients should not be impeded on account of compulsion to publish
- Electives as part of undergraduate medical education are a step forward in the right direction.[8] "*Research paper writing*" may be included as part of block 1 electives, which will be beneficial to students. Assessment of the same may be done by way of writing a review article. This will enable students to develop an attitude toward research
- Faculty who have the inbuilt aptitude for teaching may write monographs on the anatomical basis of clinical problems or publish research papers on new teaching methodologies.

To publish or perish attitude favors low quality and incomplete research. The primary focus of conducting medical research should ideally be to improve the quality of health care.[9] Medical research and its publishing should be more than just a minimum requirement and a process has to be in place for it to become a culture among the faculty.

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Original Article

Gestational Diabetes Influences Bone Morphogenic Protein Signaling during Heart Development in C57BL Mice

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Abstract

Introduction: Gestational Diabetes Mellitus (GDM) is one of the most common metabolic complications of pregnancy that causes fetal mortality and morbidity. As uncontrolled gestational diabetes could induce congenital heart defects in the offspring. Therefore, this study was done to evaluate the effect of GDM on bone morphogenetic proteins (BMPs) gene expression during heart development in the C57BL mouse embryo. **Material and Methods:** In this experimental study, twelve 8-week old pregnant C57BL with an approximate weight of 130 g were randomly allocated into control and induced diabetic groups. On day 1 of gestation, the dams of the Diabetic group were received 150 mg/kg streptozotocin. While that of the control group were received an equivalent volume of normal saline. On day 11.5 of pregnancy, six embryos were withdrawn from each group. Total RNA was extracted from the cardiac tissue pieces of the embryos for expression of BMPs by quantitative real-time PCR. **Results:** BMP6 of the induced diabetic group increased to 2.4018-fold compared to the controls ($P<0.05$). While BMP 5,7, and 10 increased to (1.58, 1.0445, and 1.7623, respectively) and 1.7623-fold respectively in GDM in comparison to controls. **Discussion and Conclusion:** Therefore, it is suggested that the GDM could induce heart malformations by the upregulation of BMPs, particularly BMP6 expression.

Keywords: *BMPs, gestational diabetes mellitus, heart*

Introduction

Gestational diabetes mellitus (GDM), a type of Diabetes mellitus, affects approximately 7% of pregnant women, which is characterized by an impaired glucose tolerance during pregnancy.[1]

On the other hand, Bone morphogenetic proteins (BMPs), a family of Transforming growth factor (TGF-βs) superfamily, is a heterodimer complex consisting of type I and II serine-threonine kinases and signals through the SMAD and non-SMAD pathways.[2-4] BMP involves in some developmental processes homeostasis of tissues.[5] BMPs are essential and play a main role in the formation of mesoderm, particularly myocardial development.[6] van Gelder *et al*., a study has indicated that gestational diabetes is associated with an increased risk of prenatal mortality and major congenital anomaly.[7] Some of the population-based studies have reported that the infants of diabetic mothers are more susceptible to complex diseases, including obesity, metabolic and cardiovascular complications during childhood and adolescence.[8,9] It has been proven that children of mothers with GDM have more complex congenital heart anomalies and it seems that, hyperglycemia is a risk factor that has adverse impacts on the development of the cardiovascular system.[10,11] There are few articles about the molecular mechanisms of congenital cardiovascular malformation due to gestational diabetes.

BMPs have crucial roles in cell proliferation, differentiation, migration, and apoptosis during organ development and adult life. As their inductive roles cardiac differentiation heart morphogenesis. Also, BMPs are pivotal in the regulation of septovalvular development during the formation of heart chambers. In the heart tissue, some of BMPs are expressed before cardioblast and throughout the later stages of heart development. It has been clear that the main roles of six BMPs (BMP 2, 4, 5, 6, 7, and 10) are expressed in the heart during development.[6]

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Despite an understanding of the effects of BMPs on cardiac development, but we were wondering whether GDM has any impacts on the expression of BMPs during development.

On days 7.5 and 8.5, the BMP2 level is prominent on day 7.5 in cardiac crescent pro-myocardium and around mesoderm cells, while lower levels are in the outflow tract on day 9.5. The BMP2 expression in the AV channel is turned off on day 10.5.[12] BMP4 in the Outflow tract on day 8.5[13] and BMP57 is highly expressed in the developing heart, as BMP6 is expressed in the myocardium and atrial-ventricular cushions of the outflow tract (OFT).[12] But it in AV (Atrioventricular) and OFT (Outflow tract) pads disappear on 9.5 and reduces on the right OFT on 10.5 and the 11.5.[12] BMP10 is expressed initially in all heart chambers of a rat. The role of BMPs as a signal involved in septation, as any defect in this process will be one of the most common causes of congenital heart disease. Therefore, signaling pathways of BMP in mesoderm formation and cardiac development is vital. BMP signaling regulates the induction of cardiac differentiation through a series of genes involved in the cardiogenesis by expression of NKX2.5 and GATA4 transcription factors.[14] That is why this study is designed to investigate the effect of STZ-induced gestational diabetes with expression changes of BMP5, BMP6, BMP7, and BMP10 in the heart tissue of E11.5 C57BL mice embryo.

Material and Methods

Ethical approve

All animal experiments were approved by the Institutional Animal Care and Use Committee of the Golestan University of Medical Sciences, Gorgan, Iran (IR.gums.REC.1395.155)

Generation of gestational diabetes mellitus model

Twelve, 8-week old C57BL mice with an approximate weight of 130 g were housed separately with a male overnight for copulation. The next day vaginal plaque is checked, so it is seen considered as day 0 of pregnancy. Pregnant mice were allocated randomly into control and diabetic groups. Diabetes induced by a single intraperitoneal injection of a freshly prepared streptozotocin solution (150 mg/kg) in saline normal (0.85%) on day 1 of gestation.[15] Dams of the control group were injected with an equal volume of saline normal. 72 hours later, blood glucose levels were checked using a glucometer (ACCU CHEK, Roche Diagnostics, Germany). And the mice with a plasma glucose level higher than 200 mg/dl, was considered as the GDM model. Also, the blood glucose level of the control group was checked before and after pregnancy.[16]

Heart tissue collection

Control and diabetic mice were sacrificed by cervical dislocation on day 11.5 of gestation. Then, the embryos were removed by cesarean section. Heart tissues were extracted from embryos under a stereomicroscope and stored at −80°C until further use.

RNA cDNA synthesis

Total heart tissue from embryos of diabetic and control groups used for RNA extraction. Briefly, RNA was isolated from heart tissues using TRIZOL (Invitrogen) reagent according to the manufacturer's protocol. Residual DNA was digested with 10 U RNase-free DNase (TaKaRa) in the presence of 20 unit RNase inhibitor. After heat inactivation, the total RNA solution was removed and kept at −80°C. The concentration and purity of total RNA samples were measured using a Picodrop Spectrophotometer. The stability and integrity of the RNAs were estimated by agarose gel electrophoresis. For reverse transcription, 1 μg of total RNA was amplified using a cDNA synthesis kit (Fermentas).

Real-time reverse transcription-polymerase chain reaction assay

The forward and reverse polymerase chain reaction (PCR) primers for the 7 genes (S18, BMP 5, 6, 7, and 10) were designed using primer 3 software and were synthesized by Metabion (Martinsried, Germany). All the primer sequences are listed in Table 1. Real-time PCR was performed using the SYBR-Green PCR Master Mix kit (TaKaRa) in the Thermo Cycler (ABI, 7300). Mouse S18 used as a housekeeping gene and cDNA from the control group used as a calibrator. The relative gene expression level between the two groups was determined by the comparative cycle threshold (CT) method. The specificity of the amplified product was confirmed by gel electrophoresis. Every Real-time PCR experiment was repeated with four samples and each sample was run in duplicate.

Data analysis

The value of 2-ΔΔCT was used to calculate relative changes in gene expression. Amplification plot comparison and CT comparison (CT, the first cycle with fluorescent intensity greater than baseline) are estimated for each gene. Finally, relative mRNA expression levels among diabetic and nondiabetic groups were determined by the CT method. Fold change gene expression was shown. Relative target gene expression (fold change) and blood glucose level data were analyzed by one-way ANOVA using Rest statistical analysis software. The differences between the two groups were compared using Student's *t*-tests and all *P* values were considered statistically significant If $P < 0.05$. Data were presented as a mean ± standard deviation.

Results

Blood glucose level

Fasting blood glucose was measured in both control and diabetic group on day zero (G0) and day 3 (G3) of gestation. In diabetic pregnant mice, blood glucose

level was significantly increased 72 h after STZ injection ($P < 0.05$). The mean ± standard error of mean of blood glucose concentrations in control and diabetic mice is depicted in Figure 1.

Quantitative Reverse Transcription-polymerase chain reaction results

In this study, we assessed whether the expression levels of bone morphogenetic genes including BMP5, BMP6, BMP7, and BMP10 were affected by gestational diabetes in the heart tissue of the embryo. Our data showed that the mRNA expression levels of all studied genes were higher in the heart tissue of embryos derived from GDM compared to controls. Data analysis showed that there was a significant increase in BMP6 in the heart tissue of the GDM-derived embryos in comparison with controls (**$P \leq 0.005$). Although GDM-derived embryos showed increases in expression of BMP 5, 7, and 10, no significant differences were seen in compared to controls [Figure 2].

Discussion

Diabetes in pregnant women is associated with a fivefold increase in the risk of cardiovascular malformations in their offspring. The most common congenital heart defects are associated with cardiomyocyte hypertrophy, interventricular septum defects, common outflow tract, and heart valves malformations.[17,18] In laboratory animals, it has been proven that the thickness of the ventricular septum and the weight of the heart in the Offspring of STZinduced diabetic rats is significantly higher than untreated Ones.[19,20] BMP is involved in the regulation of many processes underlying cardiovascular development.[21,22] Therefore, the researchers show that BMP signaling has an important role in heart morphogenesis after the midgestation stage.[3,6]

This study was designed to determine the effect of induced GDM on BMPs expression in the heart tissue of E11.5 embryos in C57BL mice. In the present study, the expression of all studied genes in the E11.5 embryos of C57BL diabetic mice was higher than controls. We observed more than a 2-fold increase in BMP6 in the heart tissue of mouse embryos obtained from diabetic mothers (**$P \leq 0.005$). Furthermore, we also showed that GDM upregulates expression of BMP10 and BMP5 in embryonic heart tissue by 1.76 and 1.58 fold, respectively.

Previous studies demonstrated that the BMP signaling pathway regulates the differentiation of cardiomyocytes from the mesoderm. Although, many studies have shown the role of BMPs in the formation of the ventricular chambers and septovalvulogenesis plus. On the other hand, both inhibition and stimulation of BMP are required for normal cardiomyocyte differentiation during heart development.[3,22] So, these proteins can play a dual role in heart development.

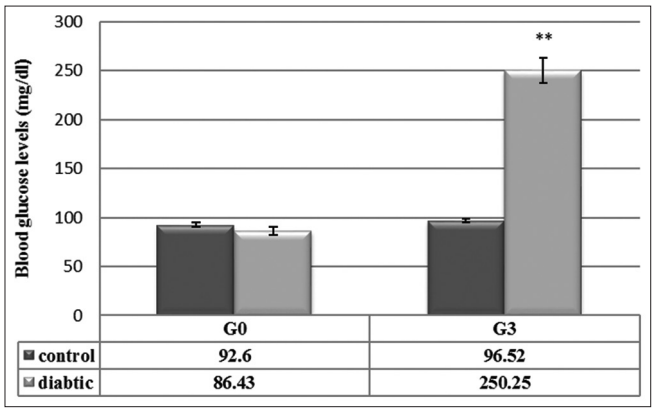

Figure 1: Serum glucose concentrations in diabetic and control pregnant mice on the zero-day of pregnancy (G0) and the third day of pregnancy (G3). Values are means ± standard error of mean. **$P < 0.01$

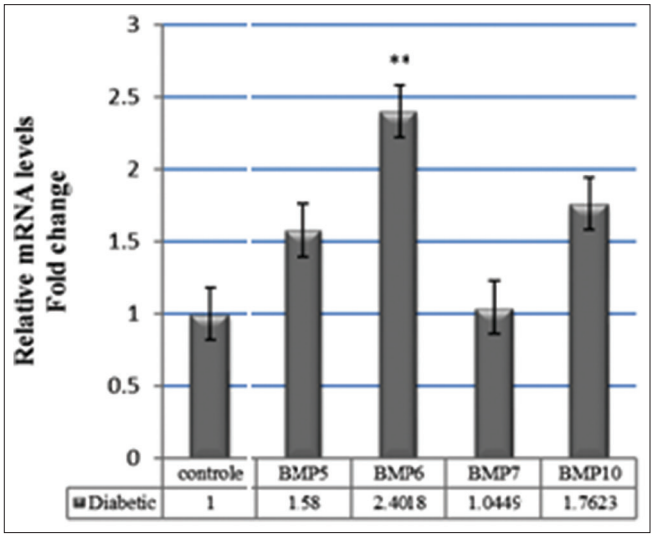

Figure 2: Real-time reverse transcription-polymerase chain reaction analysis of BMP-5, -6, -7, and-10 mRNA expression in the hearts of control and diabetic-derived embryo. Bar graph representing the fold changes of mRNA levels quantified by normalizing to the S18 as a housekeeping gene. Data are presented as mean ± standard deviation. BMP: Bone morphogenetic protein

Table 1: Real-time polymerase chain reaction primer name, sequences, size, and GenBank accession number

Genes	Forward primer	Reverse primer	Product size	GenBank accession number
BMP5	ACCTCTTGCCAGCCTACATG	TGCTGCTGTCACTGCTTCTC	169	NM_007555
BMP6	AGCACAGAGACTCTGACCTATTTTTG	CCACAGATTGCTAGTTGCTGTGA	101	NM_007556
BMP7	GTGACCGCAGCCGAATTCAG	CAACCAGCCCTCCTCAGAAG	168	NM_007557
BMP10	GACTCCTGGATCATCGCTCCTC	CAAGGCCTGAATAATTGCGTGTT	114	NM_009756
S18	CTTCCGCAGGTTCACCTAC	TGCCCTTTGTACACACCG	267	XM_021174474.1

BMP: Bone morphogenetic protein

In the developing heart under hyperglycemia, it seems that oxidative stress associated with malformations and subsequently formation of free radicals disrupt TGF-β and Wnt signaling.[23] Possible pathways concerning GDM induced congenital heart defects have occurred through BMPs shown in [Figure 3]. BMPs form a complex with type I and type II receptors, and the type I receptor causes phosphorylation of SMAD1, SMAD5, or SMAD8. Phosphorylated SMADs form a complex with SMAD4.[6] Which is transported into the nucleus and affects the genes GATA4, NKX2/5, and MEF2C, which play an important role in normal heart development.[24]

Conclusion

Despite the importance of the BMPs in cardiac development and also the influence of GDM on the induction of heart malformations, no detailed study has been conducted on the effect of maternal diabetes on the expression of these genes in developing a heart. In conclusion, our data indicated that GDM can cause the upregulation of BMPs in the developing heart of E11.5 embryos in C57BL mice. Upregulated BMPs can affect important genes involved in cardiomyocyte hypertrophy. Taken together, these findings might be helpful in the understanding of the mechanism underlying GDM caused heart failure in the offspring. However, it seems that studying normal and abnormal cardiac development is necessary to fully appreciate the exact molecular mechanism of inducing cardiac defects in offspring by gestational diabetes.

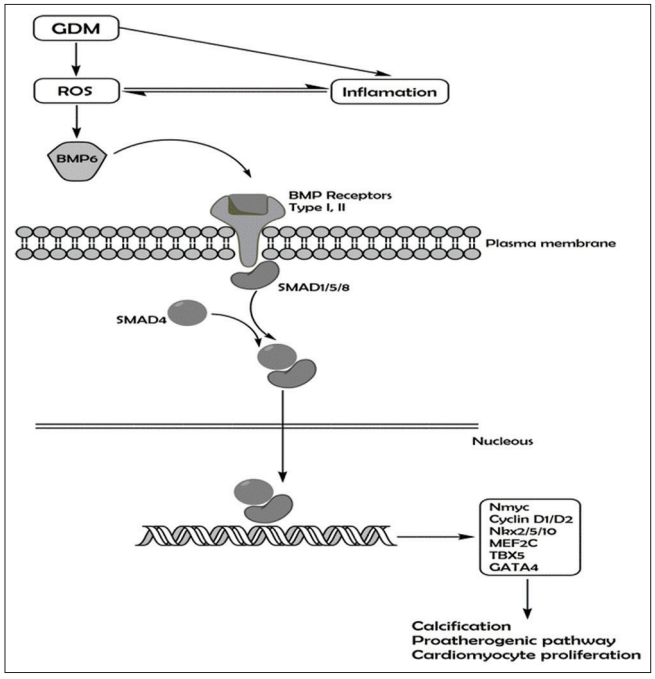

Figure 3: Possible pathway for gestational diabetes mellitus-induced congenital heart defects through bone morphogenetic proteins

Limitations

The developmental period of the heart occurs on different days in uterus (7.5–15.5), but in this study due to the limitations, only on day 11.5 of gestation. Furthermore, no histological and morphological study was performed on the tissue surface, only at the level of gene expression has been examined.

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Conflicts of interest

There are no conflicts of interest.

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Original Article

Strength, Weakness, Opportunity, Threat Analysis of the Adaptations in Anatomy Training During COVID-19 Pandemic: Example of Turkey

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Abstract

Introduction: Educational methods used in Turkey as an immediate response to COVID-19 pandemic definitely bear strengths and weaknesses. In this context, the aim of the present study is to carry out Strength, Weakness, Opportunity, Threat (SWOT) analysis of Turkey's adaptations in the anatomy training. **Material and Methods:** This descriptive study included 12 state universities. A questionnaire was used to collect information regarding the modifications of the anatomy departments. All responses were analyzed by the researchers using a thematic analysis following a 6-step process. For the purpose of SWOT analysis, these themes were assigned to either strengths, weaknesses, opportunities or threats. **Results:** According to the results of the study, increasing skills in utilizing new technologies and resources (83.3%), developing new online resources (83.3%) and alternative examination methods (58.3%) and free access to online resources (16.6%) were the strengths of Anatomy training during the crisis. Exam-related issues (83.3%), being obliged to work from home due to curfews, self-isolation, and social-distancing rules (75.0%), insufficiency in practical courses and cadaver practices (75.0%) and time restrictions (58.3%) were considered as weaknesses. The departments consider the teleworking model (83.3%), preparation for including blended learning in future curricula (83.3%) and academic cooperation (33.3%) as important environmental opportunities. There are issues that anatomy departments consider as important environmental threats. These threats include decrease in student-student (83.3%) and teacher-student interaction (66.6%) and suspension of the donor programs (58.3%). **Discussion and Conclusion:** The COVID-19 pandemic has created several opportunities and challenges. Undoubtedly, Anatomy training will need revisions in the normalization process. Results of SWOT analysis studies are thought to be a guide for the departments during the revision process.

Keywords: *Anatomy education, COVID-19, Strength, Weakness, Opportunity, Threat analysis*

Introduction

Anatomy training is one of the important building blocks of the basic medical sciences. Good anatomy training is required for optimization of both clinical and surgical skills.[1] Teaching human anatomy requires identifying the most appropriate teaching tools and approaches and constantly revising these methods from the students' perspective.[2-4] Cadaver dissection, which has been practiced as gold-standard for many years, has important advantages such as improving active and profound learning, preparing students for clinical practice and applying manual skills and helping them understand the relationship between patient symptoms and pathology.[5] Despite all the benefits, traditional cadaver-based training methods have transformed into integrated/system-based curriculum over time.[6]

In the traditional curriculum of medicine, the preclinical years of education are generally devoted to basic sciences, so students have limited chance for further training in anatomy during clinical years.[6] Due to the lack of anatomical knowledge in intern doctors and newly graduated medical doctors, these traditional methods have often been criticized and a vertically integrated curricula has been proposed.[7,8] In the vertically integrated curricula, clinical sciences are again the center of focus during early years of education. In the following years, however, depending on the branch of the specialization (e.g., surgery, which requires a higher level of anatomical knowledge) a blended anatomy training is placed within the curricula to further expand anatomical knowledge of the interns.[9] In this context, system-based education is emphasized in the literature as an important method that supports integrated education.

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In any anatomical region, there are many structures with various features, functions and relationships, each of which belongs to different systems and are taught in different subject lectures. This makes it difficult for the students to fully understand the function of each anatomical region. In a system-based curriculum, learning is facilitated as it clearly demonstrates that each system is a material that forms the basis for subsequent systems.[10] As students proceed in their education, the relationships, functional significance and clinical correlations of structures belonging to different systems are constantly discussed and reviewed. Therefore, these two methods are considered as locomotives among current anatomy training methods.[11]

Since the outbreak of COVID-19 on December 31, 2019, in Wuhan, Hubei province of China, the number of infected cases has grown exponentially in the country and in the world.[12] The situation is identified by the World Health Organization as a public health emergency of international concern.[12,13] This unprecedented emergency has affected all global industries, including education. With the implementation of policies such as social-distancing and self-isolation, it is not feasible for educators and students to attend lessons or lectures as they did previously. The pandemic has disrupted our educational practices and has urged many institutions to implement alternative educational strategies.[14,15]

Online learning is being used as an alternative method for anatomy training in Turkey as well as in other countries. As mentioned above, different techniques and methods of anatomy training have various advantages and disadvantages and have been revised and reformed over time.[16] Educational methods used in Turkey as an immediate response to COVID-19 pandemic definitely bear strengths and weaknesses. In this context, the aim of the present study is to carry out Strength, Weakness, Opportunity, Threat (SWOT) analysis of Turkey's adaptations in the anatomy training in response to COVID-19 pandemic.

Material and Methods

Study design

This descriptive study included 12 state universities that modified their Anatomy teaching methods to meet self-isolation and social-distancing measures during COVID-19 pandemic.

Participants

Anatomy departments of 12 state universities in Turkey were included in the study. Due to ethical issues, the names of the universities are kept confidential.

Ethics committee

This study was approved by Kırşehir Ahi Evran University Medical Faculty Clinical Research Ethics Committee. Before the study, written and verbal consents were obtained from all Anatomy Departments.

Outcome measures

A questionnaire based on previous procedure was used to collect information regarding the modifications of the anatomy departments as an immediate response to COVID-19 pandemic [Table 1].[16] Two biggest opportunities and challenges that they encountered during the COVID-19 pandemic was asked based on Longhurst *et al*.' study results.[16] All responses were analyzed by the researchers using a thematic analysis following a 6-step process that was published in 2012.[17] For the purpose of SWOT analysis, these themes were assigned to either strengths, weaknesses, opportunities or threats. This analytical approach is commonly used in strategic planning and decision making.[18]

Results

In Turkey, there are a total of 82 anatomy departments; 61 in state universities and 21 in private universities. The sample size of our study accounts for 19.67% of the state universities, and 14.63% of all universities with anatomy departments in Turkey.

Theoretical and practical courses

The most common method of training for the theoretical courses was the asynchronized training with the rate of 50.0%. Synchronized method was used in 25.0% of the departments, and a combination of both methods was used in 25.0% of the departments [Table 2]. Apart from local software, universities also use other software such as "Zoom" (Zoom Voice Communications Inc., San Jose, CA), "Collaborate Ultra" (Blackboard Inc., New York, NY), "Microsoft Teams" (Microsoft Corp., Redmond, WA) and "Big Blue Button" (Big Blue Button Inc. Ottawa, Canada) for their synchronized training. For asynchronous training purposes, the most frequently used methods were uploading course materials to the virtual learning platform (58.3%) and video recording (50.0%). Local distance education software and YouTube videos were commonly used for video recordings [Table 2].

Table 1: Questions that were replied by all contributors

1. Which city is your university located in?
2. What is the number of teaching staff in your anatomy department?
3. What methods do you use in the delivery of theoretical courses?
4. What methods do you use in the delivery of practical courses?
5. What methods do you use in the evaluation of the theoretical courses?
6. What methods do you use in the evaluation of the practical courses?
7. What are the two biggest challenges you encountered during the COVID-19 pandemic?
8. What are the two issues that you see as the biggest opportunities during the COVID-19 pandemic?

YouTube videos (YouTube, San Bruno, CA), Cadaveric images, Acland's Video Atlas of Human Anatomy (Acland, 2013), Bespoke videos (prosected/plastinated specimen) and Visible Human Project (US National Library of Medicine, Bethesda, MD) were the most common methods of digital cadaver in descending order of frequency of use [Table 3]. Visible Body (Argosy Publishing, Inc., Newton, MA) and Anatomy TV (Primal Pictures Ltd., Colchester, UK) were the most frequently used 3D virtual reality methods. Complete Anatomy (3D4Medical/Elsevier, Dublin, Republic of Ireland), Sectra virtual dissection table (Sectra AB, Linköping, Sweden) and Sketchfab 3D models (Sketchfab, New York, NY) had similar frequency of use [Table 3].

Evaluation of the theoretical and practical courses

According to the responses, the COVID-19 pandemic mostly affected the evaluation of practical courses. While 33.3% of the universities had no plans regarding the date and format of the exam, 50.0% either cancelled the practical exam (25.0%) or postponed it (25.0%) [Table 4].

One university (8.3%) the practical exam would be held digitally, and one university (8.3%) would use students' performance assignments as an evaluation method.

In 3 universities, theoretical written exams would be in forms of multiple-choice questions, matching questions, single answer questions and single best answer questions (25.0%). 3 departments (25.0%) planned to postpone the theoretical exam, 2 (8.3%) decided to cancel it, 2 (8.3%) replaced it with performance assignments, and online written and online oral exams would be held in 2 departments [8.3%, Table 4].

Opportunities and challenges

Despite the difficulties the COVID-19 pandemic has created in the education system, there seems to be several opportunities in terms of the investigated parameters. Anatomy departments stated that the remote study model (83.3%), increasing skills in utilizing new technology and resources (83.3%) and developing new online resources (83.3%) were among the most important opportunities. Generating alternative examination methods (58.3%), setting ground for including blended learning in future curricula (33.3%), academic collaboration (33.3%) and free access to online resources (16.6%) were considered as other opportunities [Table 5].

Apart from these opportunities, the departments believed that the pandemic has created serious difficulties and challenges for the education system. The reduction in student interaction (83.3%) and exam-related issues (83.3%) were considered as the most important challenges. Being obliged to work from home due to self-isolation and social-distancing rules (75.0%), insufficiency in practical courses and cadaver practices (75.0%),

Table 2: Theoretical and practical courses

	n (%)
Theoretical courses	
Synchronized method	3 (25.0)
Asynchronized training	6 (50.0)
Uploading course materials to the virtual learning platform	7 (58.3)
Event planning	5 (41.6)
Video recording	6 (50.0)
Tape recording	2 (16.6)
Video recording + tape recording	3 (25.0)
A combination of both methods	3 (25.0)
Practical courses	
Digital cadaver	9 (75.0)
3D virtual reality methods	5 (41.6)
Uploading course materials to the local software	7 (58.3)
Postnormalization feedback applications	3 (25.0)

Table 3: Resources used for the practical courses

Resources	Universities												
	1	2	3	4	5	6	7	8	9	10	11	12	Percentage
Digital cadaver													
Bespoke videos (prosected/plastinated specimen)		✓	✓										16.6
Visible Human Project (U.S. National Library of Medicine, Bethesda, MD)	✓												8.3
YouTube videos (YouTube, San Bruno, CA)	✓	✓		✓	✓	✓	✓	✓	✓				66.6
Cadaveric images	✓		✓	✓					✓				33.3
Acland's Video Atlas of Human Anatomy (Acland, 2013)	✓							✓					16.6
3D virtual reality methods													
Anatomy TV (Primal Pictures Ltd., Colchester, UK)				✓	✓								16.6
Sectra virtual dissection table (Sectra AB, Linköping, Sweden)						✓							8.3
Complete Anatomy (3D4Medical/Elsevier, Dublin, Republic of Ireland)				✓									8.3
Visible Body (Argosy Publishing, Inc., Newton, MA)		✓	✓			✓							25.0
Sketchfab 3D models (Sketchfab, New York, NY)				✓									8.3
Uploading course materials to the local software	✓	✓			✓	✓	✓	✓	✓				58.3
Postnormalization feedback applications										✓	✓	✓	25.0

decrease in teacher-student interaction (66.6%), time constraints (58.3%) and suspension of the donor program (58.3%) were also reported as challenges due to the crisis [Table 5].

Discussion

Our study was designed to make the SWOT analysis of the strategies that have been adopted by anatomy departments in Turkey due to COVID-19 pandemic. The pedagogical perception of opportunities-challenges was mostly similar between departments. A SWOT analysis diagram was created based on the themes extracted from the responses to the questionnaire, and this diagram was used to construct the discussion [Figure 1].

Table 4: Evaluation methods of theoretical and practical courses

	n (%)
Theoretical written exams	
MCQs, EMQs, SAQs, SBA	3 (25.0)
Online written exam	1 (8.3)
Online oral exam	1 (8.3)
Cancelled	2 (16.6)
Students' performance assignments	2 (16.6)
Postponed	3 (25.0)
Practical exams	
No plans regarding the date and format of the exam	4 (33.3)
Exam would be held digitally	1 (8.3)
Cancelled	3 (25.0)
Students' performance assignments	1 (8.3)
Postponed	3 (25.0)

MCQs: Multiple choice question, EMQs: Extending matching questions, SAQs: Single answer questions, SBA: Single best answer

According to the results of the study, increasing skills in utilizing new technologies and resources (83.3%), developing new online resources (83.3%), developing alternative examination methods (58.3%) and free access to online resources (16.6%) were the strengths of Anatomy training during the COVID-19 crisis. Exam-related issues (83.3%), being obliged to work from home due to curfews, self-isolation and social-distancing rules (75.0%), insufficiency in practical courses and cadaver practices (75.0%) and time restrictions (58.3%) were considered as weaknesses. The departments consider the teleworking model (83.3%), preparation for including blended learning in future curricula (83.3%) and academic cooperation (33.3%) as important environmental opportunities. There are issues that anatomy departments consider as important environmental threats and that should be addressed during the normalization process after the crisis. These threats include decrease in student-student interaction (83.3%), decrease in teacher-student interaction (66.6%) and suspension of the donor programs (58.3%).

Anatomy departments in Turkey have demonstrated a significant effort to avoid any interruption in the process of education during COVID-19 pandemic. Their adaptation response in relation to the global changes in learning methods seem to provide an effective and safe learning environment and help to overcome difficulties with minimal damage. Adaptation to online teaching and learning is not an easy task for academics and students.[19] Although there are many online anatomy software programs available to students, these programs were generally cost-bearing before the COVID-19 crisis.[20] According to our SWOT analysis, the development of new online resources, the increase of

Table 5: Opportunities and challenges of teaching methods developed as an immediate response to COVID-19 pandemic

	Universities												
	1	2	3	4	5	6	7	8	9	10	11	12	Percentage
Opportunities													
Remote study model	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			83.3
Setting ground for including blended learning in future curricula	✓			✓				✓		✓		✓	33.3
Generating alternative examination methods	✓				✓	✓	✓	✓		✓	✓		58.3
Academic collaboration			✓	✓				✓		✓			33.3
Increasing skills in utilizing new technology and resources	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	83.3
Developing new online resources	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		83.3
Free access to online resources	✓			✓									16.6
Challenges													
Decrease in teacher-student interaction	✓	✓	✓	✓		✓	✓		✓		✓		66.6
Being obliged to work from home due to self-isolation and social-distancing rules	✓		✓	✓	✓	✓	✓	✓	✓	✓			75.0
Time constraints	✓			✓		✓		✓	✓	✓		✓	58.3
Reduction in student interaction	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		83.3
Exam-related issues	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	83.3
Insufficiency in practical courses and cadaver practices	✓	✓		✓	✓	✓	✓	✓	✓	✓			75.0
Suspension of the donor program	✓			✓	✓			✓	✓	✓		✓	58.3

Figure 1: A Strength, Weakness, Opportunity, Threat analysis diagram

new technologies and resources and free access to these online resources are important strengths of the pandemic. Theoret and Ming studied the effects of COVID-19 on education in medical schools and reported that the availability of a wide variety of free online resources at our fingertips is reassuring and should be used frequently to promote communication and learning.[21] There were several other pandemics before the COVID-19. Green and Whitburn reported that academics should consider the online resource development and free access to these resources by completing their feasibility studies in the prepandemic period in order to be able to handle the undesirable impacts in the most efficient way.[22] Since self-isolation and social-distancing measures preclude the traditional exam formats, the aforementioned strengths paved the way for the development of alternative examination methods for the assessment of Anatomy courses. According to our results, the introduction of alternative examination methods was another strength; however, these methods are considered less effective than face-to-face examinations. Franchi stated that the impact of the pandemic on assessment methods is a concern for students. Written spotter examination and oral viva are amongst the several modalities that can be used to assess anatomy. However, none of these methods can obviously be used in the current situation.[20] Franchi's study results support the strengths of our SWOT analysis and in this context, it is clearly necessary to develop online objective alternative examination methods.[20]

The weaknesses of the current situation are just as many and as important. Exam-related issues, insufficient practical courses and cadaveric practices, teleworking, and time constraints were the weaknesses of this pandemic according to the departments. Ali *et al*., stated that many higher education institutions were using cadaver dissection-prosection as a traditional method of practical training.[23] They concluded that online assessment methods were not effective in evaluating the trainings in cadaveric and other practical courses.[23] According to Meyer *et al*., one important way to increase the effectiveness of these methods is that the images used in online evaluations should be identical with the ones that were used during teaching the courses. In this context, assessment images need to be carefully and precisely selected.[24]

According to Gewin, developing an efficient response to the COVID-19 pandemic requires at least three times more workload compared to the traditional format.[25] Considering the psychological pressure of the current situations, trying to produce high quality resources while working from home may negatively affect academicians.[25] Therefore, it is necessary to make cost-benefit analysis of the time required to create new resources. This is supported with the results of the study by Mandernach, in which the author concluded that video training does not lead to a measurable improvement in student achievement and is not an efficient method according to cost-benefit analysis.[26]

The COVID-19 pandemic propounded important environmental opportunities according to the Anatomy departments. Remote working model, providing a preparation to include blended learning in future curricula and facilitating academic collaboration were reported to be by far the most important environmental opportunities. Academics are increasing their cooperation across Turkey through various social media platforms.[27] The facilities of the anatomy departments are not the same in every university.

Maican *et al*., stated that developing academic cooperation with universities, especially with those who have small number of academic staff in the anatomy department, is an important opportunity for these universities to increase their competence during the current situation.[28] Undoubtedly, with the widespread use of the distance working model, the development of online communication methods has enabled universities to collaboratively learn many techniques and methods as a result of academic cooperation. These techniques and methods will contribute to increase the efficiency of blended learning in the normalization process and will help update education curriculum.

According to the departments, the reduction in student-student and teacher-student interaction, and the suspension of the donor programs are among the environmental threats. An effective learning process necessitates student-student and teacher-student interaction, support, and social participation. Academicians who are trying to adapt to the new learning methods should consider these needs.[29] Technical issues such as poor internet connections or lack of suitable electronic devices negatively affect student participation. Wimpenny and Savin-Baden emphasized that if the aforementioned needs could not be met, problems such as decreased academic progress and student satisfaction would be inevitable.[29] One of the issues that threatens student satisfaction and should be emphasized during the normalization process is the suspension of the donor programs due to the COVID-19 pandemic. Pather *et al*., stated that the possibility of the donor body being a carrier of COVID-19 virus could be the reason of the suspension.[4] Together with the increased risk of disease exposure, delay in the donor programs will pose a risk for cadaver-based training and blended training models during the normalization process. In this context, donor programs may need to be revised during the normalization process.

This study has some limitations that need to be addressed. First, this study investigates anatomy departments in Turkey. Hence, our results cannot be generalized for all countries. The second limitation is the small sample size which accounts for 19.67% of state universities and 14.63% of all universities in Turkey. It may be useful to compare our results with studies with larger sample sizes.

Conclusion

The COVID-19 pandemic has created several opportunities and challenges. Undoubtedly, Anatomy training will need revisions in the normalization process. Results of SWOT analysis are thought to be a guide for the departments during the revision process. According to the results of the present study, developing skills in utilizing new technologies and resources, developing new online resources, developing alternative examination methods and free access to online resources are the strengths. These strengths will enrich the teaching techniques and curricula of Anatomy departments in the post-COVID-19 period. Exam-related concerns, having to work from home due to curfew, self-isolation and social-distancing measures, insufficiency in practical courses and cadaver practices, and time restrictions are the weaknesses. Anatomy departments can develop various action plans, taking into account these weaknesses. The COVID-19 process also offers important environmental opportunities such as teleworking model, the preparation and opportunity for including blended learning in future curriculum programs, and academic collaboration. All these opportunities have paved the way for universities to learn many techniques and work together. It is a guiding period especially for departments with small number of academic staff. Environmental threats of the pandemic are reduction in student-student and teacher-student interaction and suspension of the donor programs. The latter is considered an important risk factor for practical courses. The negative effects of these environmental threats need to be analyzed separately from the teacher and student perspective. In this context, various post-normalization feedback applications may be useful to minimize negative effects.

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Conflicts of interest

There are no conflicts of interest.

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Original Article

Estimation of Humerus Length by Measuring the Dimensions of its Lower Fragments

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Abstract

Introduction: The aim was to obtain the dimensions of the distal fragments of humerus bone, and the objective was to derive the formulae of regression, which will assist us to estimate the humeral length. **Material and Methods:** In this cadaveric research, 166 adult dried humeri from the department of anatomy were utilized. The measurements were performed by using the osteometric board and digital Vernier caliper. The seven distal humeral fragments were measured. **Results:** We were able to associate the dimensions of the distal humeral fragments with the humeral length (P = 0.00). The distances between the radial summit of the capitulum to the ulnar part of the medial epicondyle (right side Pearson's coefficient, 0.70 and left side, 0.78) and the radial side of the lateral condyle to the ulnar most side of the medial epicondyle (right side Pearson's coefficient, 0.69 and left side, 0.77) were the finest parameters, which can predict the length of humerus. **Discussion and Conclusion:** The regression calculations can be of help in estimating the humeral length. Such equations could be utilized during the examinations of forensic cases, where the estimation of height of an individual is required to be predicted, when only a few distal fragments of humerus are available. The figures of this investigation can also help in anthropology and archaeological research.

Keywords: *Anthropology, archaeology, humerus, regression analysis*

Introduction

The different structural components or segments of bone are in certain proportion to each other and with the bone as a whole. It should be possible to reconstruct the individual skeleton from a single bone or a single bone from any of its parts. If the cranium and pelvis are not available, the long bone fragments are used in the anthropology and forensic science investigations.[1] The height of an individual can be determined with the full length of a long bone.[2] Identification of human remains and providing the stature of a person is a difficult process. This is a very imperative phase in estimating the human proportion and dimorphic features in relation to the gender.[3,4] Krishan[5] described that the physique of an individual can be estimated to a desired level of accuracy, from the available individual bones. He also noted that the long bones give the best results for the stature determination.[5] The humeral fragments were utilized, which used their articular surfaces.[6] Steele[2] noted that calculating the human stature is possible with the determination of humeral length if the best bones such as femur and tibia are not available.

This makes the relevance of developing a set of morphometric data, which will be of immense value in forensic science. It was reported that the normative data are essential for a population.[7] There are a wide variety of methods, which can be applied to assess the stature of a person. The method which is of high degree of precision and reliability is the regression analysis.[8,9] This method is reliable in determining the relationship between the size of the bony segments and the length of the bone as a whole.[9] The goal of this investigation was to measure the proportions of the distal end humeral fragments and define the humeral length by using them. The objective was to obtain the equation of regression by using the humeral length.

Material and Methods

In this anatomical research, 166 human adult cadaveric humeri were utilized. They were dried humeri, and among them, 82 were right sided and 84 belonged to the left side. They were obtained from the

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departments of anatomy of our university. Only intact adult humeri, which had normal ossification of the lower end of humerus, were included in this present research. The humeri which had congenital variations and pathological changes were excluded from this study. The humeri belonged to the adult age group (above 20 years), and they belonged to the subjects who lived on earth during the 20th–21st century. However, the age and gender of the specimens were not taken into consideration in this study. We are not sure that the right- and left-sided humeri were from the same individuals, because this is a cross-sectional study from the collections at the anatomy laboratory. All the measurements were conducted by the same researcher, thus preventing the inter-observer error. The dimension of each fragment was measured three consecutive times, and the average of it was considered, which prevented the intra-observer error. We state that this present anatomical research has the permission of the ethics committee of our college.

The maximum length of humerus (MHL) is the distance from the utmost superior aspect of the humeral head to the furthermost inferior aspect of the trochlea. The osteometric board was utilized to collect these data, and it was recorded in centimeters. The following lower-end segments of humerus were measured [Figure 1] in this study with the help of Digital Vernier Caliper (Mitutoyo, Japan):

- S1 – Vertical distance among the distal extents of medial flange of trochlea and inferior edge of the medial epicondyle
- S2 – Distance between the two flanges of the posterior aspect of trochlea at the level of distal limit of olecranon fossa
- S3 – Largest breadth of the olecranon fossa in a horizontal plane
- S4 – Total combined width of the trochlea and capitulum
- S5 – From the lateral extent of capitulum to the medial limit of medial epicondyle
- S6 – From the medial limit of trochlea to the lateral extent of lateral epicondyle
- S7 – From the lateral edge of lateral condyle to the most medial part of medial epicondyle.

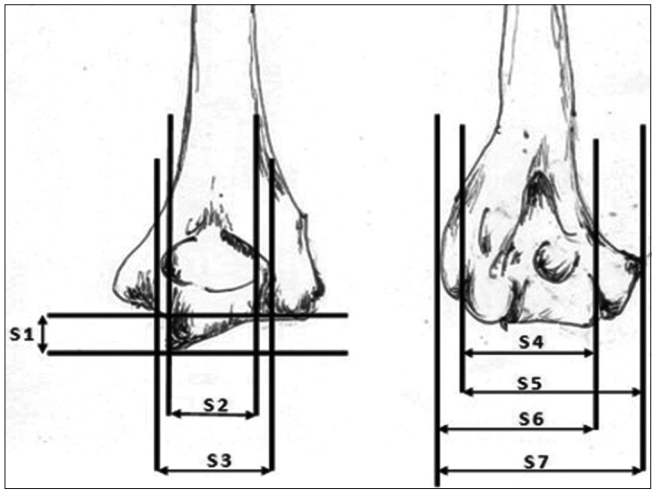

Figure 1: Schematic representation of the measurements of lower end humerus segments in this study

The statistical comparison for the right- and left-sided specimens was performed with the help of independent samples *t*-test. The SPSS software (version 15, company-SPSS Inc., city- Chicago, state- Illinois, country - United States of America was utilized for the statistical analysis, and the mean and standard deviations were tabulated for each of the measurements. The comparison was considered as statistically significant if $P < 0.05$. Pearson's correlation coefficient (R) was used to correlate the proportions of the distal humeral fragments and the length of humerus. The regression coefficient (COE) was obtained by the simple linear regression for the data of the right- and left-sided distal fragments. The Pearson's correlation coefficient between the dependent and independent variables was considered. Various fragments of humerus are correlated with the humeral length, and the Pearson's coefficient helped in finding the power of relation among the variable fragments. The regression equations were then determined from these parameters, which will calculate the expected MHL from its various distal segments.

The prototype of the formula is, MHL = constant + A × fragment length ± standard error of estimate, where "MHL" is the dependent variable (full length of humerus), and "A" is an unstandardized coefficient (multiplication factor). The "fragment length" is an independent variable (measurement of distal fragment of humerus). The SPSS software offered the "constant." The regression equation which has the largest multiplying factor was considered as the best.

Results

The mean length of humerus was 30.7 ± 2 cm and 30.3 ± 2.3 cm over the right and left sides. The dimensions of distal segments of humerus are represented in Table 1. The data were compared over the left- and right-sided humeri, but the significant difference was not observed statistically ($P > 0.05$). However, the vertical space between the distal extent of the medial flange of the trochlea and the inferior edge of the medial epicondyle (S1 segment) was greater [Table 1] on the right humerus than the left

Table 1: Sidewise comparison of the dimensions of the distal humeral fragments

Fragment	Right	Left	*P*
S1	0.82±0.18	0.76±0.14	0.01*
S2	2.08±0.24	2.04±0.23	0.22
S3	2.63±0.26	2.61±0.25	0.75
S4	3.86±0.46	3.84±0.37	0.79
S5	5.30±0.48	5.16±0.49	0.07
S6	4.35±0.39	4.34±0.45	0.93
S7	5.67±0.51	5.57±0.49	0.23

*Dimensions represented in cm, mean±SD, unpaired *t*-test, statistical significance, $P>0.05$. SD: Standard deviation

humerus ($P < 0.05$). The Pearson's coefficient of the fragments is represented in a descending order in Table 2. Table 3 shows the Pearson's coefficient, the coefficient of determination (R^2), and "P" value over the left and right sides, separately. Association between the proportions of distal humeral segments and humeral length were relative, as observed in this study. This association was highly significant as it was not happened with chance ($P > 0.05$).

The best parameters are the S5 segment on the right side and S7 segment on the left side. The Pearson's coefficient was 0.70 (S5) and 0.69 (S7) over the right side and 0.78 (S5) and 0.77 (S7) over the left side. The least value of Pearson coefficient was observed in S1 segment, irrespective of the sides, Pearson coefficient being 0.26 and 0.25 for the right side and left side, respectively.

Table 2: Pearson's coefficient for the distal fragments of humerus in descending sequence

Right	Pearson's coefficient	*P*	Left	Pearson's coefficient	*P*
S5	0.7	0	S7	0.78	0
S7	0.69	0	S5	0.77	0
S6	0.68	0	S4	0.71	0
S3	0.58	0	S2	0.62	0
S2	0.57	0	S3	0.61	0
S4	0.53	0	S6	0.59	0
S1	0.26	0.02	S1	0.25	0.02

These regression equations to the lower-end segments of the humerus over the right and left sides are represented in Table 4. Among them, the regression formula for S2 segment appears to be the best, the multiplying factor being 6.06 for the left side and 4.79 for the right side. The linear regression of the different lower-end segments (S1–S7) of the right and left humeri is represented in scatter diagrams [Figures 2-5].

Discussion

The formulae developed by Pearson in 1899 were revised in 1951, because of the objection that this was based on the measurements taken on a population of fairly short stature. This was inadequate for estimating the living heights of the taller people. Hence, question was raised about its compatibility for the other races.[1] The equation for height determination from the long bone lengths was used in the

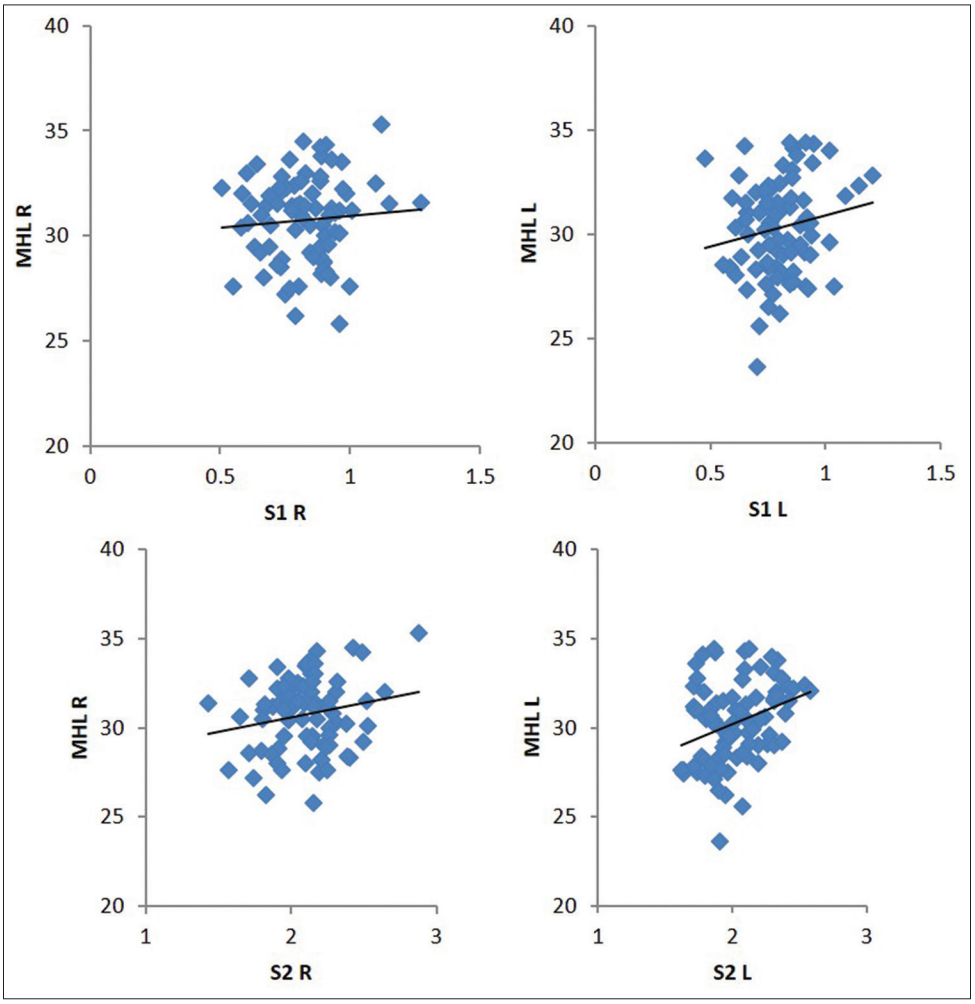

Figure 2: Scatter diagrams showing the linear regression of right and left humeri with S1 and S2 segments

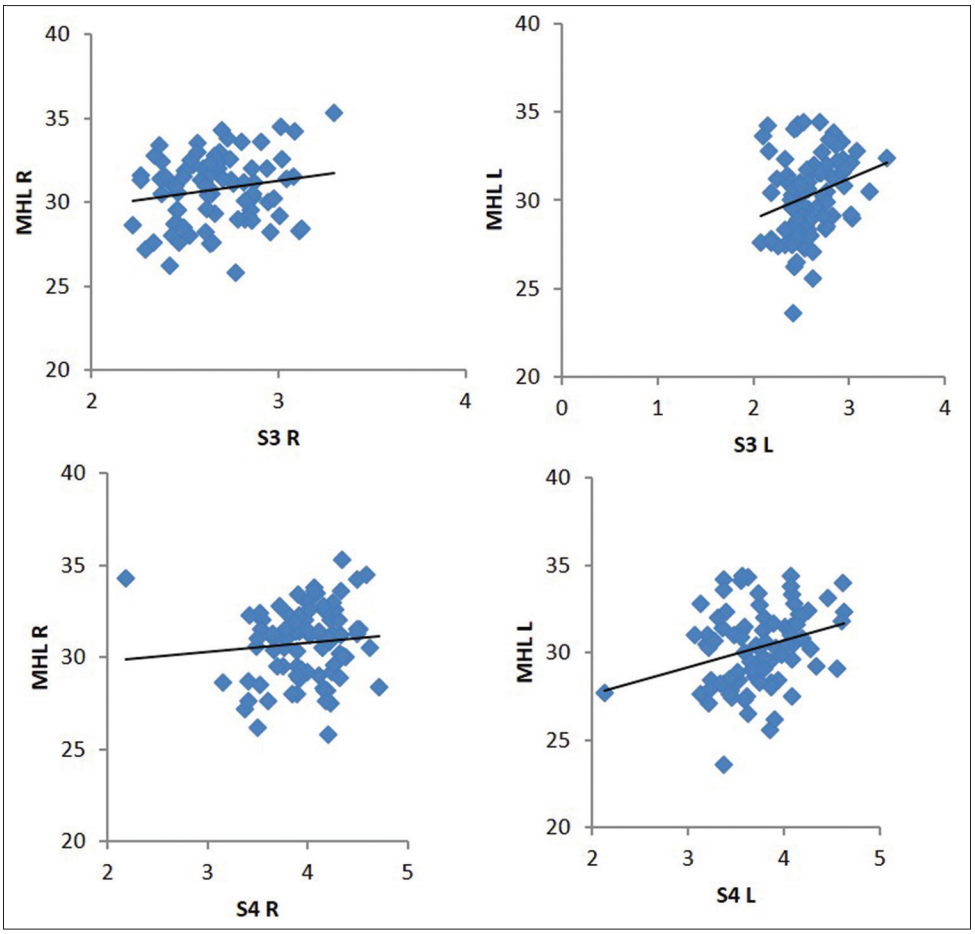

Figure 3: Scatter diagrams showing the linear regression of right and left humeri with S3 and S4 segments

Table 3: Pearson coefficient for the right- and left-sided distal fragments of humerus

Segment	Pearson's coefficient		R^2		Significance (*P*)	
	Right	Left	Right	Left	Right	Left
S1	0.26	0.25	0.07	0.06	0.02	0.02
S2	0.57	0.62	0.32	0.39	0	0
S3	0.58	0.61	0.34	0.37	0	0
S4	0.53	0.71	0.28	0.51	0	0
S5	0.7	0.77	0.49	0.6	0	0
S6	0.68	0.59	0.4	0.35	0	0
S7	0.69	0.78	0.42	0.61	0	0

Table 4: Regression equations for determining total length of humerus (maximum length of humerus) by utilizing the dimensions of distal fragments of humerus

	Right humerus	Left humerus
MHL	28.29 + 2.91 (S1)±1.97	27.25 + 4 (S1)±2.22
MHL	20.74 + 4.79 (S2)±1.68	17.89 + 6.06 (S2)±1.79
MHL	18.87 + 4.51 (S3)±1.66	15.72 + 5.56 (S3)±1.81
MHL	21.86 + 2.30 (S4)±1.73	13.27 + 4.42 (S4)±1.60
MHL	15.18 + 2.93 (S5)±1.45	11.94 + 3.54 (S5)±1.44
MHL	16.58 + 3.25 (S6)±1.58	17.37 + 2.96 (S6)±1.85
MHL	15.84 + 2.63 (S7)±1.55	10.08 + 3.63 (S7)±1.42

MHL: Maximum length of humerus

identification of American people remains following the war in Korea.[10] The stature of a person can be figured out with some amount of accuracy, if a long bone measurement is available.[11,12] The delinquent lies with the archaeological excavation sites, which yield the remains of both adult and subadult population.[3] There were some regression formulae available for the adult remains, and there was none for the subadult bones. The regression equations are globally accepted for the stature determination.[13,14] Mysorekar[15] determined that the regression formula by using the femur and radius was also utilized.[16] Rao *et al*.[17] deducted a formula to determine the sizes of fragmented skeletons of the higher extremity, which in turn is used to determine the stature of the individual. Singhal and Rao[18] stated that the new equations are needed for the shorter fragments. Somesh *et al*.[19] highlighted the use of formulae in forensic, anatomic, archaeological, and orthopedic surgeries. Prashanth *et al*.[20] reported the regression formulae for measuring the length of humerus by upper fragments of humerus. The length of humerus is important to define the population as a whole.[21] The length of the humerus of the present study is comparable to the figures from a Turkey and Spain study.[22] However, it was reported that ancestral variations seemed to exist.[13,23]

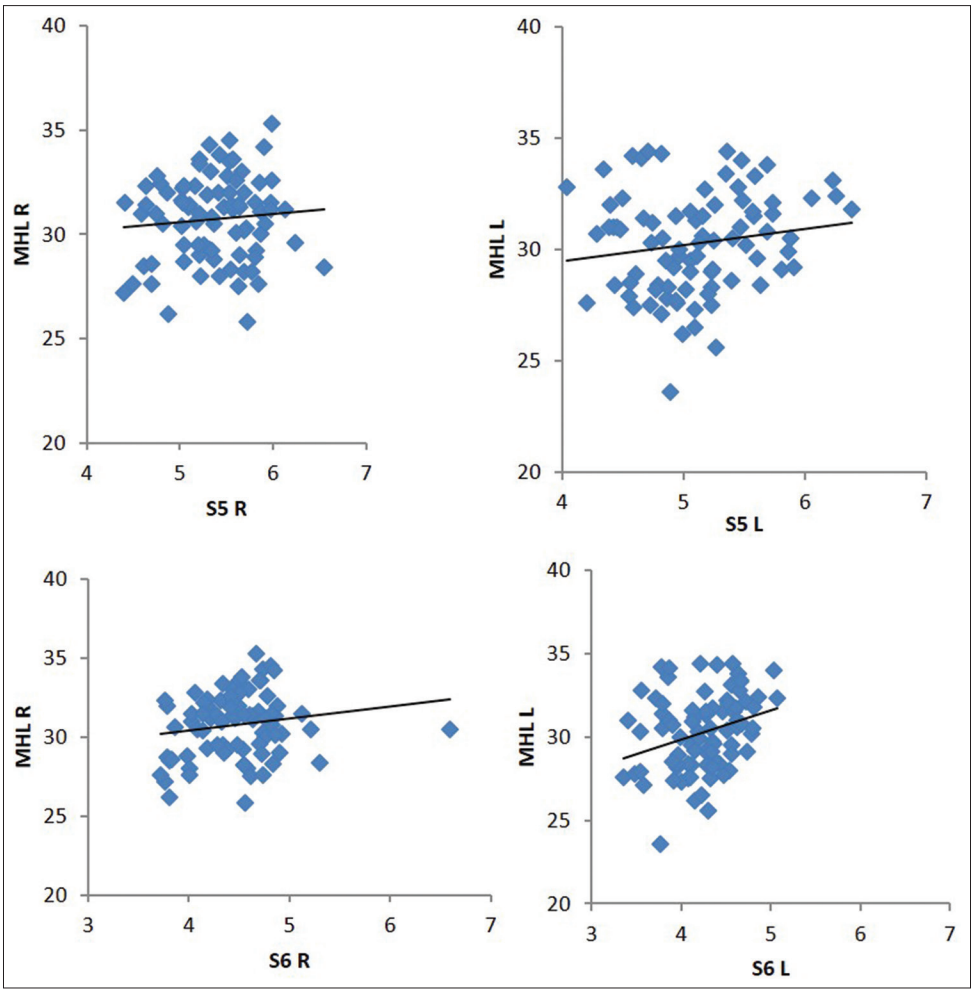

Figure 4: Scatter diagrams showing the linear regression of right and left humeri with S5 and S6 segments

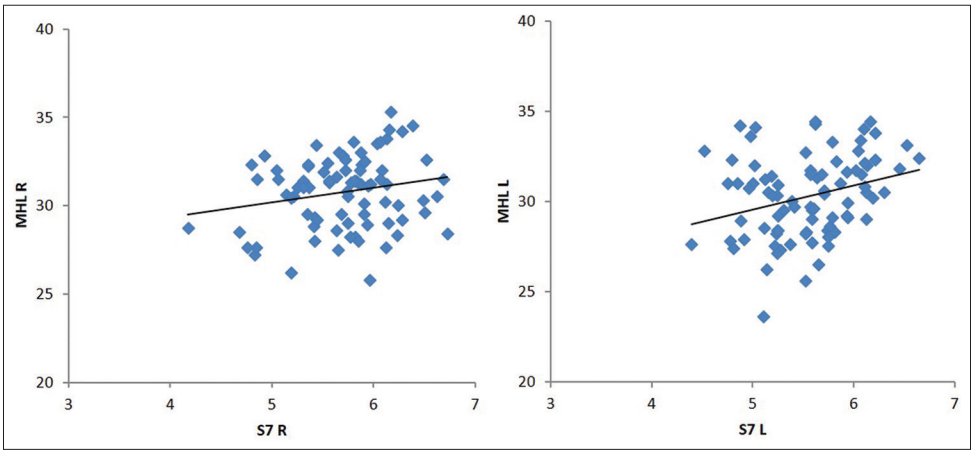

Figure 5: Scatter diagrams showing the linear regression of right and left humeri with S7 segment

In the present study, Pearson's coefficient of the horizontal segments measured, had good averages, which is better than the study by Somesh *et al*.[19] in which most of the segments measured were vertical segments. The present study from distal segments of humerus observed that, in the right side, S5, S7, S6, S3, S2, S4, and S1 are the best for the estimation of length of humerus as per their decreasing order of Pearson's coefficient. In the left side, they were S7, S5, S4, S2, S3, S6, and S1. However, the best values were from S5, S7, S3, and S2, irrespective of the side. This means that the above segments would be more appropriate in using to determine the maximum humeral length. It is

observed that most of the parameters match well among the right and left sides, with respect to the correlation coefficients. However, few were different as the humeri in the samples could not be matched as right and left from the same individual. The humeri in this study were randomly selected from the disarticulated skeleton.

The S4 segment is the total width of trochlea and capitulum, which had a mean of 3.8 ± 0.4 cm and 3.9 ± 0.5 cm for the left and right sides in this investigation. The values for similar segment in Brazilian samples[24] were 3.9 ± 0.4 cm and 4 ± 0.4 cm for the left and right sides, which is slightly higher. The distance from the lateral extent of the capitulum to the medial limit of the medial epicondyle (S5) in this study for the right and left side were 5.3 ± 0.5 cm and 5.2 ± 0.5 cm individually. The previous Brazilian study[24] reported these data as 5.8 ± 0.5 cm and 5.6 ± 0.4 cm, respectively. In the present study, the distance from the lateral edge of lateral condyle to the most medial point of medial epicondyle (S7) was 5.6 ± 0.5 cm and 5.7 ± 0.5 cm at the left and right sides. This is comparable to the data by Salles *et al*.,[24] as the values were 5.8 ± 0.6 cm and 5.7 ± 0.4 cm. These values were marginally on the upper side than the data of our study. These findings compare very well with our present study.

The present study observed that all the segments of humerus had a significance value ($P < 0.05$), which is statistically significant. It was observed that the horizontal segments showed greater Pearson's coefficient of correlation values, suggesting that the horizontal segments were in better ratio relationship with the total humeral length. It was observed that there were some side-based variations. This may not be considered significant as the sample bones are not paired as such. However, the regression formula is applied to the best five of the parameters on either side. In the present study, the regression equation involves a constant, multiplying factor, and the standard error of estimate. The regression formulae, which are derived here, can approximately estimate the humeral length, whenever an incomplete bone is found or need to be studied. The formulae cater to some of the well-demarcated segments of the distal end of humerus.

The data of the present study are of use when only a few fragments of lower end of humerus are available for the medicolegal investigation. The dimensions of the distal humeral fragments can assist in determining the identity of the corpses throughout the medicolegal inquiry. By knowing the humeral length, one can plan to evaluate the height and built of a person. It was reported that the regression formulae of one population cannot be applied to another, as the stature of an individual can vary depending on their ethnicity.[19] The morphological data of distal humeral fragments are important in the orthopedic surgery. The orthopedicians can utilize the morphometric data during the management of distal humeral fractures and reconstructive surgeries.[19] The data are also helpful during the designing of prosthesis in terms of size and positioning. However, the present study has some limitations like the age and gender of the humeri were not taken into consideration. In the present study, the specimens were randomly selected, and it was not possible to confirm the relation among the humeral length and the height of the person, because of the deficiency of data in this anatomical collection of dried humeri.

Conclusion

This study adds to the present data concerning the dimensions of the distal fragments of humerus. The equations, which are derived in this research, may be utilized in medicolegal examinations, where the stature of an individual has to be determined and there are only a few bony fragments of humerus are available for the medico-legal examination. The dimensions are also required in anthropological and archaeological surveys.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Original Article

Estimation of Stature from Stride Length and Lower Limb Length of Efiks in Calabar South, Cross River State, South-South Nigeria

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Abstract

Introduction: The stride length of individuals is believed to correlate with their stature. The aim of the present study was to estimate stature using stride length and lower limb length of Efiks who are indigenes of Calabar South, Cross River State, South-South Nigeria. **Material and Methods:** Stature, lower extremity length, and stride length were measured and recorded for 300 subjects, 150 each of males and females who were recruited randomly from the community. The subjects were between 15 and 45 years. **Results:** Data obtained showed that the mean values for all measured anthropometric parameters including stature were higher in males than in females ($P < 0.05$). The correlation coefficient value derived from the linear regression equation for the estimation of stature using stride length and lower limb length revealed that there is a significant relationship between stature and the measured parameters for the studied population. **Discussion and Conclusion:** The positive correlation between stature and the measured parameters showed that stature can be estimated using the derived linear regression equations specific for the Efik natives of Cross River State. This can be of immense value in the field of crime detection toward stature estimation by forensic experts.

Keywords: *Efik ethnic group, Lower limb length, Stature, Stride length*

Introduction

Stature is the maximum vertical height of an individual in an upright posture. It is an essential component of biological profiling which is mostly employed when developing and reproducing physical features of missing individuals and/or criminals. Stature is the sum of the length of the various segments of the body such as skull, spine, pelvis, and lower limbs.[1]

Stature estimation is very important especially when the biological profile of the individual being sorted for is not known. This will certainly assist in cases of crime, mass disaster, skeletons from mass grave sites and persons having amnesia. In a crime scenario, the physical evidence that can be seen include fingerprint, footprint, shoe print, as well as footsteps marks; in a mass disaster scene, fragmented and commingled body parts are always present. Whereas in a mass grave site, the physical evidence present includes full skeleton, complete, and fragmented bony elements. All these physical evidence have been of great interest in forensic science toward estimation of stature to aid identification process. This can be achieved by finding the correlation values of each segment and then use the values to developing linear regression equations for stature estimation for a particular ethnic group or race.[2-5]

Studies have also revealed that morphometric features of long bone fragments that correlated well with its maximum length can also be used to derive linear regression equations for the estimation of that particular long bone specific for that ethnic group.[2,6] These studies become useful in forensic investigations that involve the identification of the remains of unknown bodies which have been skeletonized.

Different body segments have also shown significant correlation with stature in different population of the world. This fact has been utilized by many researchers who in various studies use different body parts such as hands, cephalo-facial anthropometry, upper and lower limbs segments, arm span length, foot, and footprints to estimate stature.[3-13] Gaur's work on estimation of stature from percutaneous lengths of tibia and fibula showed that the percutaneous

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Figure 1: Measurement of stature in a male subject

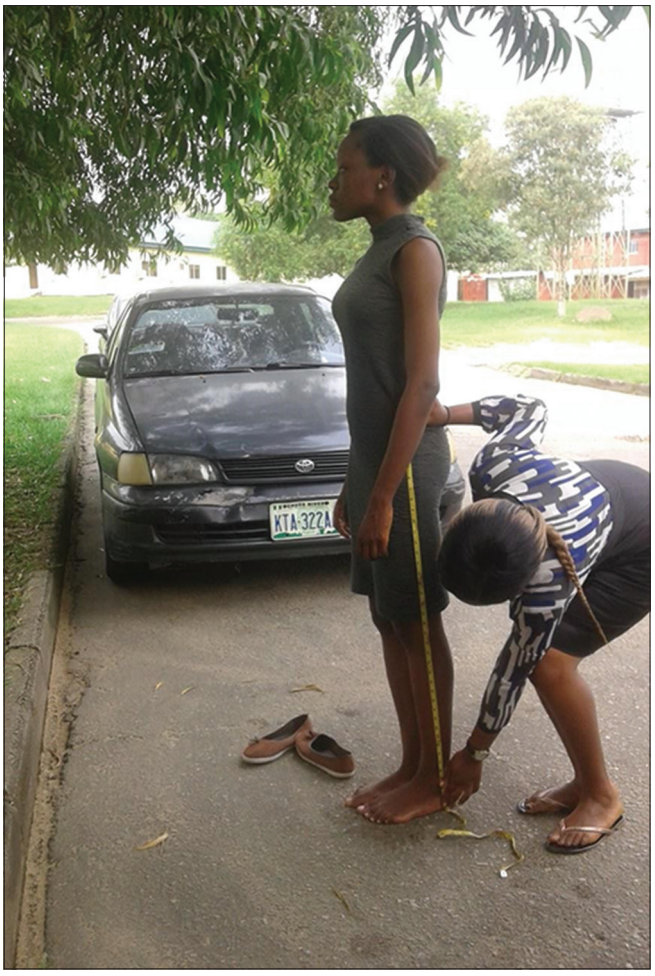

Figure 2: Measurement of lower limb length

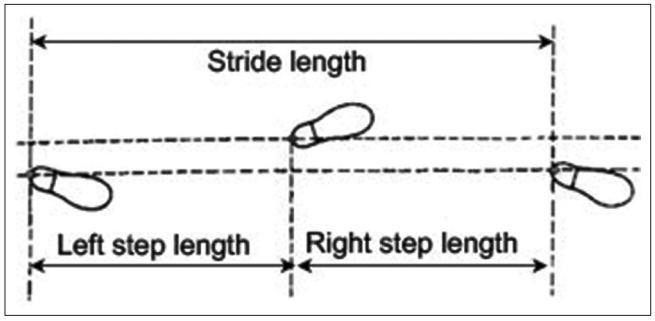

Figure 3: Showing measurement of stride length

mean length of the tibia was a better predictor of stature for males while the fibula was a more reliable predictor of stature in females.[14] Swati *et al*. also estimated stature using the inferior extremity length and foot length in children comprising of 576 male children and 544 female children of the age group ranging from birth to 5 years and observed that stature can also be reliably estimated using the inferior extremity length and foot length.[15]

The aim of the present study was to estimate stature using stride length and lower limb length of Efiks in Calabar South, Cross River State, Nigeria. An extensive review of literature reveals that very few studies have evaluated the use of stride length to estimate stature in different populations.[12,16] Therefore, further investigation into the relationship between stride length and Stature is a *sine qua non* in the comprehensive evaluation of Stature, as an anthropometric and forensic parameter among various climes. It is also important that lower limb length which is completely involved in determining stride length is assessed as it will give further insight in the understanding of the concept of stature.

Material and Methods

900 subjects (450 males and 450 females) were recruited through convenience purposive sampling from among the Efiks in Calabar South, Cross River State, South-South Nigeria. The subjects were between the ages of 15–45 years. The Efiks are the most populous ethnic group in Calabar South of Cross River State. They are predominantly fishermen and shore traders as they are almost surrounded by water bodies. All the subjects included in this study were healthy and free from any apparent deformity of any part of the lower limb.

Methodology: Measurement

Stature was measured with an anthropometer as a vertical distance from the floor to vertex of the skull when the person is standing barefooted with his/her head in the Frankfurt Plane [Figure 1].[17]

Lower limb length

Lower extremity length was measured in centimeter as the distance between iliac crest to the floor [Figure 2], in standing position where back of the shoulders, buttocks, and heels will be close to the wall without any rotation.[9]

Procedures for measuring stride length

The stride length is the distance from the back of the heel of one footprint to the back of the heel of the next footprint of that same foot as shown in Figure 3.[16]

Each subject was made to stand on a plain surface. A mark was made on the floor with a marker indicating the starting line and the subject was asked to place both heels together so they are touching the starting line and walk 10 strides away. On the 10th stride, the feet are brought together and a mark is made behind the heels (heel to heel) as the second reference point. Thereafter, the distance between the two reference points was measured. This distance was divided by 10 to derive the mean stride length of that subject.

Ethical approval

Ethical approval for this research was granted by the ethical committee of the University of Calabar Teaching Hospital, Calabar, Nigeria.

Statistical analysis

Data were collated and scrutinized manually. Data entry and analysis was done using SPSS (Statistical Package for the Social Sciences, Version 21) Statistical Package for Social Sciences (SPSS), IBM Incorporated, New York, USA. Data analysis involved linear regression and correlation techniques.

Results

Data obtained were analyzed, and mean values were derived for stature, stride length, and lower limb length. Student's *t*-test was used to compare differences in the mean of the measured parameters between the sexes. Pearson's correlation coefficient was used to determine the association between stature and stride length as well as stature and lower limb length. Linear regression was carried out to determine equations for the estimation of stature from stride length and lower limb length parameters. A significant difference was taken at $P < 0.05$.

Table 1 above shows that mean values of stature were significantly higher in males than in females ($P < 0.05$). It also indicates that stride length and lower limb length for males were of significantly higher values than their female counterparts ($P < 0.05$).

Tables 2 and 3 present the correlation values and linear regression equations for the estimation of stature using the stride length and lower limb length of Efiks. Correlation coefficient values were significant and positive for both parameters.

Table 4 shows the mean values of the observed stature and the mean values of the estimated stature derived from linear regression equations for the estimation of stature using the stride length and lower limb length of the Efiks,

Table 1: Mean and standard deviation values of the measured anthropometric parameters for male and female Efiks in Calabar South Cross River state

Age	Sex	Stature	Stride length	Lower limb length
15-45	Male	162.8±14.8	62.6±8.3	97.2±18.5
	Female	159.4±14.0	60.1±7.7	92.9±17.5

*Variations in the mean values of parameters along the column are significant at $P<0.05$

Table 2: Correlation values and linear regression equations for the estimation of stature (S) using the stride length of Efiks

Age	Sex	Correlation coefficient value	Significant level	Linear regression equation	Standard error of estimation
15-45	Male	0.454	0.000	S=112.1+ (SL) 0.809	13.26
	Female	0.393	0.000	S=116.7+ (SL) 0.710	12.91

SL: Stride length

Table 3: Correlation values and linear regression equations for the estimation of stature using the lower limb length of Efiks

Age	Sex	Correlation coefficient value	Significant level	Linear regression equation	Standard error of estimation
15-45	Male	1.00	0.00	S=85.00 (LLL) 0.800	0.00
	Female	1.00	0.00	S=84.97 (LLL) 0.800	0.1425

LLL: Lower limb length

Table 4: The mean values of the observed stature and the mean values of the estimated stature derived from linear regression equations for the estimation of stature using the stride length, and lower limb length of the Efiks

Age	Sex	Observed stature	Estimated stature from SL	Estimated stature from LLL
15-45	Male	163.3±13	166.2±8	163.1±13
	Female	157.9±12	162.6±11	157.8±12

*Mean values are not significant at P>0.05. LLL: Lower limb length, SL: Stride length

and there was no significant difference ($P > 0.05$) noted when the mean value derived from observed stature was compared with the mean value for stature derived from the linear regression equations using stride length and lower limb length.

Discussion

In recent times, difficulties are experienced in forensic investigations as criminals now strive to leave no bodily physical trace at any crime scene. They wear hand gloves to cover the fingerprints, face mask to evade facial recognition, rubber sole shoes to cover up footprints, and leather clothing to make sure no hair is dropped at the crime scene which can be used for DNA analysis. The only likely feature of the criminal that is sometimes present in such crime scenarios will be his foot print and foot strides as he moves away from the crime scene.

The stride length invariably can be secured by the forensic investigators as a physical evidence which can be used for possible estimation of the stature toward personal identification of the criminal since it is believed to have a possible correlation with the lower limb length. The lower limb length and part of its component segments like the tibial length have been reported to correlate well with stature.[5,18] Jasuja *et al.* reported that the stride length of a person is related to the height of the person.[16] Although it can be argued that stride length may vary in different walking speeds, Jasuja *et al.*, in their bid to estimate stature from stride length revealed that stride length of individuals while walking fast when compared with the stride length in the normal pattern of walking remains almost the same.[16] Therefore, weather the criminal is working fast or walking with a normal stride, it can still be measured for possible use in stature estimation. The propensity of footprints and footsteps to correlate positively with lower limb length (leg length) and stature have been reported by Ekezie *et al*. and Jasuja, respectively.[12,19] Jasuja studied the estimation of stature from footstep length. He revealed that a positive and statistically significant correlation also exist between stature and footstep length.[12] The results of the present study clearly demonstrate that stride length and lower limb length correlate positively and can be used in the estimation of stature.

For the Efik ethnic group, the average stride length and stature were observed to be 64.0 cm and 161.7 cm in male which is higher than the female values of 61.8 cm and 159.7 cm, respectively. It showed that male values for the measured parameters are significantly ($P < 0.05$) higher than their female counterpart. Sex differences can be explained by the fact that females are genetically shorter than males and by earlier maturity associated with earlier cessation of growth of girls than boys.[4]

The mean values for stature recorded for the Efik ethnic group of Cross River State were similar in range to the reported values for the Igbos of South East of Nigeria for ages between 16 and 45 years.[13] They revealed that the mean observed stature of their studied population was 167.55 ± 9.10 cm, which is slightly higher than that of the current study with a mean value of 160.7 ± 14.6 cm. This slight difference could be due to their genetic variations and geographical location.

The correlation coefficient value derived from the linear regression equation for the estimation of stature using stride length and lower limb length of Efik ethnic group in Cross River State as represented in Tables 2 and 3, respectively, revealed that there is a significant relationship between stature and the measured parameters for the studied population. Mani also established a definite association between stature, limb length, and foot extent.[8] As seen in Tables 2 and 3, all correlation coefficient values were positive. This shows that stature increases as the measured parameters increased in length. Invariably, the longer the stride length or lower limb length, the taller the individual.

This study has actually established the mean stature, lower limb length, and stride length specific for the Efik ethnic group of Cross River State. Stature, lower limb length, and stride length were positively and significantly correlated with each other ($P < 0.05$). The higher correlation coefficient between stature and lower limb length over that of stature and stride length points to the fact that lower limb length is a good predictor of stature. This is the first study in Sub-Saharan Africa to evaluate the accuracy of stride length in estimating stature for forensic purposes. This will further serve as a guidepost in understanding the various components of stature estimation as specific for different ethnicities in Nigeria.

Conclusion

In summary, stride length is significantly larger in male than in their female counterparts. Lower limb length is significantly higher in male than in their female counterpart. Estimation of stature from stride length correlates positively $P < 0.05$ in male and female. The positive correlation between stature and the measured parameters showed that stature can be estimated using the derived linear regression equations specific for the natives of Efik ethnic group of

Cross River State. The linear regression equations derived using the lower limb length and stride length were reliable as tested [Table 4] and it was noted that it can be of immense value in the field of crime detection.

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Conflicts of interest

There are no conflicts of interest.

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Original Article

Study of Variations of Posterior Communicating Artery and Types of Posterior Circulation in Human Cadaveric Brains of South Indian Population

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Abstract

Introduction: Posterior communicating artery (PComA) is the communicating channel between the internal carotid and vertebrobasilar arterial systems. The hemodynamics of the circle of Willis is influenced by variations in the PComA. Such variations may predispose to ischemic stroke due to inadequate collateral supply. Knowledge regarding the variations of the PComA and posterior circulation is of much clinical importance. **Material and Methods:** Eighty-eight posterior communicating arteries in 44 human cadaveric brains were studied. The morphological variations and morphometry of PComA and the various types of posterior circulation were noted and analyzed. **Results:** Morphological variations in PComA consisted of hypoplasia (17.04%) and aplasia (7.95%). The mean length of PComA was 12.72 ± 3.10 mm on the right side and 13.11 ± 3.37 mm on the left side. The four types of posterior circulation were adult type (78.41%), persistent fetal type-partial (12.5%), transitional type (5.68%), and persistent fetal type full (3.41%). **Discussion and Conclusion:** This study provides a comprehensive description of variations of PComA and types of posterior circulation. Awareness of these anatomical variations will be useful to anatomists, neurophysicians, neurosurgeons, and radiologists.

Keywords: *Aplasia, circle of Willis, hypoplasia, partial persistent fetal type and full persistent fetal type, transitional type*

Introduction

Posterior communicating artery (PComA) is a branch of the intracranial part of internal carotid artery (ICA). It courses posteriorly and ends by anastomosing with posterior cerebral artery (PCA). It is the communicating channel between internal carotid and vertebrobasilar arterial systems and contributes to the formation of circle of Willis (CW). PComA gives off many small branches which pierce the posterior perforated substance and supply the medial surface of thalamus and walls of the third ventricle. Internal carotid system or anterior circulation supplies the frontal, parietal, and part of temporal lobes. Vertebrobasilar system or posterior circulation supplies the occipital and part of temporal lobes, along with the brainstem and cerebellum.[1]

Padget described 8 stages in the morphogenesis of cranial arteries in human embryos. In Stage III (7–12 mm embryo), the developing ICA gives off ophthalmic artery, anterior cerebral artery, middle cerebral artery, and PCA [Figure 1a]. In Stage VII (40 mm embryo), communication is established between the PCA and the developing basilar artery, so that the precommunication segment of PCA becomes PComA [Figure 1b]. Henceforth, the definitive PCA appears to be a branch of basilar artery. Eventually, the vertebrobasilar system becomes the main source of blood supply to PCA and the caliber of PComA is reduced till its adult size is attained.[2,3]

In literature, posterior circulation has been classified into four types based on the relative contribution from basilar and carotid systems [Figure 2a-d].[4-6]

1. Adult type – The main contribution to PCA is from the basilar system [Figure 2a]
2. Transitional type – Equal contribution to PCA from the basilar system and carotid system [Figure 2b]

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3. Persistent fetal type-partial – The main contribution to PCA is from the carotid system [Figure 2c]
4. Persistent fetal type-full – Entire contribution to PCA is from the carotid system [Figure 2d].

The greatest variation in arterial caliber between individuals occurs in PComA. It is normally very small so that only limited blood flow occurs between the anterior and posterior circulations. However, in case of occlusion of either of the arterial systems, PComA serves as an important collateral channel and maintains cerebral perfusion. The hemodynamics of CW is influenced by variations in PComA. This predisposes the individual to ischemic stroke due to inadequate collateral supply.[1,7] Hence, our study data will be of much use to anatomists, neurophysicians, neurosurgeons, and radiologists. There is added significance as very few studies have been done so far about the types of posterior circulation, out of which extremely few have looked explicitly for the presence of persistent fetal type-full.

Objectives

1. To study the incidence of PComA
2. To study the length of PComA
3. To study the external diameter of PComA and the incidence of hypoplastic PComA
4. To classify posterior circulation based on the relative external diameter of PComA and the Precommunicating part of PCA
5. To provide South Indian data for the above-mentioned parameters.

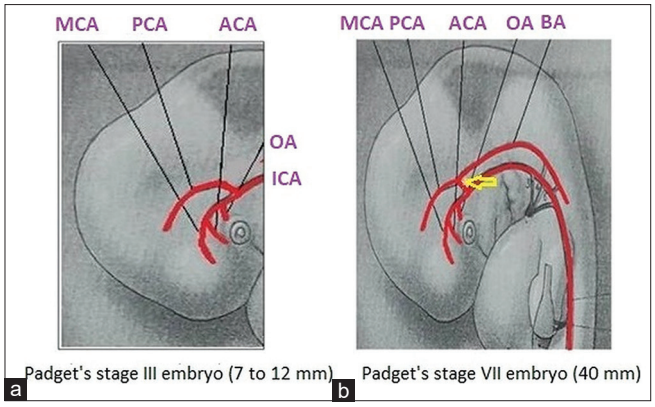

Figure 1: (a and b) Lateral view of human embryo showing the development of posterior communicating artery. ICA: Internal Carotid Artery, OA: Ophthalmic Artery, ACA: Anterior Cerebral Artery, MCA: Middle Cerebral Artery, PCA: Posterior Cerebral Artery, BA: Basilar artery. Yellow arrow in Figure b indicates posterior communicating artery

Material and Methods

Eighty-eight PComA of 44 cadaveric human brains were studied. Measurements were taken using digital vernier callipers. In the base of the brain, interpeduncular fossa was identified. Arachnoid mater was carefully dissected to expose the CW. Individual specimens were serially numbered and photographs were taken. Incidence, length, and external diameter of PComA were studied in detail. The type of posterior circulation was identified. The obtained data were statistically analyzed.

Parameters

1. Presence or absence of PComA
2. Length of PComA: PComA was measured from its point of origin from ICA to its point of termination at PCA
3. Hypoplastic PComA: PComA with external diameter ≤0.5 mm was considered as hypoplastic
4. Type of posterior circulation: Posterior circulation was classified based on the relative external diameter of PComA and precommunicating part of PCA (P1).
   - Adult type: External diameter of P1 > external diameter of PComA
   - Transitional type: External diameter of P1 = external diameter of PComA
   - Persistent fetal type-partial: External diameter of P1< external diameter of PComA
   - Persistent fetal type-full: P1 is absent; PCA is a branch of ICA.

Results

Absence of PComA was observed only unilaterally (5 right and 2 left). PComA was absent in 7 specimens [7.95%, Figure 3]. The mean length of PComA was 12.72 ± 3.10 mm on the right side and 13.11 ± 3.37 mm on the left side. The length of PComA ranged from 7.98 mm to 18.14 mm on the right side and 6.71 mm to

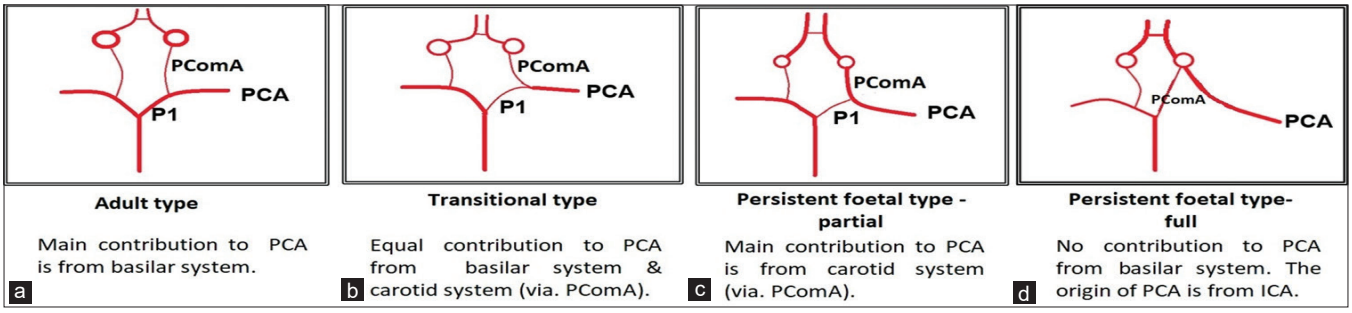

Figure 2: (a-d) Schematic representation of circle of Willis showing the four types of posterior circulation. PComA: Posterior communicating artery, PCA: Posterior cerebral artery, P1: Precommunicating part of posterior cerebral artery

17.75 mm on the left side. Hypoplastic PComA was found in 14 specimens [17.5%, Figure 4]. It was observed in 4 on the right side and 10 on the left side, of which it was bilateral in one specimen. All four types of posterior circulation were observed [Figures 5a-c]. The unilateral and bilateral incidence of each type is summarized in Table 1. Among the four types, the highest incidence noted was that of adult type (78.41%), followed by persistent fetal type-partial (12.5%). In specimens with absent PComA, PCA derived its blood supply from basilar artery. Hence, they were considered to be having adult type of posterior circulation.

Discussion

Absence of PComA found in the present study (7.95%) correlated with the findings of Kannabathula *et al*.[8] (8%) and Ghanbari *et al*.[9] (11%). Posterior communicating arteries are the main collaterals of the CW. Assessing their patency is important before any interventional procedure.[6] In the present study, the length of PComA was found to be 12.72 ± 3.10 mm on the right side and 13.11 ± 3.37 mm on the left side. This correlates with the findings of Shubhangi,[10] who reported that the mean length of PComA was 13.98 mm on the right side and 14.46 mm on the left side.

PComA with external diameter <0.5 mm, irrespective of length, was considered hypoplastic.[11,12] Incidence of hypoplastic PComA was found to be 17.5%. This finding is in accordance with that of Kannabathula *et al*.,[8] 16%. The volume of blood flow in an artery is inversely proportional to its length and directly proportional to its width. Thus, the shorter and wider the artery, more efficient is the transmission of blood to its target tissues. Individuals with hypoplastic PComA are at higher risk of developing cerebral infarctions, due to insufficient collateral circulation. Hypoplastic PComA is difficult to be depicted in computed tomography angiography. This may lead to misinterpretation as absent PComA. Embryologically, hypoplasticity of arteries is explained by a deficiency in reticular fibers in the arterial tunica, which also predisposes them to aneurysms and eventual rupture. Sometimes, aneurysmal hypoplastic PComA may be erroneously interpreted as normal in angiography.[12]

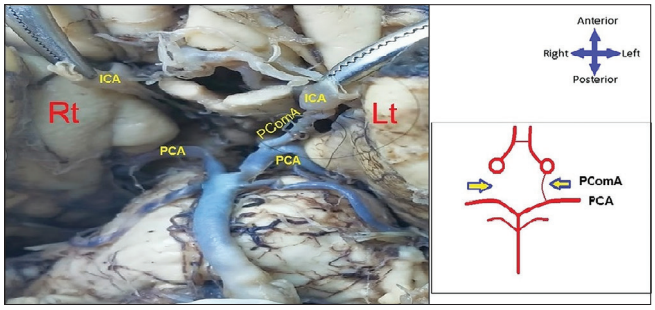

Figure 3: Absent PComA on right side. ICA: Internal Carotid Artery, PComA: Posterior communicating artery, PCA: Posterior cerebral artery

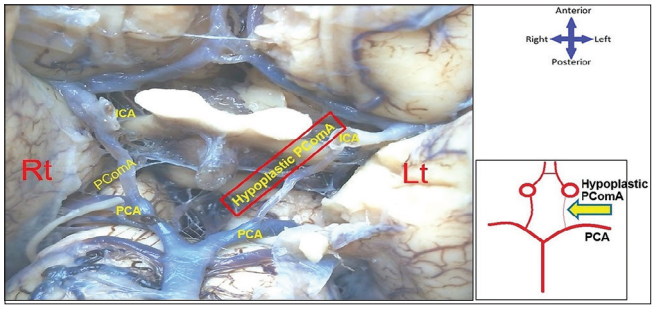

Figure 4: Hypoplastic left PComA. ICA: Internal carotid artery, PComA: Posterior communicating artery, and PCA: Posterior cerebral artery

All four types of posterior circulation were reported by Veras *et al*.[5] According to them, the most common was adult type (73.52%), followed by persistent fetal type-partial (14.70%). Transitional type and persistent fetal type-full were reported to be present in 2.94% each. The findings of the present study [Table 1] are in unison with their study. Many authors did not look explicitly for persistent fetal type-full.[11,13,14]

In two of the three specimens with persistent fetal type-full, hypoplastic PCA was also seen as an accessory vessel [Figure 5c]. PCA was considered hypoplastic, as the external diameter was <1 mm.[10,13] Hypoplastic PCA was 7–8 mm long and ended by ramifying into very small twigs. In one of the three specimens with persistent fetal type-full, the hypoplastic PCA was longer and supplied the PCA territory, along with variant PCA which arose from ICA.

Persistent fetal type of posterior circulation-partial/full is protective in ischemia of vertebrobasilar system, as the perfusion of PCA territory is well maintained through blood supply from ICA.[11]

Individuals with fetal type of posterior circulation and concomitant atherosclerotic disease of ICA are prone to ischemic events in the PCA territory. This is because thrombotic material from atherosclerotic ICA may be dislodged into PCA through the wide PComA.[6] Carotid endarterectomy might be beneficial in some patients with severe carotid stenosis and infarction in the territory of the PCA.[15] In persistent fetal type-full, occlusion of ICA may be disastrous as a large area of brain is supplied by branches of ICA.

Leptomeningeal vessels are anastomoses up to 1 mm in diameter which can be formed between the branches of ACA and PCA and MCA and PCA. In an adult type of posterior circulation, when the CW provides insufficient collateral flow during an ischemic event, leptomeningeal vessels take over as secondary collaterals. This is extremely important in cases of aplastic PComA. In persistent fetal type, obstruction of ICA cannot be compensated by the development of leptomeningeal

Table 1: Incidence of the four types of posterior circulation

Type	Adult type	Transitional type	Persistent fetal type - partial	Persistent fetal type - full
Unilateral				
Right	6	4	4	0
Left	5	1	3	3
Bilateral	29	0	2	0
Total (*n*=88), *n* (%)	69 (78.41)	5 (5.68)	11 (12.50)	3 (3.41)

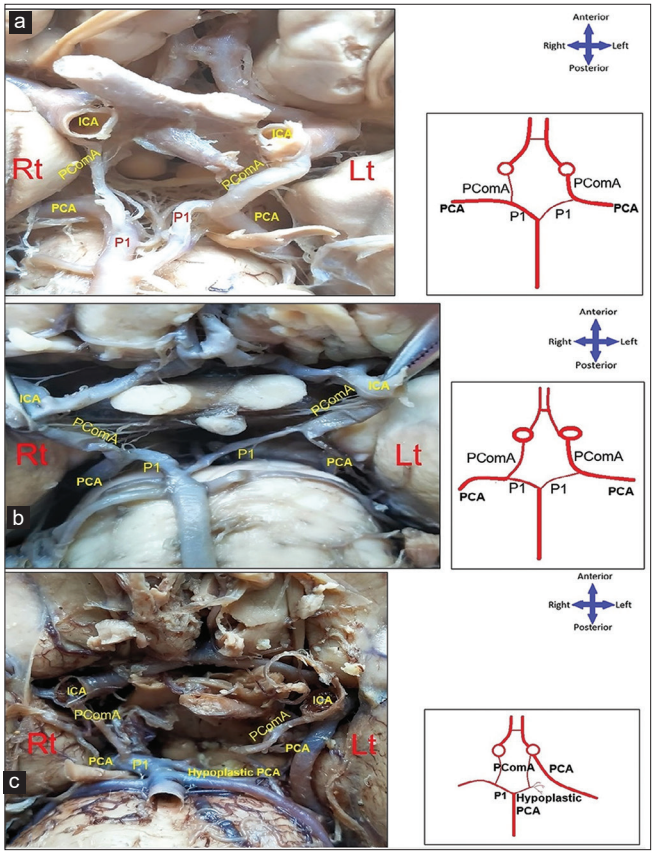

Figure 5: (a) Circle of Willis showing adult type of posterior circulation on right side and Persistent fetal type-partial on left side. PComA: Posterior communicating artery, PCA: Posterior cerebral artery, P1: Precommunicating part of posterior cerebral artery, and ICA: Internal carotid artery. (b) Transitional type on right side. Note Persistent fetal type-partial on left side. PComA: Posterior communicating artery, PCA: Posterior cerebral artery, P1: Precommunicating part of posterior cerebral artery, ICA: Internal carotid artery. (c) Persistent fetal type- full on left side. Note adult type on right side. PComA: Posterior communicating artery, PCA: Posterior cerebral artery, P1: Precommunicating part of posterior cerebral artery, ICA: Internal carotid artery

collaterals between PCA and MCA because they are derived from the same vessel. This makes collateral blood flow completely dependent on the anterior circulation of the contralateral side. Therefore, patients with fetal type of posterior circulation could be more prone to develop vascular insufficiency.[4]

Conclusion

Knowledge about the variations of PComA and types of posterior circulation is of utmost importance in diagnosing cerebrovascular diseases by analyzing clinical scenarios and interpreting radiological images. This is also important in planning interventional procedures involving the CW. Hence, awareness of these anatomical variations is important and will be useful to anatomists, neurophysicians, neurosurgeons, and radiologists.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Original Article

Comparison of Medial Longitudinal Arches of the Foot by Radiographic Method in Users and Nonusers of High-Heeled Footwear among Young Women

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Abstract

Introduction: The arches of the foot help in transmission of the body weight and permit adjustments on uneven surfaces. Prolonged use of high heels causes elevation or collapse of these arches by stress and strain over the weight-bearing bones, and also causes damage to the underlying soft tissues and ligaments. The aim of this study was to document the presence of any changes in medial longitudinal arches in young women using high heels through radiographic method taking into account body mass index, height of heels, and the type of shoes worn and to document lower back pain and foot pain. **Material and Methods:** An observational study between 40 high-heel wearers and 40 flat wearers was done. Lateral radiographs of both feet were taken in weight-bearing position with medial border of the foot touching the cassette. Lateral talocalcaneal angle, lateral talar-first metatarsal angle, angle of longitudinal arch, and calcaneal pitch were measured by a protractor and goniometer. A questionnaire documented complaints of back pain and foot pain. **Results:** Independent sample *t*-test showed a statistically significant difference in left lateral talar-first metatarsal angle between two groups. Pearson's correlation showed a negative correlation between left lateral talocalcaneal angle and low back pain, and a positive correlation between right lateral talar-first metatarsal angle and low back pain. **Discussion and Conclusion:** Frequent and prolonged use of high-heeled footwear can result in damage to the foot architecture leading to foot and back pain. Thus, keeping the high heels reserved for occasional use is the best choice.

Keywords: *Back pain, foot pain, high heels, medial longitudinal arches*

Introduction

A primary step in the evolution of plantigrade, bipedal human gait was the development of the Medial longitudinal arch (MLA).[1,2] It is considered as a terrestrial modification of the arboreal foot. It has two important effects; firstly, it provides the plantar flexor muscles enough mechanical advantage to lift the weight of one's body during stance,[2,3] and secondly, it provides one's foot with the capacity to absorb shock caused by upright striding.[4]

The arches of the foot are transverse arch and longitudinal arch; the longitudinal arch includes the Medial longitudinal arch (MLA) and Lateral longitudinal arch (LLA). The MLA is formed by bones, ligaments, and tendons. The summit of this arch is the talus which is a keystone. The anterior pillar is formed by the heads of the medial three metatarsals, and the posterior pillar is made by medial half of the calcaneus. It is designed by the joints of various bones – the tarsals, metatarsals, and phalanges; this results in ideal transmission of the body weight, and permits adjustments among joints on uneven surfaces. The ligaments, plantar calcaneonavicular ligament (spring ligament) and interosseous ligaments, provide elasticity to the arch which helps in restoring the shape once the disturbing force is removed.[5] Alterations in the normal configuration of the arch cause altered biomechanics in transmitting the body weight and may result in stress and strain over the weight-bearing bones, ligaments, and the most vulnerable part of the arch – the talocalcaneonavicular joint – and cause long-term pain in the foot.

When the medial longitudinal arch of the foot is obtained on a lateral roentgenogram, its configuration is evaluated by measuring lateral talocalcaneal angle, lateral talar-first metatarsal angle, calcaneal inclination

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angle, angle of the longitudinal arch, etc., Fashion has modified the design of the shoes to a point such that the actual function of shoes has become compromised. High heels greatly affect the joint kinetics during walking that may cause abnormalities in the foot. The weight borne with each step becomes concentrated on the metatarsal heads,[6,7] mostly the first metatarsal.

While wearing heels, a person's hips and spine are out of alignment causing an increase in pressure on knees and feet. This results in unsteady gait (in order to maintain center of gravity), restricted running and a change in posture, especially when requiring a more upright posture. They make the wearer appear taller, smarter, and confident; they make the legs appear longer; they make the foot appear smaller; they make the lower leg muscles and gluteus maximus more defined; and they make the arches of the feet higher and better defined.[8] As the great toes extend, plantar fascia is stretched which increases the height of the arch and the calf-to-calcaneus angle decreases as in normal windlass mechanism in the foot. However, high heels prevent the normal flattening during the gait cycle.[9]

Women complain of lower back pain and foot pain and feel inconvenienced by heights between 2.5" and 3.5" (6–9 cm) due to the fact that when the foot slants forward, a large amount of body weight shifts to the ball of the toes resulting in damage to the underlying soft tissues and ligaments of the sole.[10] Long-term use of high-heeled shoes disrupts the arches and causes changes in the plantar pressure distribution and gait.[11] It possesses a major risk factor for musculoskeletal problems such as ankle sprains by slips and falls, heel pain, lower back pain, muscle fatigue, ligament tears, hyperkeratotic corns and callosities, shoe bites, plantar fasciitis, hallux valgus (hammertoes), or bunions.

Till date, studies of the effects of wearing high heels have concentrated only on musculoskeletal,[12] kinetic, kinematic, neural parameters;[13-15] gait;[16,17] plantar arch index evaluation by foot impressions;[8] venous function;[18] or psychosocial behavioral aspects.[19]

The aim of this study was to document the influence of high-heeled shoes on the medial longitudinal arch of the foot by radiographic methods taking into account body mass index (BMI), height of heels, and type of shoes worn, and correlating it with the presence or absence of back and foot pain.

Material and Methods

This study was conducted in the Department of Radiology of our hospital. Ethical clearance was obtained from the Institutional Review Board prior to the start of the study (IRB No.: 2019/26/003).

Inclusion criteria

A total of 80 women in the age group of 18–25 years were included in two groups:

- Group 1 (test): 40 habitual high-heeled footwear users
- Group 2 (control): 40 flat footwear users.

Exclusion criteria

Women with history of trauma to lower limbs, any skeletal deformities of lower limbs, pregnant women, and women of age less than 18 years or more than 25 years were excluded from this study.

Prior to testing, participants were informed about the procedures and informed consent was obtained. A case report form/questionnaire was provided to each participant to enter their personal and demographic details.

Duration of usage of high heels and height and type of footwear were noted in addition to their body weight and height. History of low back pain and foot pain was also documented.

Methodology

This observational study was conducted over a period of 2 months (June–July 2019). As per Neil J. Cronin,[20] participants with a history of wearing minimum heel height of 2" for at least 40 hours per week, for about 2 years were included in "test" group, and the women who wore flat footwear or heels occasionally or rarely for less than 10 hours in a week were included in "control" group.

Foot, on standing, performs static function by giving weight-bearing support and while walking it performs dynamic function by propelling the body weight forwards. There are many ways for measuring the MLA both statically and dynamically although it is a controversial issue and there is no universally accepted clinical or radiological method. The methods can be classified into direct and indirect methods. Direct methods are anthropometric and radiographic evaluations,[21,22] while indirect methods are footprint and photographic analyses.[21,23]

Our study uses the technique of measurement under the static and direct (radiographic) method for the reason stated by Saltzman *et al*.[24] mentioned below in the discussion.

Procedure

Lateral radiographs of right and left feet of both the test and control groups were taken in weight-bearing position. Lateral talocalcaneal angle, lateral talar-first metatarsal angle (Meary's angle), angle of longitudinal arch, and calcaneal inclination angle (calcaneal pitch), as shown in Figure 1,[25] were measured by a protractor and goniometer separately, and compared between the two groups.

Standard techniques were employed in taking the lateral view. Subjects stood on a wooden platform with the medial border of the foot touching the cassette or detector plate in weight-bearing position. Proper precautions were taken, keeping in mind the harmful exposure of x-ray radiations.

The X-ray tube was placed parallel to the wooden platform with the central beam targeted on the base of fifth

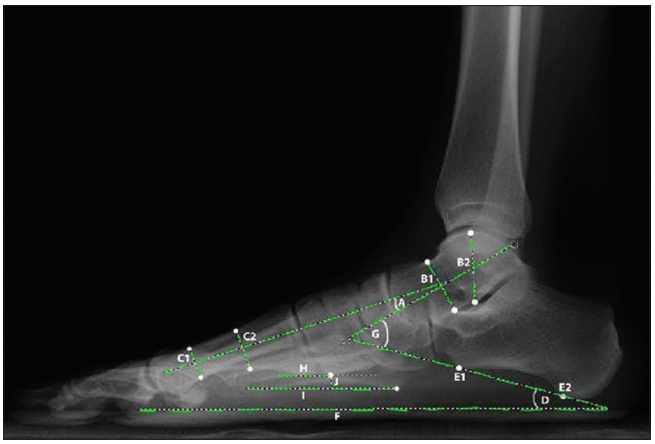

Figure 1: Angles of the arches of foot where A is lateral talar-first metatarsal angle, G is talocalcaneal angle, and D is calcaneal pitch[25]

metatarsal. The X-ray film was kept at a distance of 54" and the radiation exposure given was 8 mAs at 50 kV. The cassette size was 12" ×10" placed in landscape orientation.

All radiological measurements were independently measured by two different individuals to minimize manual and parallax errors, and care was also taken to eliminate magnification errors.

Statistical analysis

Data obtained were subjected to Independent sample *t*-test and Pearson's correlation analysis available in Statistical Package for the Social Sciences (SPSS) 17.0 statistical software, Chicago, USA. Level of statistical significance was fixed at $P<0.05$.

Results

Eighty, apparently healthy, female students were enrolled for this study. They were divided into two groups depending on the use of high heels. Test group included students who regularly used high-heeled footwear (40 students) and control group included students who did not use high-heeled footwear regularly (40 students). Table 1 gives the mean values of the age, height, weight and body mass index (BMI) of both the groups. Independent sample *t*-test statistics between the two groups is shown in Table 2. The mean values of all angles except left lateral talar-first metatarsal angle fall in normal ranges. The left lateral talar-first metatarsal angle showed a statistically significant difference (P=0.017) between the test and control groups. The other angles did not show any statistically significant difference between the two groups.

The results of the correlation analysis between foot angles and BMI did not show any statistically significant correlation as shown in Table 3.

Correlation with low back pain

Left lateral talocalcaneal angle shows a significant negative correlation (r=-0.327; P=0.04) and right lateral talar-first metatarsal angle shows a significant positive correlation (r=0.327; P=0.039) with the presence of low back pain in those who wear high heels, as shown in Table 4.

Table 1: Demographic characteristics of the study group

Parameters	Usage of high heels, mean±SD	
	Test group	Control group
Age (years)	20±1	20±1
Height (cm)	157±6	160±7
Weight (kg)	55±9	57±10
BMI (kg/m^2)	22.49±3.55	22.41±3.60

BMI: Body mass index, SD: Standard deviation

Correlation with foot pain

All the foot angles measured did not show any statistically significant correlation with the presence of foot pain in individuals who were high heels, as shown in Table 5.

Figure 2 shows that 17.5% of individuals experienced low back pain due to the usage of high-heeled footwear.

Foot pain was seen in 37.5% of individuals who regularly used high-heeled footwear, as shown in Figure 3.

Figure 4 shows the number of individuals wearing different footwear with variable height of heel. Twenty-seven individuals wore heels of >2.5" height.

Table 6 gives the information regarding percentage of different types of heels worn by participants included in Group 1.

Discussion

The medial longitudinal arch height is one of the important criteria for classifying configuration of the foot into pes rectus (normally aligned foot), pes planus (flat foot), and pes cavus (high-arched foot). It is important for evaluating foot functions.

As mentioned in a study, the arch tends to elevate into a high arch within 2–5 years of wearing high heels and then tends to flatten within 6–10 years and tends to collapse into a flat foot in more than 20 years of wearing high heels.[11]

Clinically, measurement of the arch involves measuring the soft tissue or bony landmarks of the foot with respect to straight horizontal surface. However, variations in the shape of the foot make it difficult for accurate identification and palpation of these landmarks. This shows concern about the validity and reliability of such manual measurements. Therefore, Saltzman *et al*.[24] considered the radiographic measurement of the arch structure as the "gold standard" for three reasons. Firstly, it provided a clear two-dimensional image of the skeletal components. Secondly, the reliability is high. And thirdly, correlation between foot radiographic parameters and injury of the lower extremities can be made out.

Lateral talocalcaneal angle, lateral talar-first metatarsal angle (Meary's angle), angle of longitudinal arch, and calcaneal inclinational angle (calcaneal pitch) were

Table 2: Comparison of mean values of different foot angles measured between two groups

Foot angle measured	Mean±SD		Statistics
	Test group	Control group	
Right lateral talocalcaneal angle	38.98±5.75	38.83±6.03	$t78=0.114$, $P=0.910$
Left lateral talocalcaneal angle	36.38±5.79	37.70±5.95	$t78=-1.010$, $P=0.316$
Right calcaneal pitch	19.80±4.28	20.55±3.76	$t78=-0.833$, $P=0.407$
Left calcaneal pitch	20.58±3.96	21.08±4.36	$t78=-0.537$, $P=0.593$
Right lateral talar-first metatarsal angle	5.40±5.25	3.73±3.88	$t78=1.623$, $P=0.109$
Left lateral talar-first metatarsal angle*	6.15±5.97	3.50±3.28	$t60.608=2.461$, $P=0.017$*
Right angle of longitudinal arch	160.20±4.28	159.45±3.76	$t78=0.833$, $P=0.407$
Left angle of longitudinal arch	159.43±3.96	158.93±4.36	$t78=0.537$, $P=0.593$

*Correlation significant at $P<0.05$ level. SD: Standard deviation

Table 3: Correlation of body mass index with foot angles measured in test group

Foot angle measured in correlation with BMI	Pearson's correlation	Significance
Right lateral talocalcaneal angle	−0.038	0.816
Left lateral talocalcaneal angle	−0.051	0.753
Right calcaneal pitch	−0.002	0.992
Left calcaneal pitch	−0.236	0.143
Right lateral talar-first metatarsal angle	−0.040	0.807
Left lateral talar-first metatarsal angle	−0.164	0.312
Right angle of longitudinal arch	0.002	0.992
Left angle of longitudinal arch	0.236	0.143

BMI: Body mass index

Table 4: Correlation of presence of back pain with foot angles measured in test group

Foot angle measured in correlation with presence of back pain	Pearson's correlation	Significance
Right lateral talocalcaneal angle	−0.014	0.933
Left lateral talocalcaneal angle*	−0.327*	0.040*
Right calcaneal pitch	−0.037	0.819
Left calcaneal pitch	−0.050	0.759
Right lateral talar-first metatarsal angle*	0.327*	0.039*
Left lateral talar-first metatarsal angle	0.168	0.300
Right angle of longitudinal arch	0.037	0.819
Left angle of longitudinal arch	0.050	0.759

*Correlation significant at $P<0.05$ level

measured in the lateral view roentgenogram to evaluate the medial longitudinal arch of the foot.

The following angles were measured as described by Simons,[26] Vanderwilde *et al*.,[27]

- The lateral talocalcaneal angle [Figure 5] is formed by joining the line bisecting the talus with the line along the axis of the calcaneus. A line is drawn at the inferior border of the calcaneus. The other line is drawn through two midpoints in the talus; one at the body and one at the neck. The normal range is 25°–45°[25,28,29]
- The lateral talar-first metatarsal angle (Meary's angle) is formed between the long axis of the talus and the first metatarsal [Figure 6]. In the normal foot, the midline axis of the talus is in line with the midline axis of the first metatarsal, i.e. the angle, $n=0°$. An angle of more than 4° with convexity facing downwards, is considered as pes planus; an angle of more than 4° with convexity facing upwards, is considered as pes cavus.[25,29]
- The calcaneal pitch [Figure 7] is defined as the angle formed by the intersection of a line drawn tangentially along the inferior border of the calcaneus and a line drawn along the inferior/plantar surface of the fifth metatarsal head. There is a debate on normal range, but anything between 17° and 32° is considered normal[25,28,29]
- The angle of longitudinal arch [Figure 8] is formed between the calcaneal inclination axis and a line drawn along the inferior edge of the fifth metatarsal. The normal range is 150°–170°.[28,30]

The results of our study showed statistically significant changes in lateral talar-first metatarsal angle of women who wore heels habitually, implying that wearing heels even for less than 2 years can bring about some changes in the arch height, although elevation or collapsing of the arch was not seen in our study sample and it is expected only in those who wear heels for a longer period of time. Our study group had college students who mostly wore wedges/platforms/flatforms/block heels for an average of 7–8 active working hours for about 2 years, with an average height of heel being 2.706".

Other angles did not show significant changes and they were all in normal ranges of the angles, meaning no major arch changes with respect to these angles were seen. In a similar study by Wadee,[31] changes were seen, but only in some foot angles: changes in lateral talar-first metatarsal angle, calcaneal pitch angle (in lateral view), and talonavicular (in anteroposterior [AP] view) were seen; while lateral talocalcaneal angle remained unchanged. He concluded that wearing 2" heels for about 8 weeks had an impact on the foot angles.

There is a variety of footwear available with considerable variation in design and shape of the heel. Our questionnaire recorded the height and type of heels worn because more

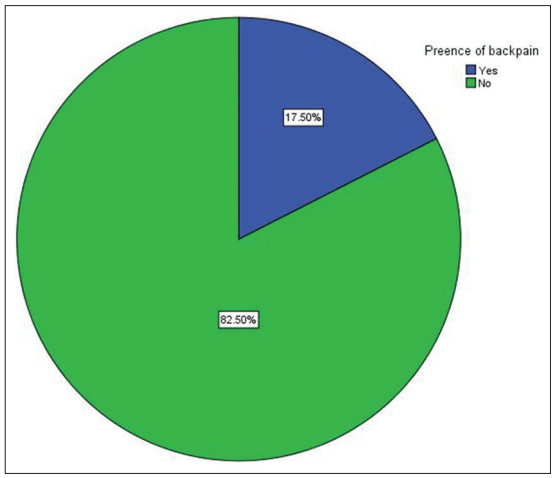

Figure 2: Percentage of high-heel users with back pain

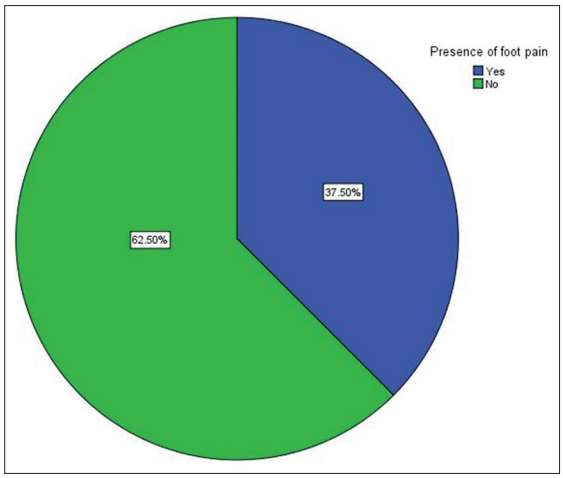

Figure 3: Percentage of high-heel users with foot pain

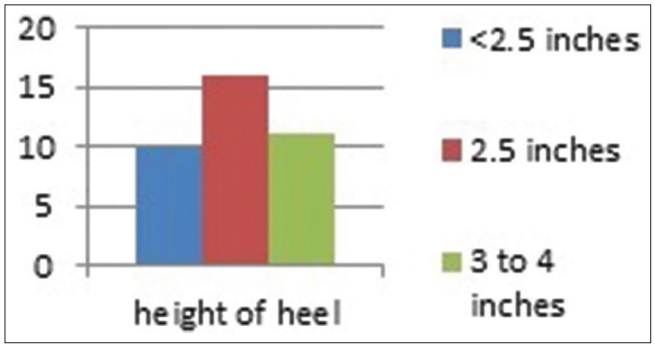

Figure 4: Frequency of individuals wearing footwear with varying heel height

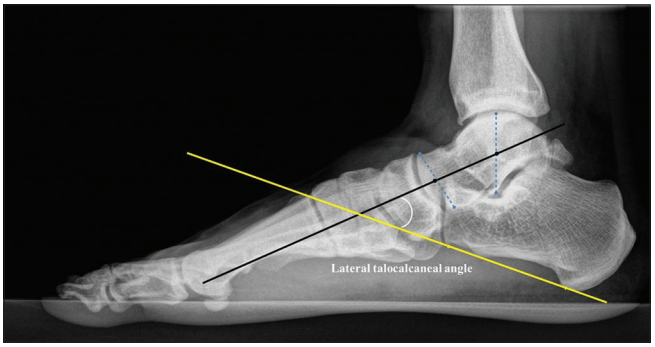

Figure 5: Lateral talocalcaneal angle

the heel height, more is the pressure applied on the balls of the toes and sole. 1" heel increases pressure by 22%, 2" heel increases pressure by 57%, 3" heel increases pressure by 76%,[12] and the type of heels will determine the degree of compression of the toes and inclination of the plantar surface from the horizontal surface by the shoe.

High heels vary from a kitten heel of 1"–2" to a stiletto heel of 4" or more. Extremely high-heeled shoes >5" are usually worn only for esthetic reasons and are mostly impractical. High heels lie between 3.5" and 5" while mid-heels lie between 2.5" and 3.5" and low heels are <2.5".[8] A graph representing the height of heels in our study population is shown in Figure 3, and Table 6 shows the percentage of women wearing each type of heels, with wedges and flatform/platform heels being the most popular.

As concluded by Borchgrevink GE *et al*,[32] high heels caused foot pains and callosities but no anatomical foot deformities. Our study also reported 37.5% of women who wore high heels complained of foot pain, of which 33% were sure that the pain was caused by wearing heels, 60% were not sure, and <6% said that the pain was not because of wearing heels [Figure 3]. 17.5% of women also complained of having low back pain [Figure 2].

Table 5: Correlation of presence of foot pain with foot angles measured in test group

Foot angle measured in correlation with presence of foot pain	Pearson's correlation	Significance
Right lateral talocalcaneal angle	−0.176	0.276
Left lateral talocalcaneal angle	−0.021	0.895
Right calcaneal pitch	−0.098	0.548
Left calcaneal pitch	0.008	0.960
Right lateral talar-first metatarsal angle	0.269	0.093
Left lateral talar-first metatarsal angle	0.107	0.510
Right angle of longitudinal arch	0.098	0.548
Left angle of longitudinal arch	−0.008	0.960

Our study showed changes in the anatomical structure of the arch with significant chnages in lateral talar-first metatarsal angle.

It can be seen that wearing wedges/platforms/flatforms caused less foot pain and back pain, suggesting that these types of shoes are comparatively better than pointed high heels like stilettos as the pressure is distributed along the entire plantar surface and provides more body balance, unaltered gait, and comfort.

Our study also showed that there was a negative correlation seen with complaints of low back pain in

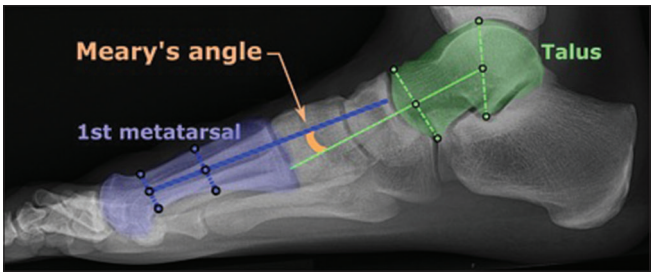

Figure 6: Lateral talar-first metatarsal angle

Figure 7: Calcaneal pitch

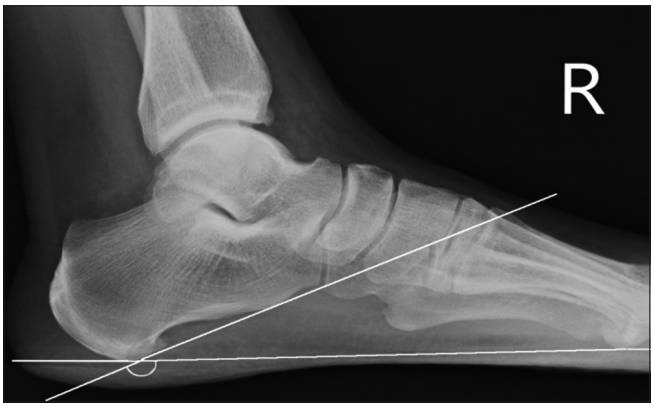

Figure 8: Angle of longitudinal arch

relation to lateral talocalcaneal angle, indicating that as the angle decreased, low back pain increased and vice versa. Further positive correlation was seen with right lateral talar-first metatarsal angle, which indicates that low back pain proportionally increased with increase of angle.

Since both the study groups complained of foot pain irrespective of the type of footwear used, it could not be considered of any significance in our study.

Limitations of this study

Further studies need to be done in women who wear heels for more than 2 years duration, with more focus on those who use pointed type of high heels, so as to find out if any significant changes exist in other major foot angles.

Our study was limited to taking lateral view of X-rays; future studies using antero-posterior (AP) view of X-rays to measure foot angles can also be done; comparison between weight-bearing angles to nonweight-bearing angles can also be done.

In addition, we have used the goniometer, which is a manual method of calculating angles due to unavailability of software and experience to handle advanced technology; further studies can be done using online software such as AutoCAD, Microsoft, and Orthopractis or by using computed tomography scans.

Table 6: Percentage of high-heel wearers

Type of high heels	Percentage
Block heels	14.5
Flatform/platform heels	18.18
Wedges	43.6
Stilettos	5.45
Kitten heels	9.09
Pencil heels	9.09

Conclusion

The findings obtained in our study indicate deleterious orthopedic changes in the plantar arch and gait because of increased stress on the foot on prolonged usage of high-heeled shoes. In addition, forcing toes into a small shoebox, can cause or worsen conditions such as corns, hammertoes, bunions, and Achilles tendinitis, along with raised concern over the presence of foot and low back pain.

In agreement with Joseph Sachithanandam,[33] we can conclude that if one wears high heels over 2" regularly, then they are more likely to develop chronic foot problems and working with them for 8 h or more in a day over a long period of time (>2 years) may lead to an altered foot arch.

This study would suggest women to use footwear with wedges/platforms/flatforms or heels less than 2" height, and to keep it occasional. It would also help young women change their lifestyle and choose appropriate footwear so as to avoid bony pains and anatomical deformities in future.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Original Article

Comparison of Human Renal Arteries in Cadavers and in Computed Tomography Scans – A Morphometric Study

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Abstract

Introduction: The right and left kidneys receive their blood supply from the lateral branches of the abdominal aorta that is, respectively, from the right and the left renal arteries. The study of renal arteries is thus very important, but the literature shows a scarcity of data for the Indian population. This study was, therefore, planned to compare the morphometry of human renal arteries in cadavers and in computed tomography scans. **Material and Methods:** The study was conducted on 36 formalin-fixed cadavers and on 36 computed tomographic scans of renal arteries. The various parameters measured included the length of renal arteries, internal diameter of renal arteries at its origin, the vertical distance between the renal arteries at its origin and the point of bifurcation of the aorta, and vertical distance between the origins of the right and left renal arteries. **Results:** The length of the right renal artery was more than the left renal artery, there was no difference in the internal diameter of both the vessels at their origin and no difference in the vertical distance between the site of origin of renal arteries and bifurcation of Aorta. **Discussion and Conclusion:** The information of the right renal artery being longer than the left kidney confirms with the data available in the literature. The vertical distance between the origins of the renal artery and bifurcation of the aorta is important as it aids the radiologists for performing angiography. Furthermore, the data from this study would aid and supplement the preexisting data for the surgeons during renal transplantations.

Keywords: *Aorta, cadavers, computed tomography scans, kidney, renal artery*

Introduction

The renal arteries are known to exhibit morphological and morphometric variations. These variations are extensive and attributed to the complex embryonic development of the kidneys.[1] With the advent of the era of renal transplantation, the morphometric study of renal arteries has become a topic of interest for anatomists, clinicians, and surgeons. Furthermore, since the dawn of laparoscopic nephrectomy as the technique of choice for organ procurement in living kidney donors, computed tomography (CT) scan has emerged in a key role. It aids in as a noninvasive preoperative planning method for anatomic evaluation.[2] Several studies have been conducted over the last few years correlating the CT angiography, MR angiography, and conventional angiographic anatomy with the surgical findings, the cadaveric studies have shown the vivid type of pattern.[3] Unfortunately, there is the dearth of comparative studies on this topic in the Indian population, Thus the present study aims to add on the existing data of comparative studies. This data will help the clinicians to understand the cause of the increasing renal diseases and the surgeons to advent more conservative methods in renal surgeries.

Material and Methods

The study was conducted on 36 formalin-fixed cadavers and on 36 computed tomographic scans of renal arteries. Thus, data of 71 formalin-fixed kidneys (36 right and 35 left sides as in one cadaver left kidney were absent) and 72 renal arteries on computed tomographic scans (36 right and 36 left sides) was studied. Cadavers were studied in the Department of Anatomy of a teaching institute and CT scans data were obtained from the Department of Radiology of a tertiary care hospital.

The data (reports) of computed tomographic scans were taken retrospectively from the medical records on DVD. The various parameters were measured using digital imaging and communications in medicine (DICOM) viewer software.

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In cadavers, after manual dissection, the length of the renal artery was measured from the level of origin to the hilum. However in cases, where the renal artery branched before the hilum, measurement was taken up to the first branch. These measurements were taken using divider and scale [Figure 1]. The internal diameter of the renal artery was measured at its origin. To measure this circumference of the vessel was taken by cutting it open [Figure 2] and using the formula (circumference = π × Diameter) the internal diameter was recorded. The vertical distance between the right renal artery at its origin and the point of bifurcation of the aorta was measured with the help of thread, divider, and scale. Similarly, the distance between the left renal artery at its origin and the point of bifurcation of the aorta was also measured [Figure 3]. The vertical distance between the site of origin of the right renal artery and the left renal artery was measured with the help of a thread, divider, and scale [Figure 4]. Similar parameters were measured in computed tomographic scans using tools in the DICOM viewer software [Figures 5-8]. Furthermore, observation for accessory renal arteries was done in both cadaveric and CT studies, but since this parameter was not an objective of the present study the details of the same are excluded.

Statistical analysis of the data was carried out to find out the mean and standard deviation in Microsoft excel.

Student's *t*-test (unpaired *t*-test) was used to determine the significance of the difference in the values between left and right renal arteries. The same test was applied to determine the significance of the difference between the values obtained in cadavers and CT study independently. (The value of "*P*" <0.05 was considered significant and >0.05 was considered not significant).

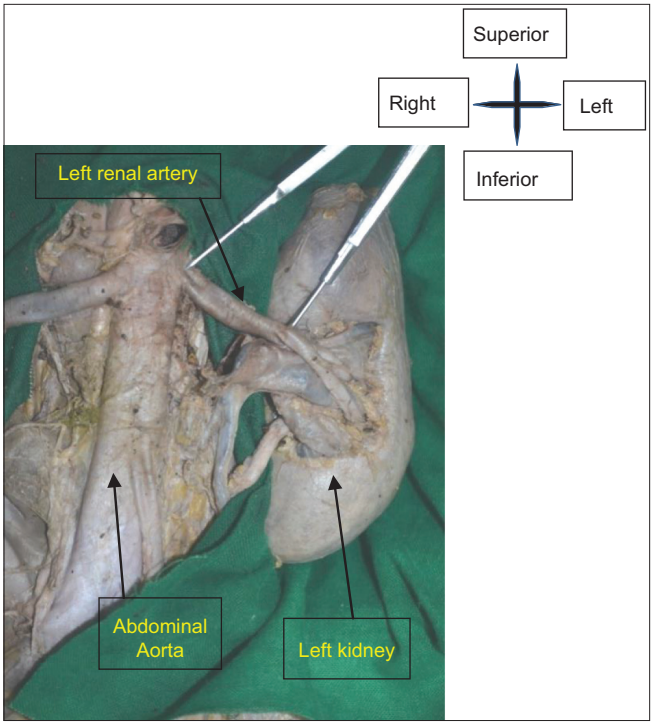

Figure 1: Illustration showing measurement of length of renal artery in cadaver

Results

The following results were obtained:

Length of renal artery Table 1

On comparing the length of the renal arteries in cadavers with same in CT study, "*P*" value was 0.0017 (<0.05) for the right renal arteries. Similarly, on the left side, the "*P*" value was 0.00016 (<0.05).

Internal diameter of renal artery at its origin Table 2

On comparing the internal diameter of renal artery at its origin in cadavers with same in CT study, "*P*" value was 0.0011 (<0.05) for the right side. While on the left side, the "*P*" value was 0.0024 (<0.05) hence significant.

Vertical distance between the site of origin of the renal artery and bifurcation of the aorta Table 3

On comparing the values of the cadaveric study and CT study, the "*P*" value was 0.0003 for the right side and 0.0007 for the left side.

Vertical distance between the site of origin of the right renal artery and left renal artery Table 4

On comparing the vertical distance between the site of origin of the right renal artery and left renal artery in cadavers and CT the "*P*" value was 0.012.

The accessory renal arteries were observed in 16 cadavers and 5 CT scans.

Discussion

The various morphometric measurements of the renal artery are important for stenting and transplantation. These information are not only useful for planning but also for

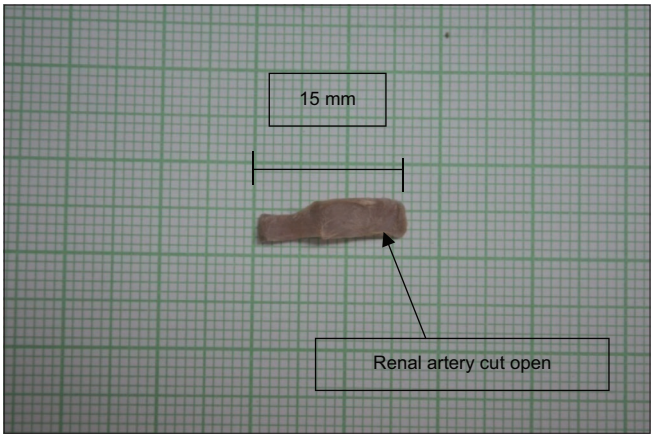

Figure 2: Illustration showing measurement of internal circumference (diameter) of renal artery (placed on a graph paper) at its origin in cadaver

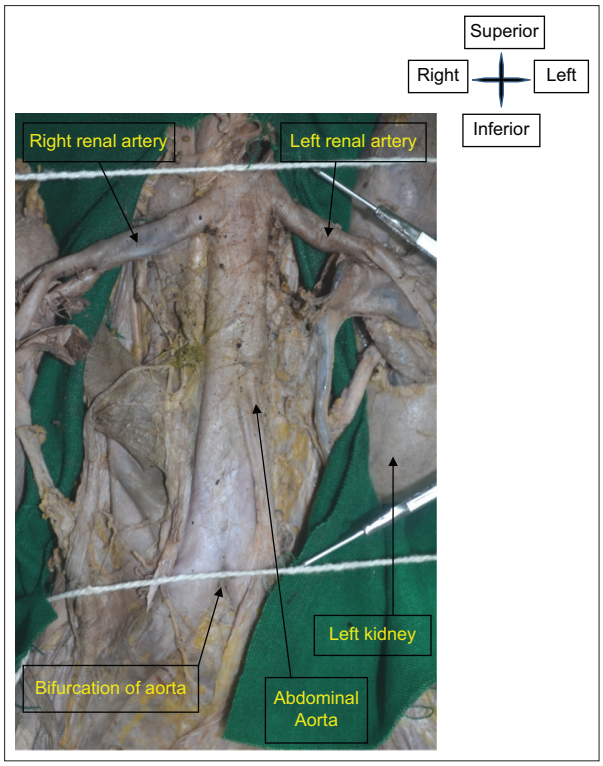

Figure 3: Illustration showing measurement of vertical distance between site of origin of left renal artery and bifurcation of aorta in cadaver

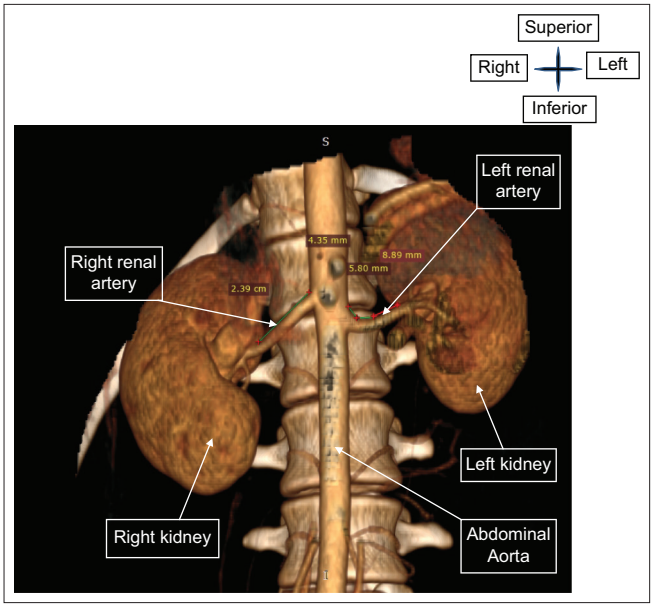

Figure 5: Illustration showing measurement of length of renal artery in CT study

performing of endovascular and laparoscopic urological procedures, vascular operation for renal artery stenosis, uroradiological procedures and also for medical device development. These data can be useful in the development of new devices or techniques which may significantly

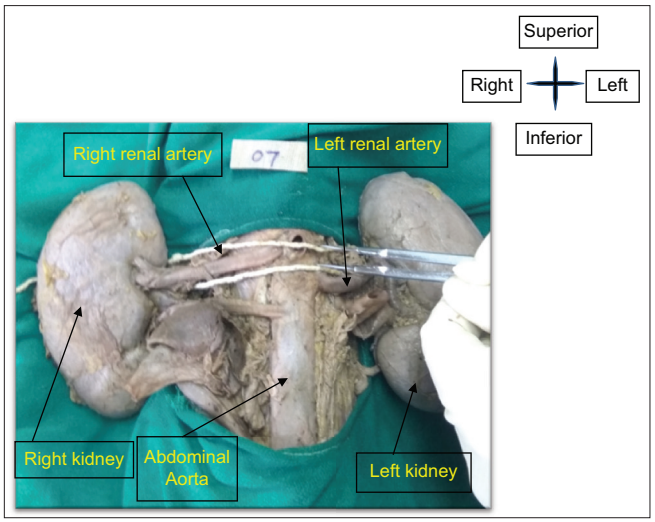

Figure 4: Illustration showing measurement of vertical distance between site of origin of right renal artery and left renal artery in cadaver

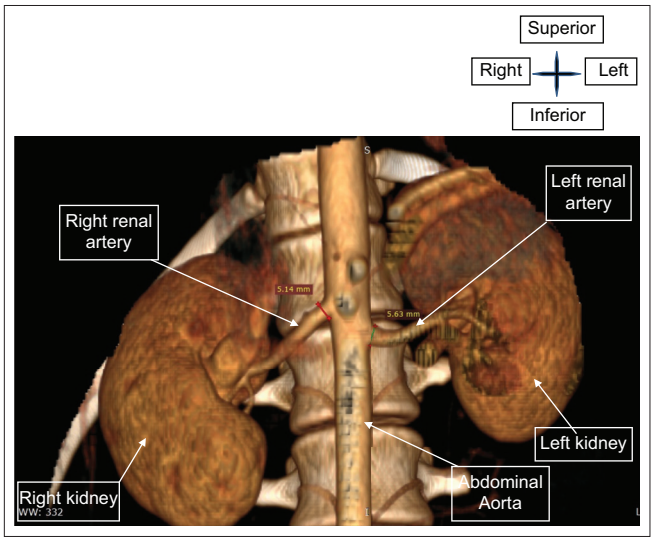

Figure 6: Illustration showing measurement of internal diameter of renal artery at its origin in CT study

increase the number of candidates for those promising therapeutic options in interpreting managing surgical approaches and diagnosing functional alterations.[4]

Length of renal artery

In cadaveric study, on comparison of the length of renal arteries of the right and left sides, the results of our study were found to be comparable with other similar studies in the literature [Table 5a].[7,8]

In CT angiography, when the length of renal arteries of both sides was compared with other studies, the mean length of the renal artery in CT Angiogram was more than our study [Table 5b].[4,9-11] This difference could be due to the difference in the software used for measuring the vessels.

Table 1: Length of renal artery

Type of study	Side	Number of renal arteries (*n*)	Minimum (cm)	Maximum (cm)	Mean (cm)	SD	*P*
Cadaveric	Right	36	1.4	5.9	3.58	1.12	0.0037
	Left	35	0.7	4.6	2.88	0.97	
CT angiogram	Right	36	0.7	5.06	2.82	0.82	0.0041
	Left	36	1.01	3.29	2.01	0.51	

CT: Computed tomography, SD: Standard deviation

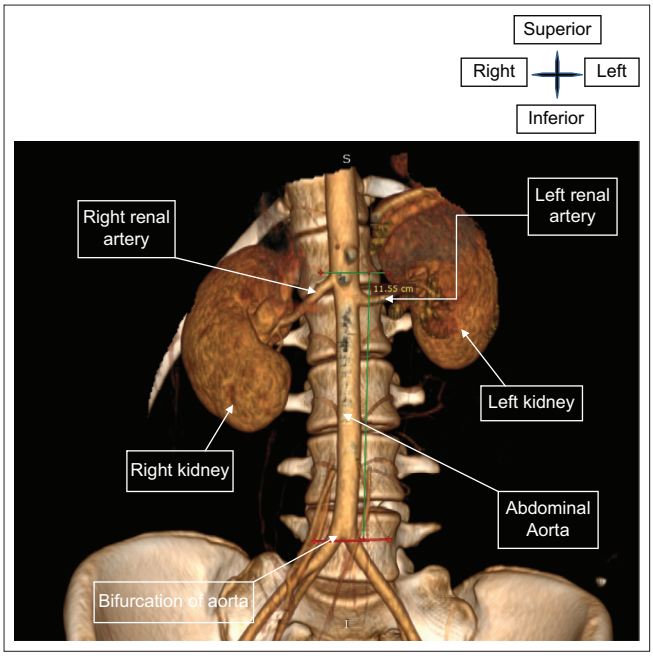

Figure 7: Illustration showing measurement of vertical distance between site of origin of right renal artery and bifurcation of aorta in CT study

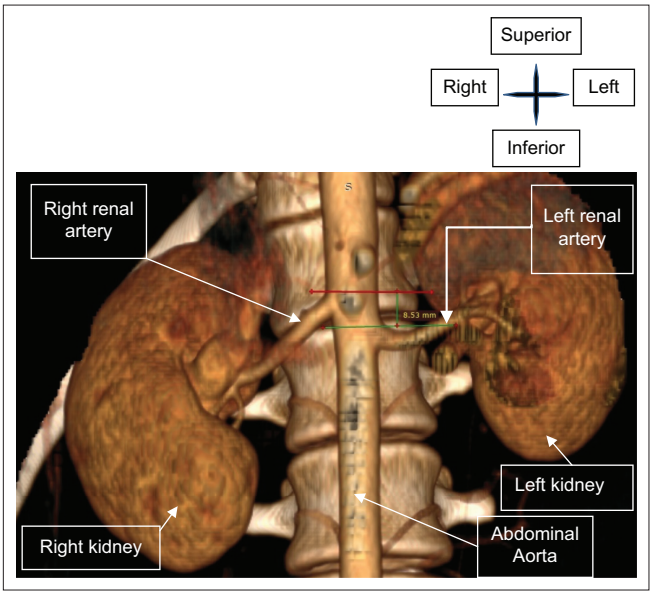

Figure 8: Illustration showing measurement of vertical distance between site of origin of right renal artery and left renal artery in CT study

Furthermore, the comparison between the length of right and left renal arteries in cadavers and right and left renal arteries in CT studies, respectively showed a significant *P* value [Table 1]. This indicates that the mean length of the right renal artery was found to be significantly longer than the mean length of the left renal artery. This is probably due to the location of the abdominal aorta to the left of the median plane in the abdomen and the long path of the renal artery on the right side. Thus, the information regarding the variations between the right and left arterial length would help the surgeons in preventing undue accidents while operating in this region.

Internal diameter of renal artery at its origin

In cadaveric study, our findings of internal diameter are comparable with Vaghela *et al*.[7] and Saldarriaga *et al*.,[8] because they have measured the "diameter" of renal artery at its origin, whereas the findings of Shalini *et al*.,[6] did not match with our study, This could be because that in their cadaveric study the "width" of the artery was measured and there is no detailing given for the measurement [Table 6a].[6-8]

In the CT study, our findings did not match with any of the previous studies in the literature. This could be because of less sample size in our study or could be because of the software variability along with inter-observer difference [Table 6b].[4,9-11]

Even though our cadaveric study did not show any difference in the right and left diameter of the renal arteries, there was a difference of 0.04 cm in the diameter measured on CT [Table 2]. This is comparable with a similar study done by Sankaran *et al*.[4] and Turba *et al*.[12] This revealed that the left kidney can be more preferable for transplantation than the right.

Vertical distance between the site of origin of the renal artery and bifurcation of the aorta

In cadaveric study, the vertical distance between the site of origin of the renal artery and bifurcation of the aorta on the right side and the left side was compared with similar studies [Table 7].[13,14] In both cadaveric and CT studies, the difference between the average vertical distance between the site of origin of the renal artery and bifurcation of the aorta on the right side and left side was statically not significant [Table 3].

Table 2: Internal diameter of renal artery at its origin

Type of study	Side	Number of renal arteries (*n*)	Minimum (mm)	Maximum (mm)	Mean (mm)	SD	*P*
Cadaveric	Right	36	3.82	7.3	5.15	0.74	0.85
	Left	35	3.1	6.36	5.12	0.80	
CT Angiogram	Right	36	2.78	5.77	4.18	0.67	0.075
	Left	36	2.75	6.32	4.50	0.83	

CT: Computed tomography, SD: Standard deviation

Table 3: Vertical distance between renal artery at origin and point of bifurcation of the aorta

Type of study	Side	Number of renal arteries (*n*)	Minimum (cm)	Maximum (cm)	Mean (cm)	SD	*P*
Cadaveric	Right	36	8.6	12.3	10.10	0.89	0.45
	Left	35	8.4	12.3	9.93	1.02	
CT angiogram	Right	36	7.23	11.62	9.23	1.04	0.44
	Left	36	7.01	11.62	9.03	1.11	

CT: Computed tomography, SD: Standard deviation

Table 4: Vertical distance between right and left renal artery

Type of study	Minimum (mm)	Maximum (mm)	Mean (mm)	SD
Cadaveric	0	15	5.52	4.43
CT angiogram	0	11	3.24	2.99

CT: Computed tomography, SD: Standard deviation

Table 5a: Comparison of length of renal arteries in cadaveric study

Study	Sample size cadavers (*n*)	Mean (cm)	
		Right	Left
Ross *et al*.[5]	34	3.9	3.3
Shalini *et al*.[6]	60	3.7	2.8
Vaghela *et al*.[7]	50	3.8	2.7
Saldarriaga *et al*.[8]	195 (renal blocks)	3.4	2.8
Present study	36	3.5	2.8

Table 5b: Comparison of length of renal arteries in computed tomography scan study

Study	Sample size CT scans (*n*)	Mean (cm)	
		Right	Left
Sankaran *et al*.[4]	100	3.7	2.8
Palmieri *et al*.[9]	100	3.96	3.41
Kapoor *et al*.[10]	118	6.8	7.3
Mohiuddin *et al*.[11]	250	4.4	3.5
Present study	36	2.8	2.0

CT: Computed tomography

Table 6a: Comparison of the internal diameter of renal artery at its origin in cadaveric studies

Study	Sample size cadavers (*n*)	Mean (mm)	
		Right	Left
Shalini *et al*.[6]	60	6.5	6.2
Vaghela *et al*.[7]	50	4.7	5.2
Saldarriaga *et al*.[8]	195 (renal blocks)	4.8	4.9
Present study	36	5.1	5.1

In the majority of the other similar studies (cadaveric and CT) this parameter is not considered, instead, most of them have measured the distance between the origin of the superior mesenteric artery and renal arteries. In his study, the distance of the renal artery from the bifurcation of the aorta was measured as it would help the radiologists with the data for easy access for catheterization during angiographic studies.

Vertical distance between the site of origin of the right renal artery and left renal artery

Although in most people right kidney sits in a lower position in the retroperitoneum than the left, data indicate that the right renal artery has a higher point of origin from the aorta than the left.[1]

However, in our study, we found that renal arteries of both sides originating at the same level in 16.6% of cases in cadavers and 33.3% of cases in CT study [Table 4]. This was similar to the dissection study done by Merklin and Michels on 185 autopsy kidneys. They have reported renal arteries of both sides originating at the same level in 30% of cases.[15] Furthermore, our results match with R. Shalini *et al*. who had done their study on 30 pairs of kidneys and reported that both-sided renal arteries originating at the same level in 46.6%.[6]

Conclusion

The present study provides comprehensive data about the morphometry of renal arteries. It shows and supports the fact that renal arteries show diverse variations. The study provides cadaveric and CT values of renal artery morphometry for reference purposes in the Indian population. The significant difference seen after comparing the values obtained by the two groups (cadaver and CT) could be attributed to the software used which failed to give realistic values in addition to the subjective errors in calculating them. Probably, an increased study population would yield an actual comparable value.

Table 6b: Comparison of the internal diameter of renal artery at its origin in computed tomography studies

Study	Sample size CT scans (*n*)	Mean (mm)	
		Right	Left
Sankaran *et al*.[4]	100	6.3	6.5
Palmieri *et al*.[9]	100	6.8	6.9
Kapoor *et al*.[10]	118	10.9	11.06
Mohiuddin *et al*.[11]	250	6.6	6.7
Present study	36	4.1	4.5

CT: Computed tomography

Table 7: Comparison of the vertical distance between the site of origin of the renal artery and bifurcation of the aorta

Study	Sample size cadavers (*n*)	Mean (cm)	
		Right	Left
Kapildev and Vimala[13]	16	9.57	9.54
Mane and Kulkarni[14]	40	9.3	
Present study	36	10.1	9.9

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Conflicts of interest

There are no conflicts of interest.

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Original Article

Relationship between Difficulty and Discrimination Indices of Essay Questions in Formative Assessment

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Abstract

Introduction: Assessment drives learning; assessment is the key component in medical education. Written examination plays a major role in assessing cognitive domain and well-constructed essay questions helps to assess the higher order of knowledge. Item analysis supports to assess the quality of items written and in turn which helps the faculty to retain, modify, or vomit the items. **Material and Methods:** Item analysis was done on anatomy essay questions of two internal assessment of 200 first MBBS students. Difficulty and discrimination indices were calculated, and relationship between the two indices was also analyzed. Analysis of the data indicated that there was a wide spectrum of level of difficulty among the essay items. **Results:** 83.33% items were within the acceptable range of difficulty index (DIF) and 1.67% items were not within the acceptable range. 91.67% items were good to identify students who have studied and only 8.33% (one question) item to be discarded and replaced. The relationship between the item discrimination index (DI) and DIF was determined using regression analysis and it is statistically significant, as the difficulty level of item increased the DI also increased. **Discussion and conclusion:** By this kind analysis, we can have a question bank with validated different grades of acceptability. Before deciding on test, this will help to consider whether the item difficulty level appropriate for testing given objective and does the item discriminate adequately and then to decide which items to include, revise, or omit from a test.

Keywords: *Difficulty index, discrimination index, essay questions*

Introduction

Anatomy is normally considered as the foundation of medical sciences and students need to acquire core anatomical knowledge for a strong foundation for clinical encounters and professional practice.[1] Assessment is the essential component of teaching and learning process. Assessing the students in the anatomy does not differ from assessing in other disciplines. Assessing in the anatomy has to obey the same general parameters as there are objectivity, validity, and reliability. Assessing educational objectives of cognitive domain will need different assessment tool than assessing educational objectives of psychomotor or the affective domain.[2] The introduction of new education methods, tools, and innovative curricula has necessitated a change in the assessment and evaluation, as well.

Assessing teaching-learning outcomes in anatomical knowledge is a composite task that necessitates the evaluation of theoretical, practical, and clinical knowledge.[3] Assessment of anatomical understanding in problem-based or competency-based curriculum requires many assessment tools and no single method of assessment can effectively test the knowledge, skills, and attitudes.[4]

Written examinations are the most commonly employed method for the assessment of cognitive skills in medical education. Written examination has various types of questions such as essay type, modified essay type, short answer type, and multiple-choice questions. The most common type of question used in the written examination is the essay questions. The essay questions allow students to express their ideas, assess the higher order of cognitive domain and as there are no options to select by guessing such bias are eliminated. The disadvantages of essay questions are a smaller number of questions, limited sampling, and unfair distribution of questions over topics, vague questions, etc., Blueprinting overcomes these issues and increases the validity of examinations.

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The evaluations depend upon the assessment tool and item analysis which is consisting of analysis of individual questions and analysis of the whole test after the test is conducted. Postvalidation process is basically a statistical method that is called as item analysis. The item analysis is a valuable, relatively simple but an effective process to check the reliability and validity of questions.[5] The difficulty index (DIF) and discrimination index (DI) usually calculated for objective type of questions and it is difficult to analyze essay questions. In the literature, only one study has been done on the item analysis of essay questions. Analyzing the essay questions will aid the teachers to decide whether the particular item to be retained, modified, or discarded. The present study was taken to evaluate the quality of essay questions by analyzing DIF and DI. It will help us in identifying specific technical flaws in the questions and improve the skill of examiners in item writing.

Material and Methods

The cross-sectional study was conducted on a cohort of 200 1st year undergraduate medical students in the department of anatomy at our institution during the academic year 2018–2019. Three internal assessments were conducted during this duration. Question paper for the same was prepared based on the blueprint and validated by subject experts of the medical education unit. Each paper comprised of one long essay question for 10 marks, 5 short essay questions each carrying 5 marks and 5 short answer questions each carrying 3 marks. Each question was assigned to a particular faculty for the evaluation and key answers were provided to avoid interobserver variability. The answer scripts were evaluated, and marks were allotted for the items. In the current study, long and short essay questions of the first and second internal assessments were analyzed. The study protocol was approved by the Institutional Ethics Committee.

Data collection

For item analysis, results of all students were ranked in the descending order, from highest marks to lowest marks. Then papers were divided into quartiles based on scores. Top 27% scores as upper quartile or high scored groups (n = 54) and bottom 27% scores as lower quartile or low scored (n = 54) groups. Only these two (high and low scored) groups were considered for the analysis. Papers with average scores, middle quartiles were excluded from the study. Mark range was decided for short essay questions with the help of ANGEL group who formulated the score range and mean of individual question.[5] For each question if students achieve 5 − 3.5 marks, it was considered as correct answer, i.e. A. For each question if students achieve 3 − 2 marks it was considered as near to correct answer, i.e. B. For each question students achieve 1.5 − 0.5 marks, it was considered as near to incorrect answer, i.e., C. For each question students achieve 0 marks or not answered was considered as incorrect answer, i.e., D. Mark range for long essay was decided by experts with the help of ANGEL group. For each question, students achieve 10-6.5 marks will be considered as correct answer, i.e., A, who achieve 6-4.5 marks will be considered as near to correct answer, i.e. B, who achieve 4-0.5 marks will be considered as near to incorrect answer, i.e., C and who achieve 0 marks or not answered will be considered as incorrect answer, i.e., D.

Item analysis

DIF and DI were calculated to evaluate the essay questions.

DIF:

H = Number of students gave correct options in high score group
L = Number of students gave correct options in low score group
N = Total number of students in both groups
DIF was calculated using the formula
DIF= ([H + L]/N) ×100
DIF value is expressed in percentage. Its range is 0–100. Its recommended value is 45–60, and its acceptable value is 25–75.[1]

Interpretation of DIF:[2]

- >70% = Too easy
- 30%–70% = Average
- 50%–60% = Good
- <30% = Too difficult.

DI:

- DI was calculated using the formula, DI = 2 × ([H-L]/N)
- DI value is expressed as fraction, which range from 0 to 1.[5]

Interpretation of DI is:[2]

- ≤0.2 = Poor
- 0.21–0.24 = Acceptable
- 0.25–0.35 = Good
- ≥0.36 = Excellent.

Statistical analysis

All data are reported as mean ± standard deviation of n items (number of questions). The relationship between the item DI and DIF values for each test paper was determined using the regression analysis with the help of SPSS (Statistical package for the social science) Windows, Version 26.0. (IBM Corp. Released 2019. IBM SPSS Statistics for Armonk, NY, USA) and the coefficient of determination was given by R^2. P of < 0.05 was considered to indicate statistical significance.

Results

Item analysis was done for essay questions of 1st and 2nd internal assessment papers (06 items of each). The difficulty and discrimination indices of items according to cognitive levels were obtained, and these statistics are shown in Table 1. Out of 12 items, difficulty value of

25% was under recommended range, 58.33% were under acceptable range and 1.67% were not within acceptable range [Table 1]. DI of 91.67% indicates that the questions can be recommended for assessment and DI of 8.33% indicates that the question should be discarded.

Analysis of the data indicated that there was a wide spectrum of level of difficulty among the essay items in both the papers. The DIF of paper 1 ranged from 27.14% to 54.28% and of paper 2 ranged from 12.85% to 67.14%. The DI of paper 1 ranged from 0.54% to 0.77% and DI of paper 2 ranged from 0.14% to 0.74% [Table 2].

The relationship between the item DI and DIF was determined using the regression analysis, and it is statistically significant. Both in the 1st and 2nd internal assessment essay questions we can observe as the difficulty increased the discrimination also increased [Figures 1 and 2].

Discussion

The effective assessment of knowledge acquired is an essential element of medical education. Developing an appropriate assessment tool plays a major role in curriculum development and the it should be regularly evaluated.[6] Having prepared and assessed a test, a faculty needs to know how good the test questions are and whether the test items were able to reflect students' performance in relation to their learning.[7]

The reliability and ability of assessments to effectively discriminate between good and poor candidates of the assessment are the important considerations in evaluating an assessment tool.

Assessment instrument should not only assess appropriate cognitive domain but also should be able to withstand the scrutiny of content and construct validity, reliability, fidelity and at the same time discriminate the performance levels of the students being tested.[8]

Essay questions are the commonly used item to test the cognitive skills and the effectiveness of the assessment tool depends on how the questions are framed. The first mandatory step for quality assessment is standardization of essay questions[9] and for an assessment to be reliable and valid, a systematic selection of items with degree of difficulty and discrimination is necessary.[10]

Usually, faculty believes that the questions framed are satisfactory and they are able to assess the real ability of students. Item analysis is a valuable procedure performed after the examination that provides information regarding the reliability and validity of the test item.[5] It allows recognizing too difficult or too easy items and the items which are not able to differentiate between students who have learned and those who have not[5,11] and this serves

Table 1: Difficulty index and discrimination index of different questions

Question number	Difficulty index		Discrimination index	
	Value	Range	Value	Range
1st IAE				
1	54.28	Recommended	0.74	Excellent
2	28.57	Acceptable	0.57	Excellent
3	31.42	Acceptable	0.63	Excellent
4	27.14	Acceptable	0.54	Excellent
5	30	Acceptable	0.54	Excellent
6	41.43	Acceptable	0.77	Excellent
2nd IAE				
1	67.14	Acceptable	0.6	Excellent
2	12.85	Not acceptable	0.14	Poor/discard the question
3	28.57	Acceptable	0.51	Excellent
4	15.71	Not acceptable	0.39	Excellent
5	48.57	Recommended	0.74	Excellent
6	57.14	Recommended	0.74	Excellent

IAE: Internal assessment examination

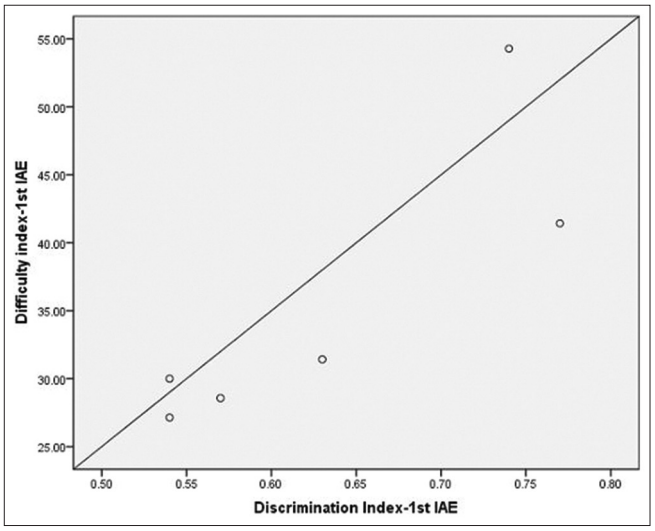

Figure 1: The relationship between item difficulty index and discrimination index values of 1st internal assessment

Table 2: Mean difficulty index and discrimination index for the questions in internal assessment

Items	Number of questions	Mean±SD	Minimum	Maximum	R^2	Significance
Difficulty index-1st IAE	6	35.4733±10.51342	27.14	54.28	0.731	0.030
Discrimination index-1st IAE	6	0.6317±0.10147	0.54	0.77		
Difficulty index-2nd IAE	6	38.33±22.56033	12.85	67.14	0.681	0.043
Discrimination index-2nd IAE	6	0.52±0.23004	0.14	0.74		

SD: Standard deviation, IAE: Internal assessment examination

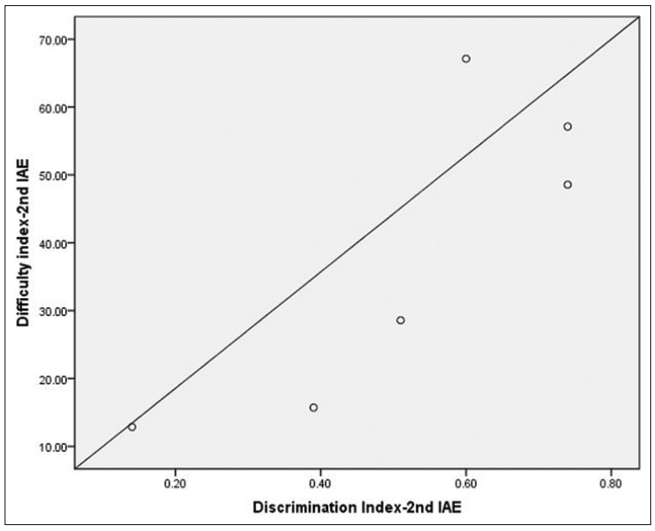

Figure 2: The relationship between item difficulty index and discrimination index values of 2nd internal assessment

as an effective feedback to teachers about quality of each item.[12] The items can be removed, changed, or modified based on the item analysis for future use.

Item analysis results are influenced by the factors such as the number and quality of students and purpose of the test.[10] Hence, before discarding an item for poor discrimination, think of the factor(s) that may contribute to such poor discrimination.[13] Frequent evaluation of questions through item analysis helps to make a valid pool of essay questions[9] and save time and energy for faculty.[11] The process of developing a good test and good items is complex and time-consuming and involves numerous steps from creating items to pretesting them, revising, and editing items, etc.[14]

DIF is a measure of how easy or how difficult a question is which is given to students, higher the index lower is the difficulty of the question and vice versa. DI indicates the ability of a question to discriminate between a higher and a lower ability student and its range is between 0 and 1.0. DI value of 1.0 indicates an ideal question with perfect discrimination and minus value means more students in the lower group are answering that item correctly than students in the higher group. The DIF and DI are reciprocally related.[5,6]

Before deciding on test consider whether the item difficulty level appropriate for testing given objective and does the item discriminate adequately and then to decide which items to include, revise, or omit from a test. Qualitative techniques also be used for generating and analyzing the data which is grounded in the voice of students rather than psychometric-statistical inferences. The units of analysis are the words of students rather than their numerical scores.[15]

Item analysis is frequently done for multiple choice questions while there is only one study done on essay questions in the literature. In the present study, 83.33% items are in acceptable range of DIF and 1.67% items are not acceptable. 91.67% items were good to discriminate between students who have studied and who are not and only 8.33% (one question) item to be discarded and replaced. Item analysis done on physiology items showed that DIF value of 62.5% questions were within recommended and acceptable range and 50% questions were within acceptable range while 37.5% questions were within nonacceptable range. Discrimination value of 100% questions was under recommended and acceptable range and none of the questions were under nonacceptable range.[5]

Mean DIF calculated for MCQ items was 57.92% ± 26.88% ($P < 0.05$, confidence interval >95%). Out of the 04 test papers conducted in the anatomy, the mean DIF scores of the individual tests were ranging from 40% to 70%, except in abdomen paper in which higher range for mean DIF was 83%. Abdomen test paper contained higher in the number of very easy questions (7 out of 15), leading to test paper easy for students. DIF of 76.90% items was between 30% and 70%, thus majority of items were of ideal to acceptable in difficulty.[7]

Conclusion

In the present study, among all the items analyzed, only one item was not within acceptable range and need to be discarded while remaining items were within acceptable range. A well-framed essay question is an efficient tool to evaluate different levels of cognitive domain among students. Item analysis helps to observe the item characteristics and to improve the quality of the test by item revision. The faculty has to be trained to frame an essay question which can assess the higher order of cognitive domain and can clearly discriminate between the students who have studied and who are not.

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Conflicts of interest

There are no conflicts of interest.

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Original Article

Cytogenetic Evaluation of Congenital Anomalies in Manipur

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Abstract

Introduction: Birth defect, congenital malformation, and congenital anomaly are synonymous terms used to describe structural, behavioral, functional, and metabolic disorders present at birth. Birth defects are the leading cause of infant mortality. The most common serious congenital disorders are heart defects, neural tube defects, and Down syndrome. The objective of the study is to determine the chromosomal abnormalities (structural and numerical) in congenital anomalies of suspected genetic causes, by peripheral lymphocytic culture and cytogenetic evaluation. **Material and Methods:** The study was a cross-sectional study undertaken for a duration of 2 years in a total of fifty cases of congenital anomalies with suspected genetic abnormalities. Peripheral blood from these cases was collected, and lymphocyte tissue culture was done for about 48–72 h. The best metaphase spread was selected, photographed, printed, and karyotypes were prepared. Findings of the study were then described by descriptive statistics. **Results:** Most common congenital anomalies were seen in the musculoskeletal system with 19 anomalies (38% of all cases) followed by genital organs with 12 anomalies (24% of all cases) and cleft lip and cleft palate with 8 anomalies (16% of all cases). Chromosomal anomalies were seen in six cases (12% of all cases). All were cases of Down syndrome and had trisomy 21. **Discussion and conclusion:** The present study might be of help in an earlier and better diagnosis of the cases of congenital anomalies, particularly the cases presenting with chromosomal abnormalities so that their counselling can be started at the earliest. It might be suggested that cytogenetic evaluation of cases of congenital anomalies should be included in routine investigation.

Keywords: *Chromosomal abnormalities, congenital anomalies, Down syndrome, karyotyping*

Introduction

Birth defect, congenital malformation, and congenital anomaly are synonymous terms used to describe structural, behavioral, functional, and metabolic disorders present at birth. Birth defects are the leading cause of infant mortality, accounting for approximately 21% of infant deaths and 30%–50% of deaths after neonatal period. They are the fifth leading cause of potential life lost prior to 65 years of age and yield major contribution to disabilities.

Causes of malformations – in 40%–60% of cases of malformations, the cause of the birth defect is unknown. Genetic factors such as chromosomal abnormalities and mutant genes account for approximately 15% of cases. Environmental factors produce approximately 10% of cases. A combination of genetic and environmental influences (multifactorial inheritance) produces 20%–25% of cases; and twining contributes 0.5%–1%.[1]

The birth prevalence of congenital anomalies in the developing world is underestimated by deficiencies in diagnostic capabilities and lack of reliability of medical records and health statistics. The prevalence of birth defects in India (per 1000 live births) is 64.3. The contribution of birth defects to neonatal mortality rates is 9.6%, to perinatal mortality rate is 19.5%, and to stillbirths is 9.9%. The annual report of the Indian Council of Medical Research says that the most common congenital malformations are cardiac in nature. Cardiovascular, musculoskeletal, and genitourinary were the most commonly affected systems in a descending order of frequency. The most common serious congenital disorders are heart defects, neural tube defects, and Down syndrome.[2]

The laboratory evaluation of a malformation is helpful but complex. Cytogenetics with Giemsa-banded peripheral leukocyte karyotype (or chromosome analysis) is the gold standard and should be performed in most evaluations.[3]

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The objective of the study is to determine the chromosomal abnormalities (structural and numerical) in congenital anomalies suspected of genetic causes, of outdoor and indoor patients, attending the Regional Institute of Medical Sciences Hospital, Imphal, by peripheral lymphocytic culture and cytogenetic evaluation.

Material and Methods

The study was a cross-sectional study undertaken in the Department of Anatomy for a duration of 2 years. A total of fifty cases of congenital anomalies with suspected genetic abnormalities, of the outdoor and indoor patients, attending the Regional Institute of Medical Sciences, Imphal, were studied and cases with known teratogenic causes were excluded. The sample size was calculated by applying the nonprobability sampling technique of convenient/purposive sampling. Formal permission was sought from the Institutional Ethics Committee to take up this study. Informed consent was obtained from the parents and their data were collected. Antenatal history, perinatal history, present history, family history, age, sex, height, and phenotype were used as study variables. Type of abnormality and karyotype of the cases were the outcome variables. Peripheral blood from these cases was collected and lymphocyte tissue culture was done for about 48–72 h. Fifteen–twenty metaphase spread was examined under trinocular research microscope. The best metaphase spread was selected, photographed, printed, and karyotypes were prepared.

Data of the study were entered in a master chart using Microsoft Excel 2013 (Washington, USA). Data were analyzed by using appropriate charts and graphs. Percentage and ratio were calculated. Findings of the study were then described by descriptive statistics.

Results

Sex

The study was done in 26 females (52%) and 24 males (48%) with congenital anomalies making a total of fifty cases. The ratio of female-to-male cases was 1.08:1. One of the 26 female cases was of the disorder of sexual development presenting with ambiguous genitalia, which was found to be a normal female on karyotype [Figure 1].

Age

(A) Patient: Maximum number of cases were in the age group 0–5 years of age, 39 cases (78.0%), of which 16 (41.0%) were males and 23 (58.9%) were females. In this age group, 27 cases were <1 years of age, of which 16 were females and 11 were males. In the age group of 6–10 years, six cases (12.0%) were seen, with four (66.6%) males and two (33.3%) females. This was followed by three cases (6%) in the age group 11–15 years, with two males (66.6%) and one female (33.3%). Age groups of 16–20 and 21–25 years each had one case (2%), with both being males (100%). The youngest case was of 1 day and the oldest was of 21 years of age

(B) Mother: For the cases studied, the minimum age of conception for the mother was 16 years, with the maximum age being 45 years.

Figure 1: Shows ambiguous genitalia in a case of disorder of sexual development taken 3 days after birth

Birth order

The birth order in maximum cases, 19 cases (38%) were as a second child. The cases were delivered as a first child in 18 cases (36%), as a third child in 11 cases (22%), and as fourth and five children in one case each (2%). In one case, the child was delivered as twins. Hence, it can be concluded that cases of congenital anomalies were seen more in a multiparous mother (64%) as compared to a primiparous mother (36%).

Family history and consanguineous marriage

The family history was significant in three cases (6%) and consanguineous marriages were seen in four cases (8%). In all these four cases, parents were first cousins that is third-degree relatives.

Systemic involvement

Systemic involvement was classified as per the International Classification of Diseases (ICD, ICD 10 Version: 2016),[4] as depicted in [Table 1].

As there is an overlap of anomalies, so the number of anomalies in Table 1 is 61, which is higher than the total number of cases (50), as a single case may contain more than one anomaly.

Most common congenital anomalies were seen in the musculoskeletal system with 19 anomalies (38% of all cases), followed by genital organs with 12 anomalies (24% of all cases) and cleft lip and cleft palate with 8 anomalies (16% of all cases). Circulatory system had five anomalies (10% of all cases), followed by other congenital anomalies in four

Table 1: The international classification of diseases classification of the types of anomalies

ICD classification of congenital anomalies[4] among fifty cases			
Code	**Anomalies**	**Number of anomalies seen**	***n*=50, *n* (%)**
1. Nervous system		2	4
Q02	Hydrocephalus	1	
Q03	Microcephaly	1	
2. Eye, ear, face, and neck		3	6
Q12.0	Congenital cataract	2	
Q17.2	Microtia	1	
3. Circulatory system		5	10
Q20.1	Double outlet right ventricle	1	
Q21.0	Ventricular septal defect	1	
Q21.1	Atrial septal defect	2	
Q21.3	Tetralogy of fallot's	1	
4. Cleft lip and cleft palate		8	16
Q35.1	Cleft palate, hard palate	1	
Q35.7	Bifid uvula	1	
Q36.1	Cleft lip, median	1	
Q36.9	Cleft lip unilateral	2	
Q37.1	Cleft lip unilateral, cleft hard palate	2	
Q37.5	Cleft lip bilateral, cleft hard, and soft palate	1	
5. Genital organs		12	24
Q50.3	Streak ovaries	1	
Q53.1	Undescended testis, unilateral	2	
Q54.1	Penile hypospadias	4	
Q54.2	Penoscrotal hypospadias	2	
Q55.1	Hypoplasia scrotum, testis	1	
Q55.6	Hypoplasia penis	1	
Q56.4	Ambiguous genitalia	1	
6. Urinary System		2	4
Q60.3	Renal hypoplasia unilateral	1	
Q63.2	Ectopic kidney	1	
7.Musculoskeletal system		19	38
Q66.0	Talipes equinovarus	11	
Q67.3	Plagiocephaly	1	
Q67.5	Scoliosis	1	
Q69.1	Accessary thumb	1	
Q69.2	Polydactyly toes	2	
Q70.1	Webbed fingers	1	
Q70.3	Webbed toes	2	
8.Other congenital malformations		4	8
Q89	Other congenital malformations not elsewhere classified	4	
9. Chromosomal abnormalities not elsewhere classified		6	12
Q90.0	Down syndrome, trisomy 21	6	

ICD: International classification of diseases

cases (8% of all cases) and anomalies of eye, ear, face, and neck in three cases (6% of all cases). Urinary system and nervous system each had two anomalies (4% of all cases). Chromosomal anomalies were seen in six cases (12% of all cases), out of the total fifty cases studied [Table 1].

Karyotype

Karyotypes observed and their interpretation are shown in Table 2. Six cases of abnormal karyotype were seen. All were cases of Down syndrome and had trisomy 21. All cases presented with dysmorphic features. They also presented with jaundice, birth asphyxia, distended abdomen, bronchopneumonia and jaundice, midline abdominal wall defects with hypospadias with club foot, and heart defects.

Phenotypically, all the cases showed mongoloid features such as a flat facial profile, an upslanting palpebral fissure, and an open mouth in varied combinations. All the

Table 2: The karyotypes observed and their interpretation

Karyotype	Cases	Interpretation	
46, XX	23	Normal female	Normal karyotype
46, XX	1	Normal female, ambiguous genitalia	
46, XY	20	Normal male	
47, XX, + 21	2	Down syndrome, female	Abnormal karyotype
47, XY, + 21	4	Down syndrome, male	

cases had a broad flat depressed nasal bridge. One case had epicanthic folds and one case had small-sized ears. One case had deep creases in feet, two had proximally displaced toes, and three had wide gaps between toes, first and second as well as third and fourth. One case had talipes equinovarus in both feet and one case had clubbing with inverted feet. Simian crease was present in two cases, one in the right hand and one in both hands. One case had a single crease in the fifth little finger. A clenched fist was also seen in one case. A wide gap was seen between fourth and fifth fingers of the right hand with clubbing in all fingers, in the case with the heart defect. Neck appeared shorter in all cases with loose folds present in the posterior part of the neck in one case and a low hairline in one case each. External genitalia showed undescended testis right side in one case and penile hypospadias in one case. Two cases had hypotonia and one case had a midline abdominal wall defect. In terms of karyotype, four cases had 47, XY, and +21 and two cases had 47, XX, and +21 as their karyotype. All cases were eventually diagnosed to be Down syndrome with trisomy 21, nondisjunction [Figures 2-5].

In three instances, cases presenting with dysmorphic features were found to be normal on karyotyping.

In the first instance, an 11-day-old female baby presented with facial dysmorphism, jaundice, and low birth weight. The baby had a prominent occiput, small mouth, and a flat nasal bridge. Left foot had a proximally displaced great toe. Right foot had proximally displaced and dorsiflexed toes with synechiae between first and second and third and fourth toes. Clenched fists were seen. Hypertonia was present. The karyotype of the baby was found to be normal, 46, XX [Figure 6]. In the second, a 14-year-old male presented with mental retardation and anemia. The child had a flat facial profile with a flat depressed nasal bridge. Epicanthal folds were present. Neck appeared shorter. Mild scoliosis was present. There was a lateral deviation of the first toe of the left foot. Abdomen was distended. Karyotype of the child was normal, 46, XY [Figure 7]. In the third, a 21-year-old male presented with hypoplasia of the penis and small testis since childhood. Secondary sexual characteristics were absent with no pubic hair and axillary hair. Learning disabilities were present since

Figure 2: (a) Shows a case of Down syndrome presenting with a flat facial profile, upslanting palpebral fissure, and a flat nasal bridge. Rt (b) right foot. Lt (c) left foot. Both feet were inverted with clubbing. Wide gap was present between first and second toe and third and fourth toe. (d) Hands show clubbing with a wide gap between fourth and fifth finger. A single Simian crease is present on the left fifth finger

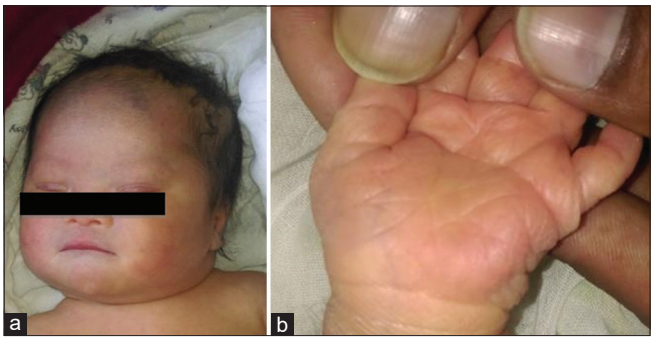

Figure 3: (a) Shows a case of Down syndrome presenting with a flat facial profile, a broad nasal bridge. (b) Simian crease on the left hand

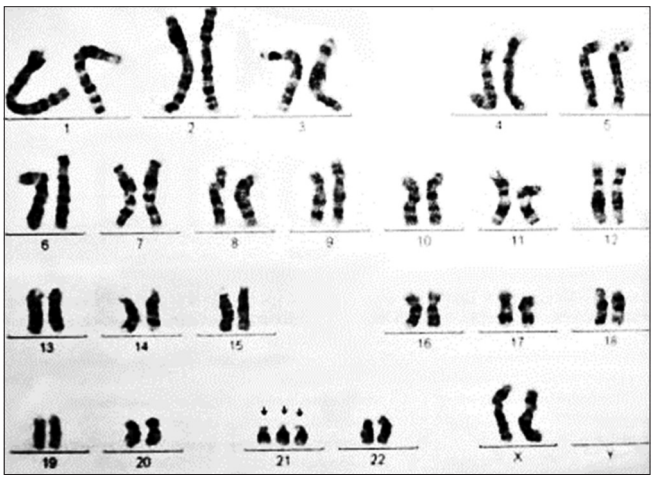

Figure 4: Karyogram showing karyotype of a case of Down syndrome female 47, XX, +21

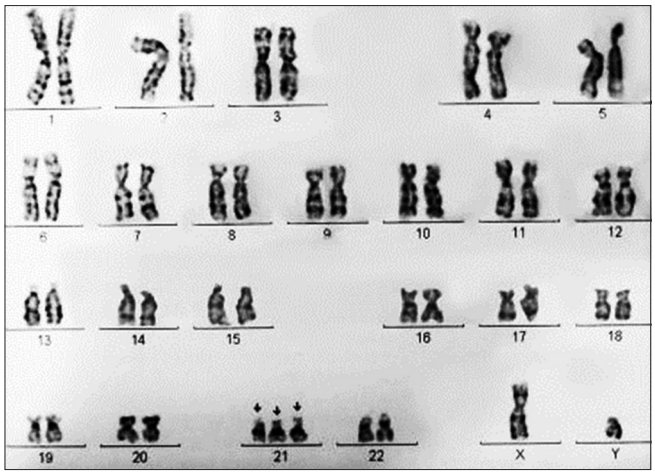

Figure 5: Karyogram showing karyotype of a case of Down syndrome male 47, XY, +21

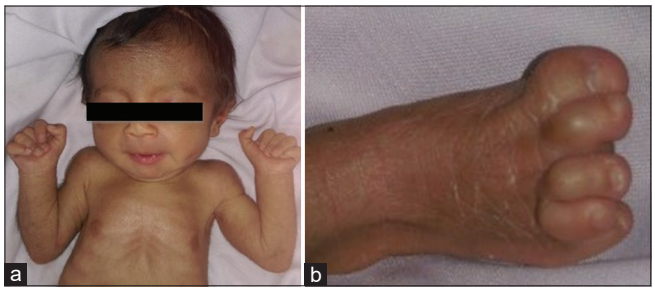

Figure 6: (a) Shows a case presenting with a prominent occiput, flat nasal bridge, clenched fist, and hypertonia. (b) shows proximally displaced and dorsiflexed toes, synechiae between first and second and third and fourth toes

Figure 7: A case with flat facial profile, epicanthal folds, flat depressed nasal bridge, and a short neck

childhood. Tall and slim stature was also noted. Karyotype showed a normal result, 46 XY.

Discussion

The findings of the present study are elaborated, compared, and discussed with the findings of the previous studies.

Sex

There are many reports on the incidence of congenital anomalies, being more in females. One study reported a female-to-male ratio of 1.6:1[5] and another studied 51.1% of females and 48.3% of males.[6] Similarly, in the present study, 52% of cases were of the female sex and 48% of cases were of the male sex. The female-to-male ratio was 1.08:1.

Age

The spectrum of age in cases of congenital malformations varied in previous studies, ranging from birth to 50 years with a mean of 14.3 years,[5] few hours after birth to 15 years,[7] and 1 day to 14 years of age.[8] In the present study, the age of cases ranged from 1 day to 21 years of age and this variation in the age may be due to nature of the study. Maximum number of cases were in the age group of up to 5 years of age.

Birth order

The findings in the present study indicate that congenital anomalies were common in multiparous mothers (64%). This finding is almost similar to the available literature.[2,9-14] The maximum cases in the present study were born as a second child, a finding was also seen earlier.[13]

Consanguineous marriage

In the present study, 8% of cases of congenital anomalies had parents with consanguineous marriages. Previously, consanguineous marriages have been reported to be 8.16%,[15] 8.1%,[9] and 8.5%[13] in cases of congenital malformations. Effect of low sample size on the incidence, and prohibition of consanguineous marriages among the Meitei population, to which the maximum number of cases belong, may be a reason for the low incidence of consanguinity seen in the present study.

Systemic involvement

The comparison of the present study with others on the basis of systemic involvement is described in Table 3.

The difference in the percentage of anomalies can be explained by different nomenclature used for classifying the anomalies. In the present study, ICD (ICD 10 Version: 2016) classification for congenital anomalies is followed.

Karyotype

The findings of the present study, with reference to the percentage of chromosomal abnormal cases found, are compared to the other studies, in the Table 4.

As can be seen from the table, the findings of the present study are comparatively less than some authors but are extremely less in comparison to some. This can be explained due to a variable sample size in all studies, due to some undetectable causes by simple karyotyping in some of the cases, and a very small sample size in the present study.

Table 3: The type of anomalies as reported by different authors

Studies	Percentage of anomalies (%)									
	MSK	GO	CL/CP	GIT	CS	OCA	EEFN	US	NS	CHR ABN
Patel and Adhia[15]										4.08
Parmer *et al.*[5]				14.17					64.56	
Kaur and Singh[9]	19.1	53.9	2.6		3.4					
Mohammed *et al.*[11]	37.9			14.6	22.3	3.9	8.7	3.9		27.2
Temtamy *et al.*[16]	20.0	8.4	5.3	1.1	3.2	6.3	2.1	1.1	29.5	4.2
Sarkar*et al.*[12]	33.2			15					11.2	
Charmode[17]	12.6	12.1		13.2	21.4			4.4		
Capatina and Camelia[14]										3.85
Butt *et al.*[18]	4.76	4.76	9.52						87.5	
Present study	38	24	16		10	8	6	4	4	12

MSK: Musculoskeletal system, OCA: Other congenital anomalies, GO: Genital organs, EEFN: Eye, ear, face, and neck, CL/CP: Cleft lip/cleft palate, US: Urinary system, GIT: Gastrointestinal tract, NS: Nervous system, CS: Circulatory system, CHR ABN: Chromosomal abnormalities

Table 4: The percentage of chromosomal anomalies as reported by different authors in comparison to the present study

Name of the study	Percentage of chromosomal abnormalities found
Gazali *et al.*[19]	16.18
Balkan *et al.*[6]	16.1
Kim *et al.*[20]	17.5
Yashwanth *et al.*[21]	18.18
Vaz and Shyama[22]	24.1
Mohammed *et al.*[11]	27.1
Husain and Zaki[23]	34
Norlasiah *et al.*[24]	42.6
Present study	12

Table 5: The comparison of the present study with other authors according to the type of chromosomal abnormality seen

Name of the study	Percentage of Down syndrome cases	Percentage of trisomy 21
Yashwanth *et al.*[21]	93.1	92.59
Vaz and Shyama[22]	37.5	86.6
Mohammed *et al.*[11]	64.28	77.77
Gazali *et al.*[19]	67.85	100
Balkan *et al.*[6]	58.4	89.6
Kim *et al.*[20]	40.9	88.4
Husain and Zaki[23]	73.4	96.55
Norlasiah *et al.*[24]	32.3	100
Present study	100	100

In the present study, among the abnormal karyotypes, all cases, i.e. 100%, were of Down syndrome and all of them had trisomy 21 (100%). The comparison of the present study with other studies, with respect to the type of abnormality, is given in Table 5.

Conclusion

The present study might be of help in early and better diagnosis of the cases of congenital anomalies, particularly the cases presenting with chromosomal abnormalities so that their counseling can be started at the earliest. This study has also shown the limitation of the normal karyotyping in detection of genetical defects. It might be suggested that cytogenetic evaluation of cases of congenital anomalies should be included in their routine investigation.

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Conflicts of interest

There are no conflicts of interest.

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Original Article

Cadaveric Study on Variations in the Source and Level of Origin of Superior Thyroid Artery

Abstract

Introduction: Superior thyroid artery (STA) is one of the branches of the external carotid artery (ECA) which supplies the upper larynx, neck, and thyroid gland. The anatomic features of this artery and its relation to neighboring bony landmarks are important in surgical approaches. The primary objective is to find the source of origin of STA. Secondary objective is to find the level of origin of STA with reference to the origin of ECA and midpoint of the upper border of the thyroid cartilage. **Material and Methods:** The present study was carried out on 60 hemi necks obtained from human adult cadavers from Anatomy Department, Bangalore Medical College, Bangalore, Karnataka. The dissection was carried out according to instructions of Cunningham's practical manual. The origin and branching pattern of the STA were noted and measured. **Results:** The STA arose from the common carotid artery in 5% (3) cases and from the ECA in 95% (57). Among the 95% cases, 46.7% (28) arose at the origin of ECA, and in 1.7% (1) case, STA arose as a common trunk with lingual and facial arteries. The mean distance between the point of origin of STA and the point of origin of ECA is 5.4 ± 5.3 mm. The mean distance between the point of origin of STA and superior border of thyroid cartilage is 40 ± 7.6 mm. **Discussion and Conclusion:** The origin of STA from carotid bifurcation ranged from 1 to 25 mm. Most studies show equal incidence of origin of STA from ECA and carotid bifurcations.

Keywords: *Cadaveric study superior thyroid artery, thyrolinguofacial trunk, variant origin*

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Introduction

Superior thyroid artery (STA) usually arises from the front of external carotid artery (ECA). The STA is the dominant arterial supply of the thyroid gland, upper larynx, and the neck region.[1,2]

Every surgery was planned based on the anatomical arrangement of the structures. The knowledge of variations in the source of origin of the STA is important for surgical procedures such as cricothyroidotomy, radical neck dissection, and catheterization. Any variation in the arterial arrangement may lead to hemorrhagic complications during the intraoperative period.[3] Various studies in recent years have found a lot of variations in the source of origin of STA.[4-6]

The distance of the point of origin of STA from the thyroid cartilage also helps the surgeons to locate the vessel during surgery. Knowledge of variations in the origin of STA will be helpful to minimize the risk of complications.

Materials and Methods

The present study was carried out on 60 hemi necks obtained from human adult cadavers from the Department of Anatomy, Bangalore Medical College and Research Institute, Bangalore, Karnataka. The study was done over a period of 3 years. The bodies which are given to the students for dissection (10 bodies per year) and also the preserved specimens were used for the study. Adult cadavers of both sexes were used in the study. The specimens in which the carotid artery was damaged while doing embalming were excluded. Cadavers with very short neck and any gross abnormality were excluded.

Careful dissection was done in the anterior triangle of neck. The carotid sheath is cut to expose carotid bifurcation and the course of ECA. Origin of STA and its branches were traced by fine dissection. The distances were measured using rulers.[7]

The data of STA origin, the distance between the origin of STA and the bifurcation of common carotid artery (CCA)

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and the distance between the origin of STA and midpoint of superior border of the thyroid cartilage, were noted and tabulated.

The following classification by Vazquez *et al*. was used to record data regarding origin of STA.[4] The schematic representation is shown in Figure 1.

- Type one-origin from the carotid bifurcation
- Type two-origin from CCA
- Type three-origin from ECA
- Type four a – thyrolingual trunks
- Type four b – thyrolinguofacial trunks.

Results

Source of origin of STA

The present study comprised of 60 STAs, out of which 33 were right and 27 were left. The result of the study is shown in Table 1, Figures 2 and 3. In a few cases, the origin of STA from CCA is bilateral. In cases where origin of STA from CCA is unilateral, the STA from the other side took origin from ECA very close (≤5 mm) to CCA bifurcation. We also found that variations on the left side are more common.

In our study, 41 specimens were from males and 19 from females. Variations among males and females are shown in Table 2. The origin of STA from carotid bifurcation is more common in females.

The level of origin of superior thyroid artery

The minimum distance between the point of origin of STA and the point of origin of ECA is one mm with a maximum of 25 mm. The mean of the distance is 5.4 mm with standard deviation (SD) of 5.3 mm.

The minimum distance between the point of origin of STA and the superior border of thyroid cartilage is 30 mm, maximum distance is 70 mm, so the mean distance is 45.9 mm with a SD of 7.6 mm.

We also noted in two of the cases, the superior laryngeal artery arose directly from the ECA rather than from STA [Figure 4].

Discussion

Origin of superior thyroid artery

The following variations of STA were mentioned in Bergmann's anatomy atlases. An unusually large STA may replace the contralateral vessel or the inferior thyroid artery on the same side. It arose from the CCA in 18% of cases, at the point of division of the CCA in 36%, or from the ECA in 36% of cases. The origin of STA from ECA and at CCA bifurcation shows an equal percentage which is same as our study.[6] Hollinshed quoted Daseler and Anson who found the STA originating from the carotid at or below the CCA bifurcation in 45% of 180 sides.[8]

Above are the variations noted in standard website and textbook, many studies done on various populations show variable results. In a study on 40 ECAs from human fetuses, it was determined that the STA originated from the carotid bifurcation in 70% (15 male–13 female) and the CCA in 5% (two female). The thyrolingual trunk was determined at a ratio of 2.5% (one female) on the left side. The thyrolinguofacial trunk was determined at a ratio of 2.5% (one male) on the right side (Zumre *et al*.)[6] In a study on 95 cadavers, four cases show that the STA was arising from CCA, and in one of the cases, STA was absent (Anu *et al*.)[9]

In another study done in Saudi Arabia by Al-Rafiah *et al*. on 60 cadavers, the STA originated in 46 cases (76.7%) from the ECA at the level of the bifurcation. In two (3.3%) cases, it originated from the ECA above the level of the bifurcation. In one (1.7%) case, it arose from a thyrolinguofacial trunk.[10] In a study by Sanjeev *et al*., the STA was found to arise from the ECA in 64.86% (24/37) of the cases, and in 35.14% (13/37) of the cases, it was found to arise from the CCA. The STA arose most frequently as a separate branch from the ECA and in only one case, the thyrolingual trunk (2.7%) was noted.[11]

Another study done in the United Kingdom by Vazquez *et al*. classified the source of origin into four types. The most frequent were type I, 49% from the carotid bifurcation (102/207), 26.6% originated from CCA (55/207), only 23% took origin from ECA (49/207).[4] The results vary from standard anatomy textbooks. Kapre *et al*. did a study on the variations in the branching pattern of ECA in 21 cadavers. They found thyrolingual trunk in 9.5% (2/21) cases.[3]

Table 1: The source and type of origin of superior thyroid artery in the present study

Source of origin of STA	Type of Vazquez classification	Number of specimens (60)			Percentage
		Right	Left	Total	
From carotid bifurcation	Type I	13	15	28	46.7
From CCA	Type II	0	3	3	5
From ECA [Figure 2]	Type III	20	8	28	46.7
As thyroid-lingual trunk	Type IVa	0	0	0	0
As thyroid-linguofacial trunk [Figure 3]	Type IVb	0	1	1	1.7

STA: Superior thyroid artery, CCA: Common carotid artery, ECA: External carotid artery

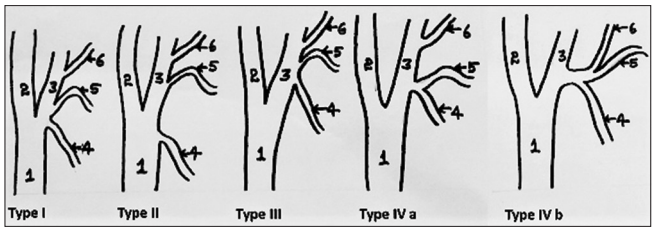

Figure 1: Schematic representation of Vazquez classification in the right carotid artery

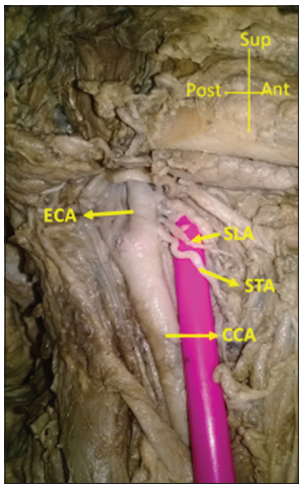

Figure 3: Left superior thyroid artery arising from thyrolinguofacial trunk

In another study on 46 cadavers from Kenyan population, they classified their results based on Vazquez types. STA origin is 2.2%, 10.9%, 80.4%, and 6.5% from type one, two, three, and four, respectively.[12]

In a cadaveric study by Gupta and Agarwal on 60 hemi necks, one case of thyrolinguofacial trunk was found on the left side (3.3%).[13]

Case reports from other studies also show variations in the origin of STA.[14-16]

Table 3 shows the comparison of the present study with earlier studies.

Level of origin of superior thyroid artery

A study by Lucev *et al*. on 40 STA found the distance of origin from the bifurcation ranged from 2 to 10.5 mm when it arose from the ECA. The distance of origin from the CCA to the bifurcation also ranged from 2 to 10.7 mm.

In another study done by Ozgur *et al*., the distance from the origin of the STA to the carotid bifurcation was 3.29 ± 4.27 mm, the distance from the origin of the STA to that of the lingual artery and facial artery was 10.45 ± 5.16 mm and 18.20 ± 8.81 mm, respectively. No differences were observed in the right–left side comparison of the data about the STA at a significance level of $P \geq 0.01$.

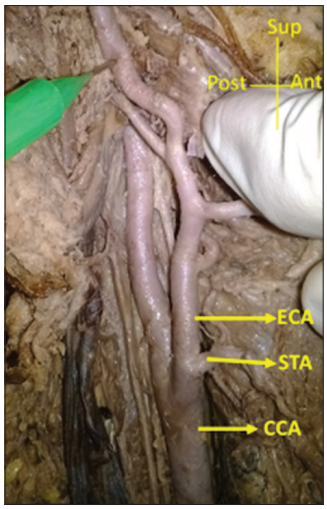

Figure 2: The right superior thyroid artery taking origin from external carotid artery

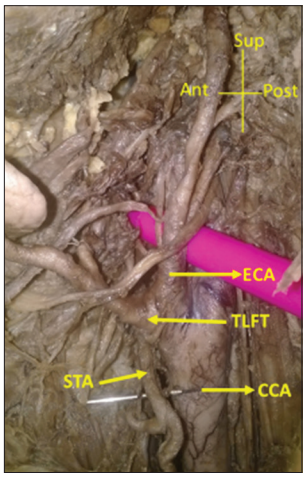

Figure 4: The right superior thyroid artery arising from carotid bifurcation and SLA taking origin from external carotid artery

Table 2: The difference in origin of superior thyroid artery in males and females

Source of origin of STA	Male-41 (%)	Female-19 (%)
From carotid bifurcation	18 (44)	11 (58)
From ECA	21 (51)	7 (37)
From CCA	2 (5)	1 (5)

STA: Superior thyroid artery, CCA: Common carotid artery, ECA: External carotid artery

In another study done in Saudi Arabia by Al-Rafiah *et al*., the distance of the origin from the bifurcation was from 0.9 to 1.1 cm. In 11 (18.3%) cases, it originated from the CCA. The distance of the origin from the bifurcation was from point four to one.[10]

A study by Sung-Yoon Won measured that the distance of origin of the STA from the ECA was 0.9 ± 0.4 mm below the hyoid bone. The STA was 4.4 ± 0.5 mm distal to the midline at the level of the laryngeal prominence of the

Table 3: Comparison in the source of origin of superior thyroid artery found in the present study with earlier studies

Source of origin of STA	Vazquez T, Cobiella R *et al.* (2009)	Sanjeev I K, Anitha H *et al.* (2010)	Ongeti and Ogeng'o (2011)	Rafiah A, Haggagy E *et al.* (2011)	Bergmann R A, Affifi A K *et al.*	Present study
Number of specimens	207	37	92	60	-	60
From ECA (%)						
As single trunk	48 (23)	6 (16.2)	80%	2 (3.3)	36%	28 (46.7)
At CCA bifurcation	102 (49)	18 (48.65)	-	46 (76.7)	36%	28 (46.7)
As common trunk with lingual and facial artery	1 (0)		6.5%	1 (1.7)	-	1 (1.7)
As common trunk with lingual artery	2 (1)	1 (2.7)		-	-	-
From CCA (%)	55 (26.6)	13 (35.14)	13%	11 (18.3)	18%	3 (5)

STA: Superior thyroid artery, CCA: Common carotid artery, ECA: External carotid artery

thyroid cartilage and 3.1 ± 0.6 mm distal to the midline at the level of the inferior border of the thyroid cartilage. Sanjeev *et al*. also found that the STA origin was 5 to 16 mm above the carotid bifurcation.[11]

In our study, the origin of STA from carotid bifurcation ranged from 1 to 25 mm which shows not many variations from other studies. We also measured the distance between laryngeal prominence in the midline to STA origin, which ranged between 45.9 ± 7.5 mm which is comparable to the study above.

Conclusion

Standard textbook descriptions of origin of STA from ECA should be reconsidered, as most of the studies shows near equal incidence of origin of STA from ECA and carotid bifurcations. Even variations between male and female and sides also should be kept in mind. Variations like origin from CCA as a common trunk with other anterior branches of ECA should be kept in mind while doing surgeries in neck region to minimize risk of bleeding. However, large scale study is needed for better reliability of most common variations.

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Conflicts of interest

There are no conflicts of interest.

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Case Report

Multiple Anomalies of Derivatives of the Left Cardinal Veins

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Abstract

We hereby report several anomalies of the cardinal veins derivatives. First, a continuous hemiazygos trunk was identified replacing the hemiazygos, accessory hemiazygos, and left superior intercostal veins. Second, a reno-hemiazygos-lumbar trunk was found to connect the left ascending lumbar and renal veins. In the same patient, a persisting left superior vena cava was also found. These findings are related to developmental anomalies of both supra-and subcardinal veins. Such combination of different anatomic vascular variants in the same patient recommends an evaluation of the vascular anatomy prior to surgical and interventional procedures.

Keywords: *Anatomic variation, external jugular vein, hemiazygos vein, persisting left superior vena cava, reno-hemiazygos-lumbar trunk*

Introduction

Developmental variations of the cardinal veins are uncommon.[1]

The persisting left superior vena cava (PLSVC) was first described in 1738 and is determined by the persistence of the left anterior cardinal vein caudal to the left brachiocephalic (innominate) vein.[2]

The hemiazygos and left renal veins can connect through a reno-hemiazygos-lumbar trunk (RHLT), also known as "*tronc reno-rahidien*".[3]

Here is reported a CT study in which different venous variations were found in the same patient.

Case Report

A 58-year-old female diagnosed with pulmonary neoplasm was referred to the Telescan Center Timisoara for complete evaluation. Computed tomography (CT) scan showed a 3 cm nodular image in the superior segment of left upper lobe with infiltrative changes in the surrounding parenchyma, enlarged right hilar lymph nodes (12 mm), bronchiectasis in the anterior segment of left upper lobe and superior segment of left lower lobe with fibrotic changes secondary to radiotherapy. An iodine radiocontrast agent was injected in the left brachial vein (100 ml, with 6 ml/s flow), followed by 40 ml saline medium mixed with 10 ml iodine contrast. Due to a variant anastomotic pathway and the high flow injection, the contrast medium opacified retrogradely both the hemiazygos and azygos veins. We used a 16-slice scanner; 1.2 mm collimation and reconstructions of 3 mm thickness with no overlap for primary diagnosis; and 1.5 mm thickness with 50% overlap for multiplanar, maximum intensity projection (MIP), and three-dimensional volume rendering technique.

The azygos vein appeared anatomically normal; it resulted from the right ascending lumbar and subcostal veins, drained the right posterior intercostal veins and was draining in the initial segment of the superior vena cava.

We found a complex of congenital venous anomalies, at both ends of the hemiazygos system. A prominent hemiazygos trunk (HT) continued the ascending lumbar vein which, in turn, was anatomically connected to the main trunk of the left renal vein by a RHLT [Figure 1]. After receiving the left subcostal vein, the hemiazygos vein went through the posterior mediastinum where it drained left posterior intercostal veins. The HT was connected-anterior to the 10th thoracic vertebra, to the azygos vein, by an interazygos vein and further continued upward, successively replacing the accessory hemiazygos and the left

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superior intercostal veins [Figure 2]. The distal part of the HT, corresponding to the left superior intercostal vein, crossed the aortic arch and joined the left brachiocephalic vein [Figure 3].

We also found a rudimentary PLSVC, connecting the coronary sinus and the distal portion of the HT [Figure 1]. The intrapericardial course, with segments corresponding to the fold of Marshall, and the oblique vein of the left atrium were permeable, allowing the PLSVC to empty into the coronary sinus.

Apart from the CT study, an adult cadaver was used to demonstrate the PLSVC and the derivatives of the left anterior cardinal system by dissection [Supplement Figure 1].

Discussion

To understand these complex venous variants, the development of the embryonic cardinal veins should be recalled. From the 4th to the 7th week of the embryo, the cardinal, and then, the supra-, sub-, and sacrocardinal veins are formed.[4] Further remodeling of the cardinal veins system will establish the final anatomy of the vena cava system, as follows:[4] (a) the superior vena cava develops from the right anterior cardinal vein and the right common cardinal vein; (b) the azygos vein forms from the cranial part of the right supracardinal vein; (c) the left brachiocephalic vein normally results from the anastomosis of the anterior cardinal veins (the precardinal anastomosis); (d) the left superior intercostal vein results from the terminal end of the left anterior cardinal vein that adds the cranial end of the left supracardinal vein; (e) the distal portions of the left supracardinal vein will lose connection with the cephalic end and will form the hemiazygos and accessory hemiazygos veins; (f) the left renal vein will result from the anastomosis of the subcardinal veins; the proximal part of the left subcardinal vein will disappear.

In the case, we report here, the left supracardinal vein did not appear to be segmented, thus leading to the HT variant. Moreover, the left anterior cardinal vein kept the initial morphological pattern, and the PLSVC resulted. The RHLT appears as a connection that initially linked the left subcardinal vein and the primitive left renal vein.

The absence of the precardinal anastomosis (inter-precardinal vein) has been thought to explain a left superior vena cava that continued to the accessory hemiazygos vein without anastomosis with the coronary sinus.[5] This is not the case here. However, this case indicates a possible misdiagnosis that can happen when a dilated left superior intercostal vein [such as the reported one or the one presented in Supplement Figure 1], is mistaken with the left brachiocephalic vein.

The occurrence of the left RHLT varies from 16.4% to 90.9%.[6,7] The renal-hemiazygos pathway belongs to the extrahepatic collateral routes in Budd-Chiari syndrome.[6]

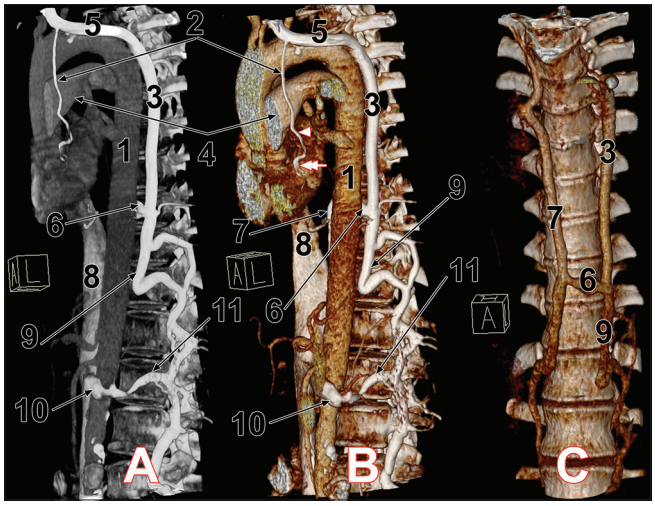

Figure 1: Anatomic variation of left supra-and and subcardinal veins derivatives, detailed in MIP (A) and 3D VR (B and C) captured images. 1. Aorta; 2. Persisting left superior vena cava (the arrowhead in B indicates it at the level of the Marshall's fold and the double-headed arrow in B indicates the oblique vein of left atrium); 3. Accessory hemiazygos vein; 4. Pulmonary trunk; 5. Left superior intercostal vein; 6. Interazygos vein; 7. Azygos vein; 8. Inferior vena cava; 9. Hemiazygos vein; 10. Left renal vein; 11. Reno-hemiazygos-lumbar trunk

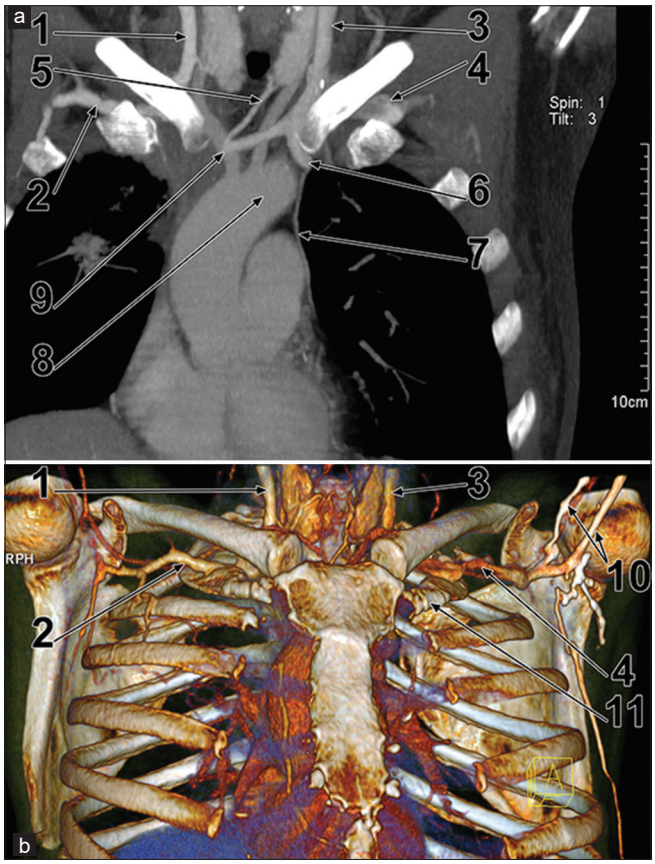

Figure 2: Anatomy of the veins at the base of neck and in the upper mediastinum, detailed in MIP (a) and 3D VR (b) captured images. 1. Right internal jugular vein; 2. Right subclavian vein; 3. Left internal jugular vein; 4. Left subclavian vein; 5. Inferior thyroid vein; 6. Left superior intercostal vein; 7. Persisting left superior vena cava; 8. Aorta; 9. Left superior brachiocephalic vein; 10. Brachial veins (the arms are abducted); 11. Left first rib

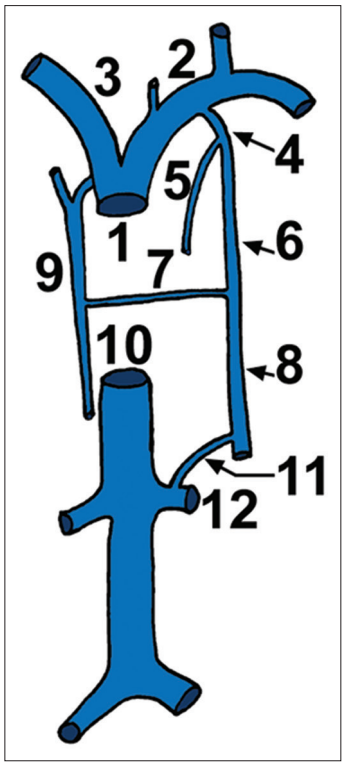

Figure 3: Diagram of the reported variant. 1. Superior vena cava; 2. Left brachiocephalic vein; 3. Right brachiocephalic vein; 4. Left superior intercostal vein; 5. Persisting left superior vena cava; 6. Accessory hemiazygos vein; 7. Interazygos vein; 8. Hemiazygos vein; 9. Azygos vein; 10. Inferior vena cava; 11. Reno-hemiazygos-lumbar trunk; 12. Left renal vein

Knowledge of variations of head-and-neck and upper mediastinum veins is important to surgeons and interventional radiologists, an unidentified anatomic venous variation could lead to catheter misplacements, which are reported with rates from 1% to 6%,[8] or leading to iatrogenic damage. The azygos-hemiazygos system can serve as an alternative for catheter placement.[9] Moreover, the anatomic variations of the renal vessels should be carefully documented before renal transplants or radical nephrectomy. Multidetector row CT is a reliable technique useful in preoperative evaluation of living renal donors.[10] Nevertheless, surgical approaches of the spine should be performed after the individual vascular anatomy is documented, especially when anterior approaches are designed.

This case report showed that multiple anatomic variants can occur in one patient. Thus, evaluation of patients should be performed carefully and thoroughly, and certain surgical interventions may need to be preceded by radiological explorations to accurately describe the vascular anatomy of the region.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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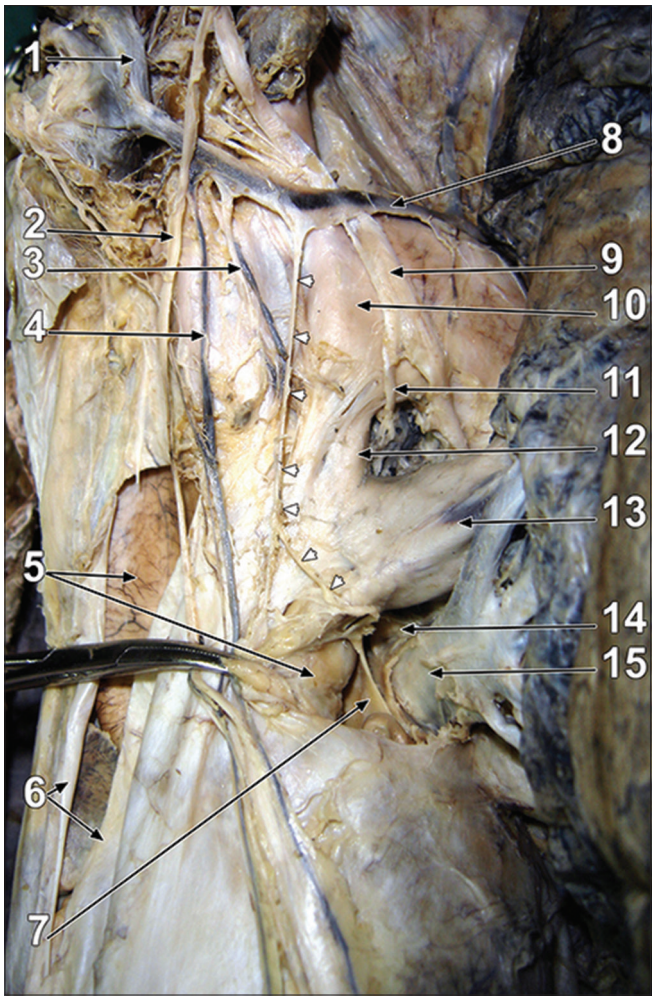

Supplement Figure 1: Dissection of mediastinum in an adult cadaver, to sample (white arrowheads) the vestigial persistence of the intermediate segment of the left anterior cardinal vein, left A-l view. 1. Left brachiocephalic vein; 2. Left phrenic nerve; 3. Pericardial vessels; 4. Pericardiophrenic vein; 5. Ascending aorta, pulmonary trunk; 6. Pericardial sac (opened); 7. Fold of Marshall; 8. Left superior intercostal vein; 9. Left vagus nerve; 10. Aortic arch; 11. Left recurrent laryngeal nerve; 12. Arterial ligament; 13. Left pulmonary artery; 14. Left bronchus; 15. Left superior pulmonary vein

Case Report

Osteosclerotic Bone Disorder - Pyknodysostosis

Abstract

Pyknodysostosis is an autosomal recessive osteoclastic dysfunction characterized by generalized hyperostosis and short stature which has mere 10 cases reported from India out of 133 globally reported cases. This rare disorder is due to defective lysosomal cysteine protease cathepsin K in chromosome 21. A male child of 11 years underwent radiological investigation for stunted growth. Examination revealed less height for age, retarded mandibular growth, dysmorphic facial growth, and proportionately short fingers. Radiological findings showed generalized osteosclorosis, hypoplastic paranasal air sinuses, spool-shaped dorsolumbar vertebral bodies, acro-osteolysis of terminal phalanges, and scalloped acetabulum with increased bone density. Management of child should be aimed at correcting anemia and primary prevention of fractures. The postnatal craniofacial development needs to be monitored. Long-term management should aim at genetic mapping and therapy with bone marrow transplantation.

Keywords: *Acro-osteolysis, osteosclerosis, pyknodysostosis*

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Introduction

Pyknodysostosis, also known as osteopetrosis acro-osteolytica or Toulouse–Lautrec syndrome, is a rare autosomal recessive bone disorder of osteoclast dysfunction, characterized by short stature and generalized osteosclerosis or hyperostosis with acro-osteolysis of terminal phalanges.[1] This condition has an incidence of 1.7 per 1 million births and shows equal sex distribution with a significant relation to parental consanguinity. So far, medical literature has 133 reports of this condition, of which 10 have been reported from India.[1-3]

The disorder is characterized by postnatal onset of proportionate dwarfism, repeated respiratory infections, sleep apnea, and diffuse generalized osteosclerosis with increased incidence of long bone fractures after minimal trauma. There is increased bone density with thickened cortex and narrow medulla. Intellectual and sexual development and lifespan are found to be usually normal in affected individuals.[1,2,4,5]

Typical dysmorphic facies, abnormal dentition, and axial skeletal abnormalities have been described. The appendicular skeletal abnormalities with hypoplastic clavicle and short broad hands with total or partial acro-osteolysis of terminal phalanges were reported as specific features of this condition.[1,2,4-6]

Case Presentation

An male child aged 11 years with complaints of delayed milestones and reduced height was investigated in the department of radiodiagnosis. No history of parental consanguinity or repeated bone fractures was noted.

On examination, the child was short statured for his age, with a measured height of 98 cm. The fingers were proportionately short with wrinkled skin over the dorsum of distal fingers and flat, grooved nails. A large head with hypoplastic face, depressed nasal bridge, Fronto-occipito-parietal bossing, persistent fontanelles, and small mandible with prognathism were noted. The oral cavity showed crowding of teeth and high arched palate. The chest wall was observed to have prominent sternum with barrel-shaped deformity. Accentuated lumbar lordosis was observed. Hypoplasia of fingers was also noted.

On radiological examination, almost all the bones showed increased bone density with diffuse osteosclerosis. The long bones were seen with thickened cortex and narrow medulla [Figure 1].

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Lateral cephalogram showed hypoplastic nasal bones and paranasal air sinuses. The mandible was hypoplastic, and the gonial angle was grossly obtuse (flattened) with prognathism. The mandibular ramus, condyle, and condylar notch were narrow [Figure 2]. The calvaria and skull base were thick with persistent fontanelles with wide-open lambdoid sutures. The bony volume of sella turcica was increased with reduced size of hypophyseal fossa [Figure 3]. Radiograph of the cervicothoracic region revealed hypoplastic clavicle with aplasia of acromial end and normal cardiac outline [Figure 4]. The dorsolumbar spine showed spool-shaped vertebral bodies, prominent in the anterior aspect [Figure 5]. Acro-osteolysis of terminal phalanges in most of the fingers was observed in both hands [Figure 6]. The roentgenogram of the pelvis showed scalloped outline of the acetabulum with increased bone density [Figure 7]. No previous signs of fracture were visible in the radiographs of the long bones. The child was advised genetic analysis to confirm the diagnosis.

Discussion

Pyknodysostosis is an autosomal recessive osteoclast dysfunction exhibiting equal gender distribution and documented parental consanguinity in only 38% of reported cases.[7,8] Similar to the present case, these cases present at an early age with short stature and open fontanelles. The presentation at later ages may be due to fractures, resulting from minimal or moderate trauma.[9,10]

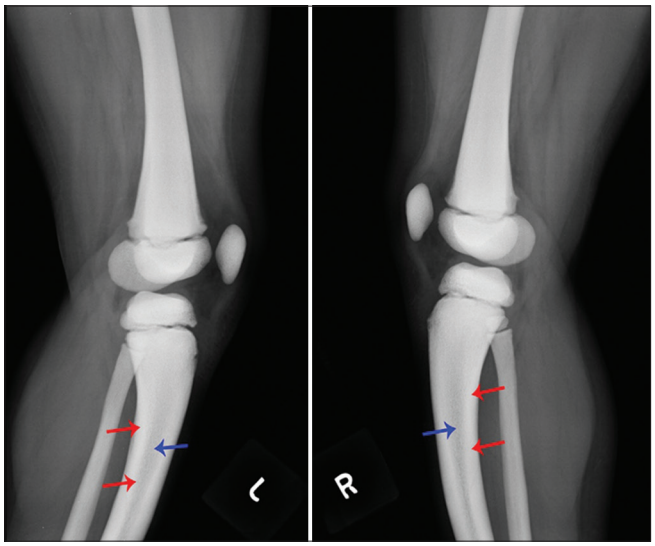

Figure 1: Increased bone density with diffuse osteosclerosis (red arrows) and narrow medullary cavity (blue arrows)

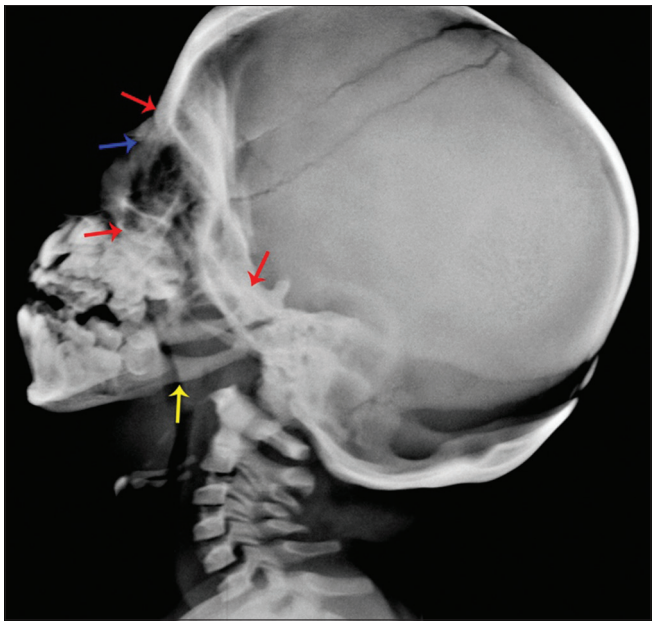

Figure 2: Hypoplastic paranasal air sinuses (red arrows) and nasal bone (blue arrow). Hypoplastic mandible with flattened gonial angle (yellow arrow)

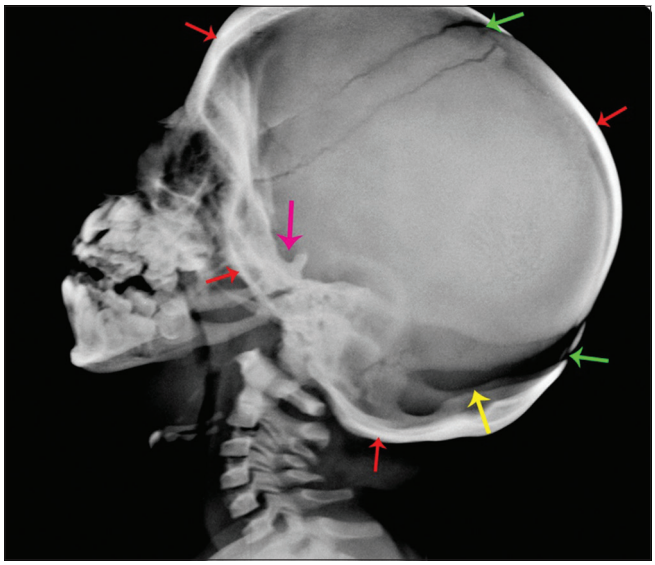

Figure 3: Thick cranial vault and skull base (red arrows), persistent fontanelle (green arrows), wide-open lamdoid suture (yellow arrow), and reduced size of hypophyseal fossa (pink arrow)

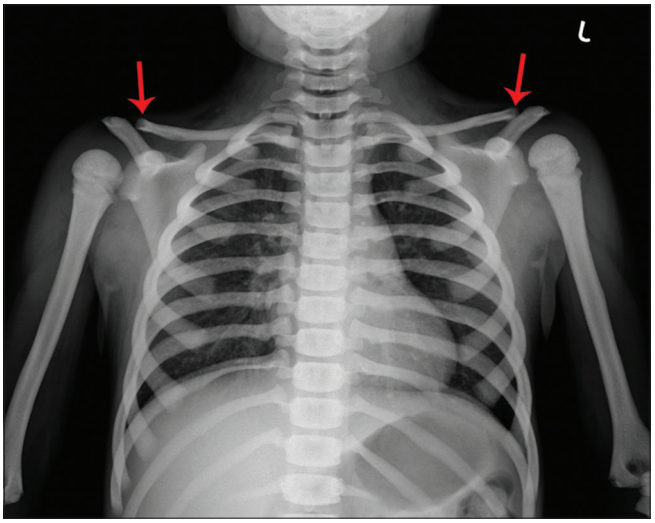

Figure 4: Hypoplastic clavicle with aplasia of acromial end (red arrow)

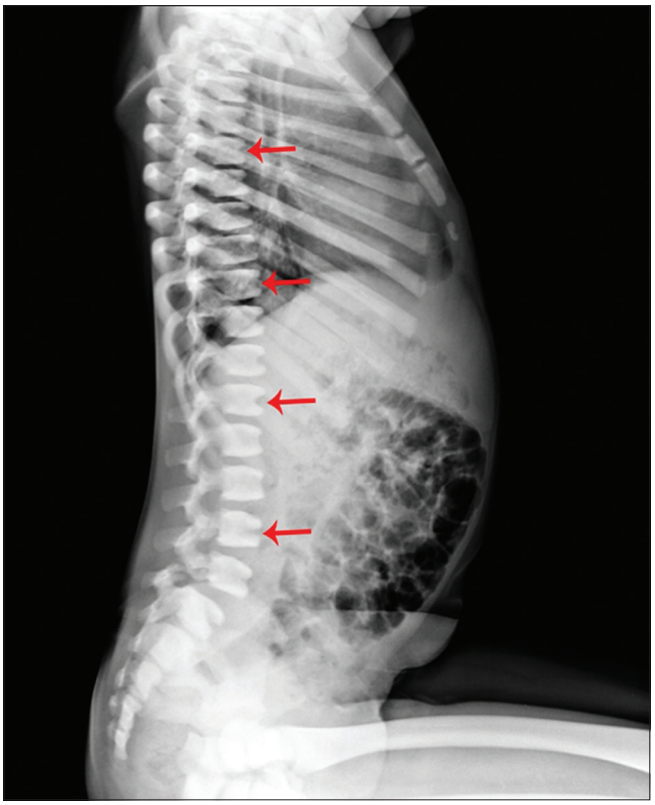

Figure 5: Spool-shaped dorsolumbar vertebral bodies (red arrows)

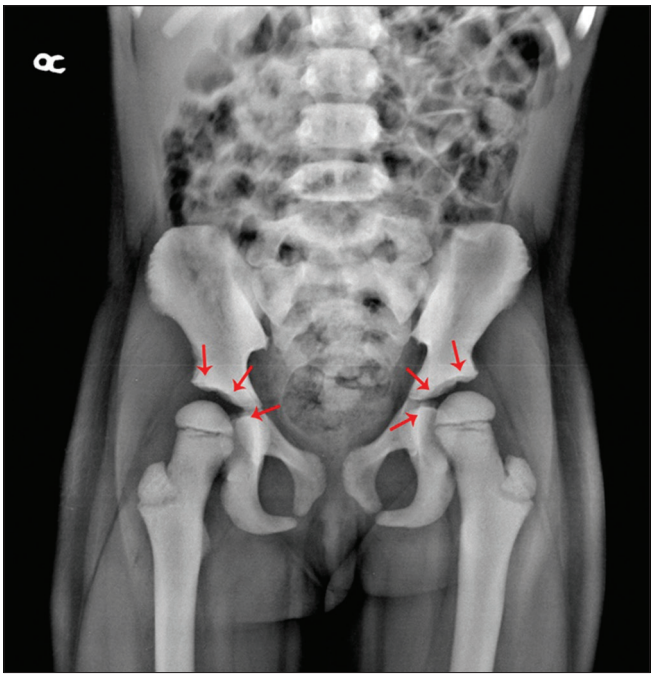

Figure 7: Scalloped outline of the acetabulum (red arrows) with increased bone density of pelvis

A genetic defect on chromosome 1q21 is claimed as the main factor, resulting in increased sclerosing activity. Cathepsin K (CTSK), a lysosomal cysteine protease which is implicated in osteoclast-mediated bone resorption and remodeling, undergoes mutational changes resulting in

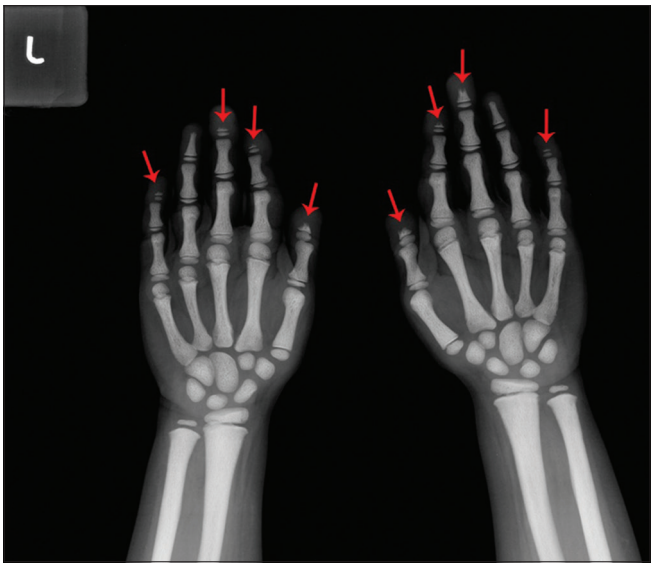

Figure 6: Acro-osteolysis of terminal phalanges (red arrows)

reduced expression in osteoclasts. The enzyme degrades type 1 collagen, which constitutes 95% of organic bone matrix. The bones become abnormally dense and brittle due to insufficient resorption by osteoclasts.[11]

The compression of pituitary gland due to increased bone volume of sella turcica resulting in deficient production of growth hormone was reported as probable reason for short stature which is observed as the most common characteristic feature of this condition.[12,13] The typical features in facial, axial, and appendicular skeleton as documented previously were observed in the present case also.[12]

Some of the additional features reported by studies, such as the presence of wormian bones in sutures, incomplete segmentation of vertebrae, coxa valga and abnormal radioulnar articulation, and hepatosplenomegaly, were not observed in our case report.[1,12]

In the process of clinical diagnosis, this condition needs to be differentiated from the comparatively common bone disorders such as osteopetrosis, cleidocranial dysplasia, and idiopathic acro-osteolysis by observation of other specific characters of those conditions. In osteopetrosis, the bone marrow may be absent without increased bone density. Signs of cranial nerve compression such as facial paralysis and deafness may exist. The hands, feet, clavicles, gonial angles, maxilla, and skull vault are normal without stunted growth or multiple fractures or diffuse osteosclerosis. Cleidocranial dysplasia/dysostosis looks similar to pyknodysostosis due to the presence of clavicular aplasia and alterations of skeletal bone membranes. The bone density and height are normal with the absence of diffuse osteosclerosis. Cranium and clavicle are involved but spare mandible and phalanges. In idiopathic acro-osteolysis, there is typical appearance with hypotelorism, exophthalmos, an upturned nose, and acute mandibular angle without increased bone density.[1,3,4,6,8,9]

Diagnosis of this condition at an early age, after considering other possible disorders, will help to plan a suitable treatment to improve the patient's quality of life. The diagnosis is primarily based on clinical features and radiographs, but CTSK gene mutation analysis is the confirmatory test.[3] The management for this condition is mainly supportive treatment considering the growth retardation and craniofacial developmental abnormalities. It should also aim at correcting anemia and primary prevention of fractures. In addition to bone marrow transplantation for providing normal osteoclasts and their targeted enzymes, gene replacement strategies are drawing more attention.[4]

The prognosis is good with normal life expectancy and without much serious systemic disabilities.[3] This case is being presented for its rarity.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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An Anatomical Model for SARS-CoV-2 Entry into Mastoid and Middle Ear in COVID-19 Patients

Dear Editor,

Recently, Frazier *et al.* detected SARS-CoV-2 RNA in the PCR-based testing of postmortem biopsy specimens from the middle ear and mastoid cavity of two out of three COVID-19 patients.[1] Detection of SARS-CoV-2 in the deeper parts of the ear is a finding of utmost clinical significance and deserves extensive deliberation. However, how did SARS-CoV-2 reach these parts of the ear, which are not directly exposed to the external environment, is intriguing and deserves an anatomical explanation. In this letter, we suggest an anatomical model which can effectively explain the route of the viral entry from the nose to the middle ear and to the mastoid.

To invade and replicate into a human tissue, SARS-CoV-2 binds to a human cell surface receptor called angiotensin-converting enzyme 2 (ACE-2) through the receptor-binding domain (RBD) present at its spike (S) protein.[2] For the successful host cell membrane fusion and infectivity, following ACE-2 binding, cleavage of the viral spike protein (S) by the proteases like transmembrane serine protease-2 (TMPRSS-2) is essential.[2] Recent studies showed enriched expression of ACE-2 (and also TMPRSS-2) in the epithelial lining of the upper respiratory tract including the nose in humans.[3] Similar evidence has been found for the epithelial lining of the middle ear and mastoid cavities in a recent mouse study.[4]

The nasopharynx, from where swab is collected for viral testing in COVID-19, is anatomically unique in the sense that it presents a common meeting place for the ear, nose, and mouth cavities.[5] The middle ear opens into the lateral wall of the nasopharynx through the "Eustachian tube (ET)" – an osteocartilaginous canal which is about 36 mm in length[5] [Figure 1]. ET has important functions of draining the mucosal secretions from the middle ear cavity to the throat and maintaining the air pressure in the middle ear cavity allowing the controlled passage of the breathing air through the slit-shaped nasopharyngeal opening of the tube.[5] The middle ear is further connected to the mastoid cavity through a very short passage called aditus[5] [Figure 1]. ET has a lining of the respiratory epithelium, and the middle ear and mastoid cavities have simple squamous secretory epithelium, which may allow them to harbor SARS-CoV-2, owing to abundant expression of the viral cell entry factors.[3,4] The nasopharynx has a mucosal continuity with the middle ear and mastoid cavity through the ET that presents a convenient route for the spread of the virus to the deep auricular parts [Figure 1].

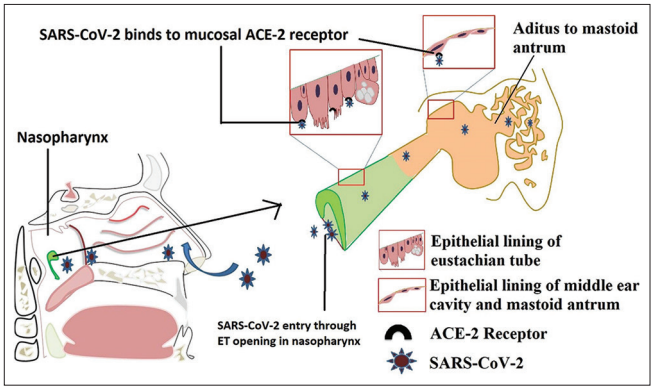

Figure 1: A model depicting anatomical route for transmucosal spread of SARS-CoV-2 from the nasopharynx to the middle ear and mastoid cavities. [There is an anatomical continuity from the nasopharynx to the middle ear and then to the mastoid through the Eustachian tube. This route is initially lined by the mucosal respiratory (nasopharynx to the Eustachian tube) epithelium and then secretory simple squamous (middle ear and mastoid) epithelium which express angiotensin-converting enzyme 2 receptors that can bind SARS-CoV-2, hence presents a transmucosal route of spread for entry of the virus while inhaling air through the nose].

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Letter to Editor

The Extensor Digitorum Profundus Muscle – An Attractive Term, but is it Appropriate for Describing the Human Hand?

Abstract

In general, when a particular term in medicine is used, it should be correct and precise. Human anatomy is an old science and has developed over the years with various and numerous terms and classifications being used. Their role is to present and summarize the described findings, simply and understandably, not only to the anatomist but also to the clinicians. The goal of our comments is to present our point of view about a term, used for a variant hand muscle, called the extensor digitorum profundus; it was first mentioned in the hands of primates but since has been used by some to describe human anatomy. We discuss why such use of the term in humans is incorrect and should be limited to various animals.

Keywords: *Commentary, extensor digitorum profundus muscle, hand, human*

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The anatomy of the hand is important to many including anatomists and hand surgeons. The unique anatomy of the human hand has culminated in the perfection needed for use by mankind and is exemplified in musicians, sculptors, painters, and surgeons. The anatomy of the hand is well known as well as its anatomical variations. However, anatomical terminology must be precise and clear when describing anatomical variations. In addition, terms should not be confusing. When determining a term for a variant muscle, three important things should be considered: (1) The precise location; (2) its exact origin and insertions; and (3) Its potential function.

Herein, our goal is to discuss and clarify the terminology used for a muscle of the upper limb that, in our opinion, has been wrongly named. The term extensor digitorum profundus (EDP) describes a variant dorsal muscle of the hand including the extensor indicis proprius (EIP) muscle and/or the extensor pollicis longus (EPL) muscle.[1-3]

Why is the term EDP inappropriate? (1) the EDP includes a muscle complex assigned to the ulno-carpal series of the antebrachio-manual muscles of primates.[4] However, Novikova and Panyutina[5] stated that in mammals, the EDP complex consists of m. EPL, m. extensor digiti secondi (extensor indicis muscle), and m. extensor digitorum lateralis (extensor digitorum muscle); (2) if the term EDP is accepted as another deep muscle similar to the finger flexors (superficial and deep) of the anterior forearm, it should have a different function compared to the flexor digitorum profundus muscle. Although based on reports in the literature, the EDP does not have another function; this muscle describes a variant of the EIP or EPL; (3) presentation of this term, in our opinion, might confuse the muscle terminology used by clinical anatomists and especially, hand surgeons.

When a term for an anatomical structure is used it has to describe and present the structure clearly as well as its function. In our opinion, the term EDP used for human hand anatomy, as a variant of the EIP or EPL might mislead clinicians and researchers so that future communications are misconveyed and a true understanding of such muscles in the human hand are not fully understood.

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