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CONTENT

EDITORIAL

Overcoming challenges to anatomy education during the Covid-19 pandemic

The year 2020 dawned with the world having to face one of the most serious pandemics in centuries. With the many health precautions having to be implemented, the education sector took a massive blow with schools and universities being closed for many months. Educationists had to adapt promptly to a set of new rules in order to keep the flame of learning from going out.

Educational institutes including universities in Sri Lanka were requested to implement online teaching and learning methods to reduce the disruption to education. As first year teachers anatomists were called upon to make the transition into online teaching. Those institutions that had previously installed LMS (Learning Management Systems) found it easier to make the transition from onsite to online. Workshops were organized by the Medical Education Department to update teachers on new features on LMS and the LMS at Peradeniya was upgraded to a more student friendly one.

Medical faculties were at the forefront of this transition, quickly moving from the regular lecture delivery system to narrated lectures and video and audio conferencing. All anatomy departments across the country commenced online teaching as soon as was practically possible. However all institutions faced many problems and criticisms during the initial period. One of the biggest hurdles was the accessibility of the material to students. Though some critics blamed the medical faculties for rushing into an educationally unsound system of delivery the students were of a different opinion. Many medical students praised the staff for implementing the system. Preclinical departments were at the forefront displaying narrated lectures and conducting audio and video conferencing to cover all online components on time.

Initial surveys done at Peradeniya showed that up to 70% of the students had good access to internet and owned devices for easy access such as smart phones and tablets. Only 2-3% of students stated that they were unable to access the internet and did not possess internet enabled devices. Teachers went so far as to offer to pay the internet bills of students and even to provide them with devices in order to ensure accessibility to all. With time the students developed systems of their own to help their fellow batch mates and each and every student was able to access if not video and audio conferencing, at least the lectures posted on LMS. At Peradeniya teachers were encouraged to record their real time sessions and upload those to the

LMS in order for the students to be able to access at their convenience. With the UGC providing free access to video conferencing and the government providing free internet for LMS the accessibility problem was solved to a great extent.

The highly technical and practical oriented field such as Anatomy was faced with the problem of delivering practical material online, imparting gross anatomy knowledge to the students becoming a major obstacle. Different faculties employed different methods to tackle this problem. At Peradeniya displaying labeled photographs of prosected specimens was employed initially. With the universities opening partially we moved on to short video demonstrations of prosected specimens and this is the main method of delivery currently. Further, access to an online dissection atlas was also given to students, which was highly appreciated by them. However, the cost for access to such atlases is very high and became difficult to procure funds continuously. Anatomy department at Peradeniya is currently in the process of developing a digital atlas for this purpose.

A problem faced by teachers during online teaching is the difficulty in judging if the students actually imbibe what is being taught. Most students prefer not to have video conferencing and prefer only audio and thereby many teachers share their screens with students and post questions for students to answer. Assignments are given at more regular intervals and answers are emailed to the teachers who do their best to correct and send the scripts back. Further at Peradeniya many departments have started social media groups which are a fast and effective method of giving information to students. Questions are posted on LMS and the answers are discussed on social media groups. Email communication too has increased between students and teachers and a better platform for them to ask questions has been set. It is observed that students feel more confident asking questions on social media groups than during lectures or tutorials.

Another difficult task ahead for all anatomists and educationists is holding examinations. Peradeniya held several examinations with minimal contact with students. The anatomy department conducted the gross anatomy spot as a projected Objective Structured Practical Examination (OSPE). Other countries have organized online examinations from home for their students using expensive software programs in order to check if students are cheating. Being a developing country we may not be able to purchase such software but this problem too needs to be addressed in the near future if universities remain closed. The way forward lies in improving internet access, reducing data cost, making internet enabled devices available to students and training staff on novel knowledge

delivery systems: basically using imagination and innovation.

The process of training doctors cannot be halted especially in a pandemic situation and as anatomists we are bound to set the foundation of medical education and therefore need to move forward as we have been doing for centuries facing new challenges and overcoming them with confidence.

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REVIEW ARTICLE

Development of a Core Curriculum for Anatomy in Sri Lanka

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Running Title: Core Curriculum for Anatomy

Doctors without anatomy are similar to moles: they work in the dark and their daily tasks are mole hills Tiedemann: Heidelberg1 (1781-1861)

Establishment of the Colombo Medical School in 1870' can be regarded as a milestone in the allopathic medical education in Sri Lanka. At present there are ten medical faculties - each of which is attached to a state university - undertake medical education in the country under the governance of university grants commission (UGC) of Sri Lanka. The UGC of Sri Lanka which is overseen by the Ministry of Higher Education, Technology and Innovation, regulates the admission of students to the state universities[2]. The UGC has decided to commence the eleventh medical faculty in the current year in order to expand the medical education in the country[3].

The state universities in Sri Lanka develop their anatomy curriculum as part of their own medical curriculum in accordance with the Subject Benchmark Statement in Medicine of the UGC, Sri Lanka[4] and the approved standards for Undergraduate Medical Education in Sri Lanka by the Sri Lanka Medical Council (SLMC), Sri Lanka[5]. In addition, universities should comply with other guidelines and standards prescribed by the UGC [such as Codes of Practice by the Quality Assurance Council (QAAC)][2] and its line Ministry [e.g. Sri Lanka Qualifications Framework (SLQF)][6]. Further, medical course should adhere to other reference points such as the learning outcomes, standards, by-laws and guidelines pertaining to the respective institution. Upon approval of the Senate of the relevant institutions, the medical curriculum is implemented. These guidelines / regulations establish an association between academic and professional accreditation and ensures maintenance of optimal standard of medical education throughout the country while permitting the universities to decide on their own type of curriculum (i.e. traditional discipline based, module based, problem based or mixed), teaching / learning and assessment methods.

Anatomy is a basic medical science and an integral component of medical education. A comprehensive knowledge in anatomy is key to safe and effective practice of medicine. The medical degrees offered by all state universities are similarly valued in terms of academic merits and on its recognition by the SLMC for professional registration of medical graduates.

Hence, any inconsistencies in the type of curriculum, overall contents, teaching and assessment methods among medical faculties often confuse the undergraduate medical students about the approach and extent of learning Anatomy. A short review on the content and dedicated hours for anatomy in the curricula of medical faculties of three selected universities was performed mainly based on the information available on the website of the respective institutions. There was a remarkable difference in the overall student contact hours for teaching anatomy between the two similar aged medical faculties established approximately four decades ago [483 hours[7] and 516 hours[8]] and one of the two youngest functioning medical faculties (733 hours[9]). In addition, time allocated for teaching main contents / sections, as an example microscopic anatomy showed considerable differences between one older (48 hours)[7] and recently established (90 hours)[9] medical faculties where the other older medical faculty occupied a position in between (78 hours)[8] these two institutions. Variation in the teaching / learning methods for the above section was also evident between the selected universities. It is noteworthy that the recent curriculum revision of one of the older Universities resulted in 25.5% reduction of anatomy curriculum from 659.5 hours (older curriculum)[10] to 491 hours (following curricular revision)[7]. These observations clearly indicate that in the absence of an empirically scrutinized - generally agreed - core curriculum for anatomy along with well-defined goals, considerable differences in anatomy education between medical faculties, is inevitable. The observations presented above are merely for highlighting the variations between existing curricula in the country and, not for suggesting or endorsing student contact hours for any institution or section which is beyond the scope of this manuscript.

The Anatomical Society[11] (previously known as "Anatomical Society of Great Britain and Ireland") has proposed a revised core syllabus in 2015 / 2016 for anatomy for undergraduate medical education. It encompasses a series of 156 learning outcomes that should be achieved by a medical student at the time of his / her graduation. However, this core curriculum does not include the learning outcomes for certain sections such as the microscopic anatomy and embryology12,13. In addition, the International Federation of Associations of Anatomists (IFAA), an organization consisting of twenty seven national and multinational anatomical associations, has initiated a core syllabus project for developing such curriculum for teaching anatomy in medicine and allied health programs14. During this process, the core syllabus for head and neck, neuroanatomy and musculoskeletal anatomy has been finalized and published. However, curriculum of medical schools should be viewed along with the differences in the entry criteria to the medical course between Sri Lanka and certain countries which prerequisite a pre-med degree for admission of students15. Preparation of core curriculum for clinical subjects by the UGC, Sri Lanka

is on progress and will be implemented nationally upon its approval. However, development of a core syllabus for anatomy was not fruitful despite of efforts taken in the past.

The proposed core curriculum should serve as a national guideline which can be adapted into individual curriculum of state universities irrespective of type of curriculum followed which itself determined by many factors including the practical availability of academic staff in the Faculty of Medicine. The intended core syllabus for anatomy should incorporate important contents while addressing the global concerns related to reduction in the anatomy teaching hours and expectation of more clinical oriented teaching. The contents of core curriculum is debatable and to be determined by the subject experts by consensus. However following areas could be considered for inclusion or at least as a framework to initiate a meaningful discussion in the development of a core curriculum for teaching anatomy for undergraduate medical students:

1. Main contents / sections in teaching anatomy (e.g. general anatomy, gross anatomy, microscopic anatomy, embryology, radiology, genetics etc.)
2. An overview and, prescribed student contact hours for each main content / section (Preferably in a range)
3. Learning outcomes for each section and subsections (e.g. gross anatomy can be further categorized into body regions such as upper limb, thorax, abdomen etc.)
4. Methods of assessment for all types of curriculum followed in the country separately

In addition, core curriculum may suggest the teaching / learning methods for each main contents / section (e.g. learning gross anatomy through complete dissection by students or prosection or teaching using prosected specimens or three dimensional computer programmes or combination of more than one methods etc.) that could be considered in the periodical revision of curriculum of individual universities.

In conclusion, development of a core curriculum for anatomy will be a corner stone in the medical education in Sri Lanka. It will enable the anatomy educators, clinicians and other stake holders to recommend an appropriate anatomy curriculum for their respective institution based on the core syllabus accepted nationally. It will overcome the inconsistencies in anatomy education between universities and ensures that the students obtain almost equal and sufficient knowledge and skills and, avoid any unnecessary burden imposed on them.

Conflict of interest

The author declares no conflict of interest.

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RESEARCH PAPERS

Morphology and the position of the pterion in a Sri Lankan population

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Running title: Morphology and position of the pterion

Abstract

Objective: The present study was conducted to describe the morphology of the pterion, and its position in an adult Sri Lankan population.

Materials and methods: Fifty eight pteria of twenty nine adult skulls of known gender in a Sri Lankan population were analyzed to determine the sutural morphology of the pterion, and its precise location in relation to the posterolateral aspect of the frontozygomatic suture, midpoint of the zygomatic arch, anterior and superior most point of the external auditory meatus, and the inferior most point of the mastoid process.

Results: The predominant type of pterion observed was sphenoparietal (82.5%), followed by stellate (8.7%), frontotemporal (5.3%), and epipteric types (3.5%). The mean distances from the center of the pterion to the frontozygomatic suture were measured as 31.11 ± 5.02 mm and 26.98 ± 3.45 mm; to the zygomatic arch, 38.92 ± 3.55 mm and 36.16 ± 3.83 mm; to the mastoid process, 81.54 ± 4.62 mm and 77.79 ± 3.88 mm; and to the external acoustic meatus, 53.62 ± 2.58 mm and 51.91 ± 2.98 mm, in males and females, respectively.

Conclusion: The pterion in the males was positioned at a higher point from the zygomatic arch than in females while sphenoparietal type of pterion predominates in the Sri Lankan population

Keywords: morphology, morphometry, pterion, variations

Introduction

The pterion is described as an irregular H-shaped sutural confluence formed by the frontal, parietal, squamous part of the temporal and greater wing of the sphenoid on the norma lateralis of the skull [1,2]. It is stated to lie approximately 4 cm above the zygomatic arch and 3.5 cm behind the

frontozygomatic suture [2]. The pterion is an important neurosurgical landmark as it overlies both the anterior branch of the middle meningeal artery and the stem of the lateral (Sylvian) cerebral fissure [2]. In addition, structures such as the middle cerebral artery, anterior pole of the insula and the Broca's motor speech area in the dominant hemisphere are also related to the pterion [1,2].

The calvarium in the region of the pterion is particularly thin, making it vulnerable to fracture during trauma. An injury to this point of the skull would damage the anterior branch of the middle meningeal artery producing a significant extradural hematoma [3]. The pterional approach is one of the most commonly used neurosurgical approaches in surgical interventions dealing with extradural hemorrhages as well as tumors involving the inferior aspect of the frontal lobe, such as olfactory meningiomas [4], neurosurgical interventions involving the Brocas motor speech area [5], lipomas of the Sylvian fissure [6], and in repairing aneurysms of the middle cerebral artery as well as those of the upper basilar complex [7,8].

Even though the pterion serves as an important exrtacranial reference point in most neurosurgical approaches 6, its location cannot be easily determined. To ascertain its precise location various palpable bony landmarks have been utilized [5]. Significant variations have been reported in the literature with regard to the position of the pterion in relation to the to the zygomatic arch and frontozygamtic suture [5, 9-11].

Despite its neurosurgical significance, data pertaining to bony articulations or sutural morphology of the pterion, and its accurate anatomical location in Sri Lankans have been scarcely discussed. The present study was conducted to determine the morphology of the pterion, and its precise position with reference to surrounding anatomical landmarks in an adult Sri Lankan population.

Materials and Methods

Fifty seven pteria in twenty nine adult dry skulls (16 male and 13 female) selected from the skeletal collection in the Department of Basic Sciences, Faculty of Dental Sciences, University of Peradeniya, Sri Lanka were analyzed. Approval for this study was granted by the Faculty Research Committee of the Faulty of Dental Sciences, University of Peradeniya (number FDS-FRC/2014/06). The sex and age of all skulls were retrieved from the personal records of body donors. The skulls with no apparent gross pathology, deformity, or traumatic lesions and those in which the suture pattern of the pterion could be clearly identified were included in the study. Skulls in which the pterion pattern could not be clearly identified owing to breakage or advanced synostosis were excluded.

The sutural pattern of the pterion was observed on both the left and right sides of each skull, and recorded based on Murphy's classification [15] (Figure 1. A-D).

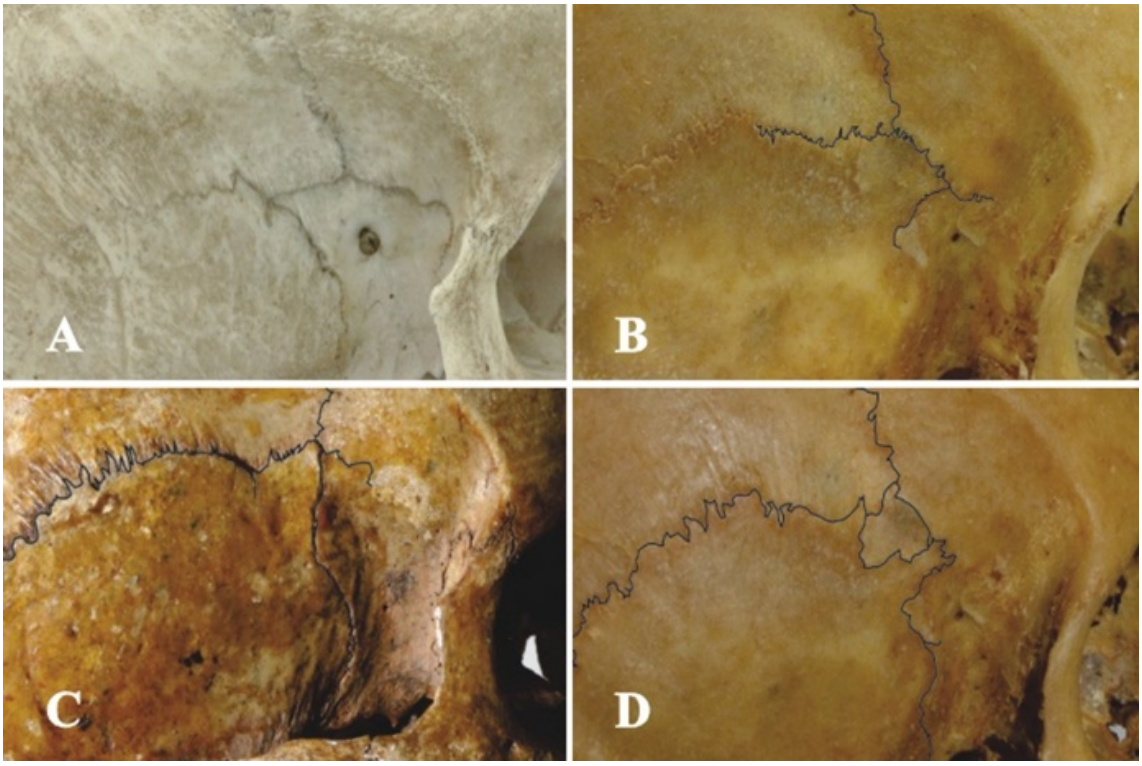

Figure 1: Types of pteria A - Sphenoparietal type of pterion, B - Frontotemporal type of pterion, C - Stellate type of pterion, D - Epipteric type of pterion

Accordingly, the pterion is classified into four types, the sphenoparietal, frontotemporal, stellate and epipteric, based on the bony articulations. In the sphenoparietal type the greater wing of the sphenoid and the parietal bone are in direct contact (Figure 1-A). The frontotemporal is the type where the frontal bone and squamous part of the temporal bone are in direct contact (Figure 1-B). The stellate type is where all the four bones articulate at one point to form a letter K (Figure 1-C), and the epipteric type is where a sutural bone is lodged between the four bones forming the pterion (Figure 1-D). In addition, the following parameters on the right and left sides were measured using a digital vernier caliper to the nearest 0.01mm (Mitutoyo, Japan):

1. The linear distance from the center of the pterion to the posterolateral aspect of the frontozygomatic suture (P-FZS)
2. The vertical distance from the center of the pterion to the midpoint of the zygomatic arch (P-ZA)
3. The distance from the center of the pterion to the anterior and superior most point of the external auditory meatus (P-EAM)
4. The distance from the center of the pterion to the inferior most point of the mastoid process (P-MP)

All measurements were recorded by one investigator. In order to minimize the intraobserver error, three repeated measurements were made for each

observation at different sittings and the average of the three measurements was taken for further analysis.

Statistical analysis

Results were expressed as means and SDs and the differences in the distance between the pterion and selected anatomical landmarks between the sides and sexes were analyzed using the Students' t-test and a $P < 0.05$ was considered as statistically significant. Statistical Package for Social Sciences (SPSS), 19th version was used for analyses.

Results

The occurrence of different types of pteria in the male and female skulls is shown in Table 1.

The type of pteria observed on the right and left sides of the skulls are also presented in Table 1.

The sphenoparietal pterion was the most common type present on both right and left sides.

The means and associated standard deviations of measurements taken from the pteria to various anatomical landmarks are presented in Table 2.

The distances of the pterion to the frontozygomatic suture (P-FZS), midpoint of the zygomatic arch (P-ZA), anterior and superiormost point of the external auditory canal (P-EAC) and, the inferiormost point of the mastoid process (P-MP) were compared between the male and female skulls. A comparison between the left and right sides of the skulls was also done (Table 2).

Table 1: The incidence of different types of pteria on different sides and sexes

Type of pterion	Side			Sex		
	Right% (n=29)	Left% (n=28)	Total% (n=57)	Male % (n=31)	Female% (n=26)	Total % (n=57)
Sphenoparietal	79.4	85.7	82.5	91.4	73.1	82.5
Frontotemporal	7.0	3.6	5.3	3.2	7.6	5.3
Stellate	10.2	7.1	8.7	3.2	15.5	8.7
Epipteric	3.4	3.6	3.5	3.2	3.8	3.5

All four types of pteria described by Murphy [15] were observed. The sphenoparietal type was the predominant type in both males (91.4%) and females (73.1%). This was followed by the stellate type (15.5%) in females, and in males stellate, frontotemporal and epipteric types occurred in similar frequencies.

The study revealed significant differences in the position of the pterion between the sexes but the differences between the sides were not significant.

Table 2: Means and standard deviations of the linear distances (in mm) between the pterion and specific landmarks according to the side and sex of crania

Distance (mm)	Side			Sex		
	Right(n=29) Mean±SD	Left (n=28) Mean±SD	p-value	Male(n=29) Mean±SD	Female(n=22) Mean±SD	p-value
P- FZS	28.99±5.03	29.59±4.75	$P > 0.05$	31.11±5.02	26.98±3.45	$P < 0.05$
P-ZA	37.20±4.52	38.54±3.10	$P > 0.05$	38.92±3.55	36.16±3.83	$P > 0.05$
P-EAM	52.90±2.95	52.87±2.83	$P > 0.05$	53.62±2.58	51.91±2.98	$P < 0.05$
P-MP	80.61±5.05	79.36±4.35	$P > 0.05$	81.54±4.62	77.79±3.88	$P < 0.05$

Discussion

The pterion is an important neurosurgical landmark as it is the primary site for pterional surgical approach used for a variety of anterior and middle cranial fossae pathologies. Hence, it is essential for a neurosurgeon to be familiar with the sutural morphology and precise position of the pterion prior to surgery.

Standard texts in anatomy define the pterion as an H-shaped suture at the junction of frontal, parietal, greater wing of the sphenoid and the squamous part of temporal bones [1,2]. Although this is consistent with the majority of skulls, it ignores a large mass of evidence regarding other types of pteria present among different populations. In the present study all four types of pteria described by Murphy [15] were observed. The present study also revealed a predominance of the sphenoparietal type as has been observed in Nigerians [12, 16], Indians [9], Australian Aborigines [15], Turks [10, 17], Thais [5] and the Japanese [18] (Table 3).

The incidence of the frontotemporal type of pterion vary in different groups, being reported as 7.7% in Australian aborigines [15], 10% in Turks [17], 8.3-19.6.% in Nigerians [12, 16], 15% in Kenyans [13], 1.1% in both Thai [5] and West Anatolians [10]. The frontotemporal type occurred in 5.3% of skulls in the present study, which is relatively low when compared to Turks, Kenyans and Nigerians, but high when compared to West Anatolians and Thai populations.

The incidence of stellate type in the current study was 8.7%. The incidence of stellate type is reported to be higher in the Japanese [18] The stellate type was absent in all male skulls in a Turkish population [17] while its incidence in the Thai population was reported to be very low [5] (Table 3). An epipteric type of pterion was observed in a small number of skulls (3.5%) in the present study. This is significantly less than that reported in Australian Aborigine (18.3%) [15] and the Thai (17.4%) populations [5]. From the perspective of a neurosurgeon, this knowledge of variations in the sutural

Table 3: A comparison of the incidence of different types of pteria in different populations as reported in previous studies

Author	Ethnicity	Type of pterion			
		Sphenoparietal	Frontotemporal	Stellate	Epipteric
Murphy [15]	Australian aborigines	73.2	7.7	0.7	18.3
Aksu et al. [10]	West Anatolian	85.2	1.1	5.5	8.2
Mwachaka et al. [13]	Kenyans	66	15	12	07
Kamath et al. [9]	Indian	79.25	10.25	6.3	4.2
Ukoha et al. [16]	Nigerian	75.5	19.6	1.8	3.6
Apinhasmit et al. [5]	Thai	81.2	1.1	0.4	17.4
Oguz et al. [17]	Turkish	88	10	0	2
Matsumara et al. [18]	Japanese	79.1	2.6	17.7	0.6
Adejuwon et al. [12]	Nigerian	86.1%	8.3%	5.6	0
Present study	Sri Lankan	82.5	5.3	8.7	3.5

morphology is important to avoid untoward surgical complications.

Although the actual determinants of the formation of pterion are not recognized, cranial suture morphogenesis and calvarial bone development is thought to be under genetic influence especially the MSX2 gene [19]. Further, it is reported that the development of calvarial bones is tightly coordinated with the growth of the brain and requires interactions between different tissues within the calvarial sutures [20]. Wang et al [21] hypothesized that skulls with higher ratios of cranial height over cranial length such as in humans are more likely to be subjected to neurocranial growth forces causing the sphenoid bone and parietal bone to meet each other, while skulls in monkeys having very low cranial length-height index are less likely to have this articulation. Hence, a sphenoparietal pattern of suture predominates in humans while the frontotemporal pterion predominates in primates.

Diverse anatomical landmarks such as the FZS, ZA, glabella, temporozygomatic suture, base of the mandibular fossa, MP have been employed to localize the pterion in previous studies [5, 9-12]. The FZS and ZA are the widely utilized anatomical landmarks to predict the location. The present study also describes the centre of the pterion to be measured as a linear distance above the midpoint of the zygoma and posterior to the posterolateral margin of the FZS. In addition, we utilized the EAM and MP which are easily identifiable and palpable clinically on a patient to localize the pterion.

The pterion and zygomatic arch

In the present study, the pterion was located 37.20±4.52 mm and 38.54±3.10 mm above the ZA on the right and left side, respectively. In a West Anatolian population [10] the pterion was located 40.02±4.06 mm and 39.88±4.01 mm above the zygoma on the right and left side, respectively. Similarly, in a Turkish population [17] the mean distance between pterion and the ZA was found to be 40.5±3.9 mm and 38.5±2.5 mm on the right and left side, respectively. In a study on Thai skulls [5] the pterion was typically located 38.48 ± 4.38 mm superior to the ZA. In a comparative study between the Nigerian and Indian skulls, the mean distance between the center of the pterion and the ZA was 39.6 mm and 38.6 mm, and 37.8 mm and 36.1 mm in Nigerians and in Indians, on the right and the left sides, respectively [23].

A comparison of the position of the pterion in males and females and on the right and left sides of crania of different population groups as reported in previous studies are summarized in Table 4.

The position of the pterion in relation to the ZA in the present sample is relatively similar to those reported by Rao et al. [24] in an Indian population. It is widely reported that the pterion of males is positioned at a higher location than in females [9, 12, 14]. The present study too demonstrated a similar observation.

The pterion and FZS

The pterion has been reported to lie 30.0 to 35.0 mm behind the FZS [1, 2]. The current study demonstrated that the pterion was located 29.00±5.03 mm and 29.60±4.75 mm posterior to the FZS on the right and left side, respectively. In a study among male Turks, [17] the pterion was located 33.0±4.0 mm and 34.4±3.9 mm behind the FZS on the right and left side, respectively. Higher values observed in the study of Turks could be attributed to the fact that the sample consisted of only male skulls. It is well documented that male skulls have larger dimensions than those of females [1]. It is interesting to note that in the study done on Nigerian male skulls [16], the pterion was located 27.4±0.70 mm and 27.4±0.60 mm on the right and left side, respectively. Lee et al. [25] on a sample of Korean skulls reported that the pterion was located 26.8±4.5 mm from the FZS, while Ma et al. [26] observed that the pterion was located at a mean of 26.6±4 mm behind the posterolateral margin of the FZS in a sample of Indian skulls. In the present study, in males and females, the pterion was located 31.11±5.02 mm and 26.98±3.45 behind the FZS. It is important to note that the position of the pterion varies in different population groups and that it is closer to the FZS than reported in some previous studies [17] and textbooks [2]. The basis for these population based differences has been attributed to genetic and environmental factors.

Table 4. A comparison of pterion position in males (m) and females (f) and on the right (r) and left (l) sides of crania of different population groups as reported in previous studies

Author	P-ZA	P-FZS	P-EAC	P-MP
Rao et al., South India [24]	(r)37.74±3.66 (l)37.07±4.19	(r)30.48±4.06 (l)30.39±4.70	(r)51.81±4.08 (l)51.54±3.89	(r)80.40±6.43 (l)79.68±6.08
Aksu et al., West Anatolia [10]	(r)40.02 (4.06) (l)39.88 (4.01)	(r)31.80±4.51 (l)31.44±4.73	(r)53.29±4.55 (l)56.22±0.60	(r)82.48 (5.45) (l)81.81(5.50)
Kamath et al., India [9]	(r) 36.09±4.00 (l) 35.45±3.77 (m)36.85±4.12 (f)34.35±3.18	(r) 31.00±4.10 (l) 30.92±4.13 (m)31.90±4.14 (f) 29.72±3.75		
Apinhasmit et al., Thailand [5]	38.48±4.38	31.12± 4.89		
Oguz et al., Turkey [17]	(r)40.5±3.9 (l)38.5±2.5	(r)33.0±4.0 (l)34.4±3.9		
Adejuwon et al., Nigeria [12]	(m)39.74±0.51 (f) 37.95±0.66 (r) 39.1±0.58 (l) 38.77±0.63	(m)31.87±0.64 (f)30.35±0.84 (r)31.52±0.68 (l)30.82±0.81		
Present study	(m)38.92±3.55 (f)36.16±3.83 (r)37.20±4.52 (l) 38.54±3.10	(m)31.11±5.02 (f)26.98±3.45 (r) 29.00±5.03 (l) 29.60±4.75	(m)53.62±2.58 (f) 51.91± 2.98 (r) 52.90±2.95 (l) 52.87±2.83	(m)81.54±4.62 (f) 77.79±3.88 (r) 80.61±5.05 (l) 79.36±4.35

The pterion and EAM

In this study, the mean distance between the center of the pterion and the anterior and superior most point of the EAM was measured as 52.90 ± 2.95 mm and 52.87 ± 2.83 mm on the right and left side, respectively. Although this landmark is easily identifiable and palpable, very few studies have investigated its utility in localizing the pterion. Previously, Aksu et al. [10] has reported this measurement to be 53.29 ± 4.55 mm and 56.22 ± 4.60 mm on the right and left side, respectively, in West Anatolians, while Rao et al. [24] reported them as 51.81±4.08 and 51.54±3.89 in a south Indian population. Although we did not detect any differences between the sides in this measurement, the difference between males and females was significant ($p<0.05$). The difference between males and females has not been investigated in previous studies of Aksu et al. [10] and Rao et al. [24] as the samples of these studies consisted of skulls of unknown sex.

The pterion and MP

The mean distance between the pterion and inferior most point of the MP was 81.54 ± 4.62 mm and 77.79 ± 3.88 mm in males and females, respectively, and

80.61± 5.05 and 79.36 ±4.35 on the right and left side, respectively. The difference in relation to sex was significant while the side differences showed no significance.

The present study demonstrates significant differences in the distances of the P- FZS, P-ZA, P-EAM and P-MP in relation to sex indicating that the position of the pterion exhibits sex dimorphism. As most studies are based on skulls of unknown sex, the sex dimorphism in the position of the pterion has not been analyzed. However, in a study by Kamath et al. [9] in skulls of known sex in an Indian population, significant sex differences were observed in relation to P-ZA and P- FZ. Their study however, did not analyze the distance of P-EAM and P-MP.

Interestingly, the position of the pterion in relation to ZA, PFZ, EAM and MP did not display any significant side related differences in our sample, suggesting that the location of the pterion is bilaterally symmetrical in any one individual (Table 2). Similar observations have been reported in other investigations conducted in Nigerian [12], Anatolian [11] and in Indian [9] skulls. In a study done in Indian skulls [26] the center of the pterion was found to be at a mean distance of 26 mm behind and 11 mm above the posterolateral margin of the FZS. According to Ma et al. [26] these measurements were both reliable and remarkably consistent between sides and sexes. However, Apinhasmit in their study involving 268 Thai skulls observed statistically significant side differences in the position of the pterion.

Conclusion

The pterional approach has been the most commonly used method in neurosurgery to approach pathologies of the anterior and middle cranial fossae such as aneurysms, olfactory meningiomas and Sylvian fissure lipomas. The present study has shown that sphenoparietal type of pterion predominates in the Sri Lankan population. A detailed knowledge of different bony articulations of the pterion and its precise position in relation to various palpable bony landmarks would be of immense benefit to surgeons while performing the pterional approach.

Conflict of interests

None declared.

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Association between the morphometric parameters of placenta and umbilical cord with the birth weight

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Running title: Association of placenta and birth weight

Abstract

Objectives: Birth weight is a vital parameter used to predict the future growth and development of a new born. The survival of the foetus in utero depends on proper functions of the placenta. The study aims to express the relation between the birth weight and placental and umbilical cord morphometric parameters.

Materials and methods: The study was conducted on 418 singleton normal vaginal deliveries. The collected placentae were washed to remove the blood clots and the weight, thickness, and diameters of placentae and the length of umbilical cord were measured. Shape and margin of the placentae, location of umbilical cord insertion and number of cotyledons and the twist pattern of umbilical cord have been determined through careful examination. the birth weight of the foetus was obtained immediately after the delivery.

Results: The collected data has been analysed by multiple linear regression test using R software with p value ≤ 0.05 as the significance. The weight of the foetus exhibited positive significant linear relationship with thickness (p=0.001), weight (p=0.000) and Surface area (p=0.000) of the placental disk. The velamentous cord insertion showed (p=0.019) negative relation with birth weight. The non-twist umbilical cord showed positive significant (p=0.04) association with birth weight. Other parameters were not significant with the birth weight.

Conclusion: Thickness, weight and surface area of the disk and non-twist umbilical cord increases the birth weight of the foetus. However, velamentous cord insertion related to reduction in the birth weight.

Keywords: Birth weight, thickness, weight, surface area, velamentous cord insertion

Introduction

Birth weight is a vital measurement to predict the future growth and well-being of the new born [1]. Birth weight of new born has been taken within first hours of life before any significant postnatal weight loss. Low birth weight babies are new born weighing less than 2,500g and it is defined by World Health Organization (WHO) [2].

The placenta plays a crucial role in the development of foetus. It provides appropriate environment for the fetal growth in various aspects like nutrition, respiration, excretion of substances and protection [3]. Insufficiency of placental function leads to low birth weight, preterm birth and birth defects [4].

Placental morphometric parameters play different role in the functions of placenta. Standard placental measures include placental disk shape, diameter, surface area, disk thickness, weight, location of umbilical cord insertion site relative to the edge or margins of the placental disk, and placental weight in relation to birth weight [5].

Placental weight takes account of the different dimensions of lateral expansion of growth plate. They are measured by chorionic plate shape, the distance from the cord insertion site to the nearest chorionic plate margin and chorionic plate diameters [6]. Lateral growth expansion of the placental disk highlights the normal placental function, requires for the high capacitance and low resistance vascular system to combat the demand of the utero-placento-fetal unit [7].

Umbilical cord is the vital structure for the development, well-being, and survival of the fetus. However, it is vulnerable to kinking, compressions, traction, and torsion which may affect the perinatal outcome. The (clockwise) left and right (anti-clockwise) twisting pattern of the umbilical cord might play a minor role in altering the blood flow and determining the vasculature pattern of placenta [8].

The size, morphology and transferring capacity of the placenta and umbilical cord determines the prenatal growth of foetus to effect the birth weight. Therefore, evaluation of placenta after the birth would be an indicator to detect the growth restriction during the antenatal life and provide the opportunity for postnatal care [9].

The present study has been aimed to explore the relation between the morphometric parameters of the placenta and its umbilical cord and birth weight of foetus as a statistical model in the form of a formula.

Materials and method

The study was conducted on 418 placentae of consecutive deliveries from obstetrics and Gynaecology unit of Teaching Hospital, Batticaloa in three-month duration. The ethical clearance was granted by Ethics Review Committee of the Faculty of Health-Care Sciences, Eastern University, Sri Lanka under approval No: EUSL/FHCS/ERC/2017/30 to conduct the study. Informed written consent has been obtained from the

participants. The study included mothers with singleton normal vaginal deliveries of gestational age between 34 - 40 weeks.

The participants without antenatal check-up, and with the history of chronic diseases, as well as the placentae with less than 34 weeks gestation were excluded from the study. The data of maternal characters, morphometry of placenta and foetal parameters were recorded in a predesigned record sheet.

The placentae were collected immediately after separation from the new born. They were washed under running tap water to remove the blood clots. Then the membranes were trimmed and dried with the help of blotting paper before the doing thorough examination.

Assessment of placental morphometry

The shape and margin of the placentae, location of the insertion of umbilical cord and number of cotyledons were determined through careful examination.

The thickness of placentae has been measured in millimetres by inserting a fine needle at the centre of the placenta.

The weight of the placentae has been determined in nearest grams by using foetal weighing scale.

The diameter of placentae was measured using calibrated metallic scale in centimetres to calculate the surface area. The maximum two diameter was taken at right angle to each other. The means of the two measurements was considered as the diameter of placenta. The surface area was determined using the formula $\pi r2$ (the radius r was calculated using the half of diameters (d) according to the formula - $r = d/2$).

Assessment of umbilical cord morphometry

The length of umbilical cord was measured using calibrated metallic scale in centimetres excluding the first 5 cm from the infant's abdomen.

The (clockwise) left and right (anti-clockwise) twisting pattern of the umbilical cord has been via thorough examination.

Assessment of new born baby's parameters

The birth weight of the new born baby was measured in nearest grams using foetal weighing scale, immediately after the delivery.

The statistical analysis has been carried out using R Software, version 4.0.0. The multiple linear regression model was done. The dependent variable is birth weight of the fetus and the independent variables are the shape of the placental disk, location of the umbilical cord insertion, Thickness of the placental disk, margins of the disk, Weight, Surface area, numbers of cotyledons, umbilical cord length and Twisting pattern of umbilical cord.

Among the independent variables shape of the placental disk, location of the umbilical cord insertion, margins of the disk, and Twist patterns are categorical variable.

In multiple linear regression, the R2 represents the correlation coefficient between the values. The value of R will always be positive and will range from zero to one [10]. The analysis was done using R software with the 95% confidence interval and p value ≤ 0.05 as the significance level to predict a model to find out the correlation between birth weight of the fetus and morphometric parameters of placenta and umbilical cord.

Results

The analysis includes morphometric parameters of 418 placentae. The thickness (p=0.001), Weight (p=0.000) and Surface area (p=0.000) of the placental disk were continuous independent variables, showed the significant (p<0.05) linear relationship with the birth weight (intercept). It showed the linear relationship among the categorical independent variables for instance, the location of the umbilical cord insertion and twist pattern were significant. Among the location of the umbilical cord insertion only the velamentous type (p=0.019) was significant when compared to Central type of cord insertion (P<0.05). The velamentous type reduced the birth weight of the fetus by -0.248 when compared to Central type. Similarly, among Twist pattern, only the umbilical cord non-twist pattern (p=0.042) was significant when compared to left twist (p<0.05). The umbilical cord with non-twist pattern increased the birth weight of the fetus by 0.322. Other parameters were not significant with birth weight according to the findings.

The overall model was significant (p<0.05) with the adjusted (R2) R squared 49.26%. The residual analysis was done to confirm the further model significance. The variation inflation factor for all independent variable was less than two and it was in acceptable level. The homogeneity of variance was tested by Breusch-Pagan test. The results showed that there was homogeneity of variance (p=0.8445/p>0.05). Auto correlation among the independent variables was tested by Durbin-Watson test and it showed that there was no autocorrelation (p=0.2448/p>0.05). The normality of residual was tested by Anderson-Darling test. The results showed that the residual was normally distributed (p=0.089/p>0.05). Since four residual analysis test showed acceptable result. We would able to confirm that the overall model was significant.

The model expressed as follow:

Birth Weight of fetus = 0.99 + 0.126(Thickness of placenta) + 0.0021(Weight) + 0.0029(Surface area) - 0.248(Velamentous cord insertion) + 0.322(non-twist pattern of umbilical cord)

Table I: Multiple linear regression analysis of morphometric parameters of placenta and umbilical cord in association with Birth Weight

Morphometry	Coefficient value	*p* Value	
Birth weight (Intercept)	0.9904160	0.000	***
Shape of placentae			
Oval	-0.0512188	0.2304	
Irregular	-0.0208177	0.6746	
Location of Cord Insertion			
Paracentral	0.0082403	0.8493	
Eccentric	-0.0403800	0.4182	
Marginal	-0.0987913	0.1205	
Velamentous	-0.2478008	0.0195	*
Thickness	0.1258761	0.0017	**
Margins of placentae			
Irregular	-0.0427965	0.2240	
Weight of placentae	0.0020508	0.000	***
Surface area of placentae	0.0028627	0.000	***
Number of cotyledons	-0.0075555	0.0620	
Cord length	0.0021164	0.1336	
Cord twist			
Anti-clock (Right) twist	0.0605055	0.0717	
Non-twist	0.3217109	0.0420	*

Discussion

Birth weight of the foetus increases by 1.98g for every one-gram increase of placental weight [11]. It is clear that placental weight determines the fetal growth and birth weight [12]. In addition, placental growth significantly associates with early childhood growth in full-term infants [13]. Increase in nutrient exchange reflects on the arborisation of the villous and thickness of the chorionic disk [6]. Therefore, reduction in the surface area and weight than normal leads to slower rate of growth in foetus [9] and increase the risk of developing fetal growth restriction [14]. The model derived from our research findings expresses the direct relationship between the birth weight and the thickness, weight and surface area of placental disk along with previous findings.

Morphometrically, the location of the insertion of umbilical cord to the placenta has been considered as central, eccentric, marginal, and velamentous (membranous) insertions. Among them, marginal cord insertion and

velamentous cord insertions are considered as abnormal insertion to the placenta. Further, Ismail and colleagues, have identified that the abnormal placental cord insertion leads to low birth weight [15]. It has also been supported by several other research studies. One of such is that the usage of tobacco increases the prevalence of velamentous cord insertion and fetal growth retardation [16]. In addition, velamentous cord insertion increases the risk of birth-weight difference in monochorionic twins [17]. Researches also shown that the occurrence of velamentous cord insertion is higher in the in vitro fertilization technique, maternal smoking, preterm delivery, single umbilical artery, lobed placenta and placenta previa [18]. Supportive to the above research findings, the model that we have derived, proves that velamentous cord insertion causes the reduction of birth weight and relates to adverse perinatal outcomes. Therefore, we could recommend that Routine examination of the placental cord insertion site need to be considered in future to avoid adverse perinatal consequences.

Considering the twisting pattern of the umbilical cord, hyper twist and non-twist umbilical cords are considered as abnormal twist. The frequency of occurrence is 4% - 5% and it is associate with gestational diabetes and pre-eclampsia [20]. Non twist pattern is more prevalent in women carrying multiples due to the limited uterine environment. Also the non-twist pattern indicates the limited movement of foetus within the uterus. It was evidenced that; Hyper twist cord is associated with lower birth weight than the non-twist cord [21]. However, research evidences shown that the birth weight of the foetus is less likely affected by any of twist pattern [10]. In accordance to the previous research evidences, our findings suggest that non-twist cords are positively associate with birth weight despite of its adverse fetal outcome.

Conclusion

Placental morphometry: thickness, weight and surface area of the disk have exhibited significant and positive relationship with birth weight of the foetus. However, the velamentous cord insertion has the negative impact on the determinants of birth weight. Even though, the prevalence of the non-twist umbilical cord is minimal occurrence, it has a positive association with birth weight.

Conflict of interest

None declared.

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Effectiveness of quadriceps muscle strengthening on knee joint stability and activities of daily living in patients with knee joint osteoarthritis

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Running title: guided quadriceps exercises for knee osteoarthritis

Abstract

Objectives: Knee is the largest weight bearing joint in the body and thereby is affected by diseases such as osteoarthritis more frequently. The aim of this study was to evaluate the effect of a 4 week physiotherapy exercise program, designed to improve quadriceps muscle strength and girth, and to observe its effect on knee pain and activities of daily life through a pre and post exercise analysis in patients with knee joint osteoarthritis (OA).

Methods: Thirty patients diagnosed with knee joint osteoarthritis irrespective of gender, over the age of 45 and less than 75 years were recruited for the study. Initially knee joint pain severity was assessed using the VAS (visual analogue scales) and WOMAC questionnaire was used to assess the activities of daily living. The thigh circumference was measured in centimeters. Data was analyzed by SPSS 20.

Results: Mean age of osteoarthritis patients was 54 years. There was a statistically significant, reduction in knee pain (p=0.001), improvement of quadriceps muscles girth (p=0.012) and an improvement of daily living activities (p=0.001) after engaging in the physiotherapy exercise program.

Conclusion: A four week guided quadriceps muscle strengthening exercise program can significantly increase the quadriceps muscles girth and knee joint stability and reduce pain and improve the activities of daily living in patients with knee OA.

Keywords : Osteoarthritis, WOMAC, VAS

Introduction

The knee joint is one of the largest joints in the body and is a complex synovial joint of the hinge variety. It is a weight bearing joint and tends to get affected by diseases such as osteoarthritis (OA). OA is regarded as a degenerative joint disease characterized by reduction of the thickness of the articulate cartilage in a focal manner (1). It is diagnosed commonly in adults over the age of 40 years and it's reported that most people will have some features of OA in their weight-

bearing joints at the age of 60 years. The disease becomes symptomatic in around 15% of all adults over the age of 40 and its impact can be debilitating (2). The knee is the joint most commonly affected by this disease and is characterized by joint pain that increases with activity, night pain, morning stiffness, limited joint motion, reduced muscles girth, crepitus, soft tissue swellings, deformity and reduction of physical function (3).

Muscles such as the quadriceps, hamstrings and the illiotibial tract that surround the knee play an important role in protecting the joint by absorbing shock during weight bearing and movements of the knee. Strengthening exercises which improve and maintain muscle strength stabilizes and protects the joints, decreasing pain and stiffness and reducing loss of cartilage. Nonsurgical treatment of OA includes, medications, weight loss, muscle strengthening and bracing (4). Strengthening exercises, for the quadriceps muscle, has been reported to reduce pain and disability in knee OA (5)

Several studies have proven the effect of hospital based and home based exercise programs to increase muscle strength and have reported reduction in pain and stiffness and improvement in physical function (6, 7, 8). With this background it was the aim of this study to assess the importance of a four week exercise program, designed to improve quadriceps muscles girth, on knee pain and activities of daily living in patients diagnosed with knee joint OA.

Materials and methods

Thirty patients over the age of 45 and less than 75 years, diagnosed with knee joint OA attending the physiotherapy Department at Teaching Hospital Ragama were recruited. Ethical clearance was granted by the ethical review committee of the Faculty of Medicine University of Peradeniya. Written informed consent was sort from all patients. Patients with a history of knee, hip or ankle injuries or surgery, those patients who claimed to have no knee pain and those who had received a cortisone injection to the knee joint within the previous 30 days were excluded.

The VAS a single dimension horizontal scale, which consists of a 10 cm line on which participants rate their pain from 0-10 established by Creamer, Lethbridge-cejku and Hochberg (1999) was used to measure the degree of knee joint pain. The WOMAC questionnaire designed according to the McMaster Universities osteoarthritis index was used to assess the activities of daily living (9). This is a widely used questionnaire which rates pain during different physical activities and the ability to perform day to day work. Each of the participants was scored with the VAS and the WOMAC questionnaire prior to implementing the exercise program.

Quadriceps muscle girth was measured as the thigh circumference. Measurement of thigh circumference was performed 15 cm proximal to the superior pole of the patella. Measurement was taken while the

patient was in the supine position. The thigh circumference was measured in centimeters with a measuring tape on both legs as described by Robert and Laprade (2012).

Next the exercise program was explained in detail to each patient at the first visit to the physiotherapy unit. During the consequent visits the treating therapist observed the exercise program at each session and guided and aided the patients in performing the exercises. This exercise program is a predesigned program conducted at the center for quadriceps strengthening routinely.

The exercise program consisted of a warm-up on a stationary bicycle or walking for 10 minutes. Next the patients were asked to do quadriceps, hamstring, and iliotribial band, stretches to hold for 20 seconds and repeat 3 times. Thereafter, Isometric vastus medialis contraction in full extension held for five seconds, Quadriceps contraction in full extension held for five seconds, Straight leg raising exercise holding five seconds, Isokinetic quadriceps contraction full extension for five seconds, Isokinetic hamstring contraction, Isokinetic hip extension in prone position and Isokinetic hip abduction inside line position was done with 30 to 45 seconds interval between exercises. Exercises were progressed by increasing weight according to 10RM by using sand bags. The participants performed these exercises twice a week at the physiotherapy unit under the guidance of the therapist. Exercises were practiced in a painless or minimally painful manner. Patients were followed up for 4 weeks.

At the end of the 4 week exercise program the patients were reassessed using the VAS pain scale, WOMAC questionnaire and measurement of muscles girth.

Data was analyzed using Statistical Package for Social Sciences (SPSS) 20. The pre and post exercise program scores were compared separately for pain, WOMAC score and muscle girth. The pre and post exercise program values of the VAS and the WOMAC score (activities of daily life score) were analyzed using Wilcoxon signed ranks test for related samples. Quadriceps girth was analyzed using the paired sample t test to evaluate the changes between the values obtained before and after the exercise program.

Mean, standard deviations were calculated for pain, muscles girth, stiffness, and physical function. Nonparametric Wilcoxon test used because of limited sample size and non-normalized distribution assessed pre and post intervention. An alpha level of 0.05 and a p-value < 0.05 was taken as significant.

Results

Out of thirty OA patients 90% (n=27) were females. The mean age of the patients was 54 years. Duration of the symptoms varied from1 month to 120 months.

All of the patients showed statistically significant reduction in their knee pain assessed by VAS, knee pain during activities of daily living and joint stiffness after going through the exercise program. Mean values of pre and post-test with standard deviations is given in Table 1. Out of the 30 patients only 27 patients complained of stiffness and all 27 showed reduction in their knee joint stiffness after going through the exercise program. Mean percentage reduction of stiffness was 30.1%. Wilcoxon test revealed statistically significantly reduction in joint stiffness after the exercise program (Table 1).

Table1: pre and posttest values for VAS score, activities of daily living, joint stiffness and physical function with the comparisons

Variable	Mean (SD)	p value
VAS pre-test pain	6.77(±1.073)	0.001
VAS post-test pain	4.37(±1.866)	
Pre-test pain during daily activities	5.90(±3.408)	0.001
Post-test pain during daily activities	3.60 (±2.895)	
Pre- test joint stiffness	1.78 (±1.316)	0.001
Post-test joint stiffness	1.06 (±1.048)	
Pre-test physical function	25.90 (±11.158)	0.001
Post-test physical function	18.00 (±9.52)	

Table 2 shows that the exercise program resulted in significant changes in quadriceps muscle girth. Pre exercise program quadriceps muscle girth mean was 47.61, SD±4.996. Post exercise program quadriceps muscle girth mean value was 47.72, SD ± 4.974. This was analyzed by paired t test and p value of 0.012 was observed. There is a statistically significant increase in the quadriceps muscle girth after going through the exercise program ($p<0.05$).

Table 2: Comparison of pre and post test means of quadriceps muscle girth

Characteristic	Pre (n=30)		Post (n=30)		T(df)	P	95% ci interval
	Mean	SD	Mean	SD			
Quadriceps muscles girth	47.61	4.996	47.72	4.974	-2.693 (29)	0.012	-0.194 - -0.027

Discussion

The knee joint is essential for activities of daily living. Running walking sitting and squatting put great strain on the knee joint. Knee joint pain during activities of daily living is the commonest reason for patients with OA to seek medical interventions. The knee joint is stabilized by the muscles and ligaments that surround it.

Strengthening exercises improve muscle bulk thereby reducing joint pain and improving activities of daily living. Muscle strength is defined as the ability

of a muscle to produce force (10) and increases with training. Our study used strengthening exercises based on 10 repetitions maximum (10RM) with progressively increasing weights using sand bags and the quadriceps bench to improve the quadriceps muscle strength.

Our study reports a statistically significant reduction of knee joint pain with improvement of activities of daily living, after engaging in an intense guided exercise program for 4 weeks. The study done by Baker (2001) (11) illustrated that high intensity home based strengthening training significantly improves muscle strength with reduction of joint pain, and improvement of physical function and quality of life of OA patients. They also report that self-reported pain improved by 36% and physical function by 38.7%.

The study done by Fisher (2015) (12) and Van baar et al. (1998) (13) reports the effectiveness of exercise therapy in patients with OA of the hip or knee in reduction of pain and disability. The present study also found that the exercise program significantly improved the activities of daily living.

In a study conducted by Deyle (2005) (14) the treatment group attended 8 treatment session of a physiotherapy exercise program and the WOMAC improved by 52% (535mm, 95% CI=426-644). Jorge (2015) (15) conducted a study on women with osteoarthritis of the knee and reports that progressive resistance exercise has a significant effect in reducing pain and improving function, some quality of life and strengthen the female knees by strengthening the muscles surrounding the knee. Similar findings were observed in our study with a significant reduction in knee joint stiffness, improvement of day to day activities and reduction of pain.

Further a study conducted by Thomas, et al. (2002) (16) reports a highly significant reduction in pain in a group of knee OA patients who underwent an exercise program for 6 weeks with that of a group who did not engage in exercise. They further report that direct contact with physical therapist has a much better improvement rate. In the current study the physiotherapist was always in contact with the patients guiding and aiding them in all aspects of the exercises and the significant improvement in muscle girth and reduction in pain was observed even though this study was done for only 4 weeks.

In our study a statistically significant reduction in joint stiffness was observed after the exercise program ($p<0.05$) of only 4 week, while Shakoor, et al. (2007) (17) reports similar findings in a longer duration program.

Cooper (1981) (18) states that increasing muscles girth reflects increasing muscles power and strength. Therefore it is rational to measure the thigh circumference as a measure of quadriceps muscle strength and our findings of the increase of the thigh

circumference indirectly prove the increase in quadriceps power. A statistically significant improvement in quadriceps muscles girth was observed in our group ($p<0.05$).

This to our knowledge is the first study in Sri Lanka to assess the effects of a physiotherapy exercise program on quadriceps muscles girth, knee pain and activities of daily living in knee OA patients. Our findings suggest that a 4 week intensive physiotherapy program with high therapist contact is extremely useful in rehabilitation of patients with OA of the knee.

Conflict of interest

None declared.

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Anatomical landmarks for Percutaneous Transhepatic External Biliary Drainage (PTBD)

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Abstract

PTBD is used for temporary decompression of an obstructed biliary system prior to surgical resection as it is believed to reduce major post operative complications. This is preferred over endoscopic biliary stenting(EBS)by most as EBS induces an inflammatory response making resection difficult. For palliation of malignant biliary obstruction and as treatment for common bile duct stones endoscopy is preferred. PTBD is used if endoscopy fails. In this subset internalization for malignancies and surgery for calculi are done once the patient's general condition improve.

Keywords: Percutaneous external biliary drainage, endoscopic biliary stent insertion

Introduction

PTBD is used for temporary decompression of an obstructed biliary system presenting as obstructive jaundice[1].

Intrahepatic ducts coalesce to form the right and left hepatic ducts. They join to form the common hepatic duct. Once the cystic duct join it is named as the common bile duct. The obstructions requiring treatment may be at the confluence of hepatic ducts at porta hepatis or along the common bile duct up to ampulla of Vater.

PTBD may be used prior to definitive surgery[2,3,4]. The indication for pre-operative placement is when the serum bilirubin levels are high and surgery getting delayed for more than two weeks. The need for such decompression may be urgent and life saving in the presence of cholangitis. Many surgeons prefer pre-operative decompression by external drainage as opposed to endoscopic biliary stent(EBS) placement as the latter induces inflammation making the surgery difficult[4]. Patients with malignancies unsuitable for curative resection need palliation. For palliation EBS is preferred1. For the patients with failed EBS, stent placement under radiological guidance is used[1].

PTBD is not usually used in common bile duct stone which are best handled by endoscopy and surgery. But in the presence of severe cholangitis it may be used as a temporary measure to bring the patient out of sepsis if endoscopy fail. In bile duct/ hepatic duct benign strictures it may be used prior to surgical reconstruction.

Method

Patients referred for PTBD were initially assessed for their fitness for the procedure. The diagnostic imaging evaluated with emphasis of the radiological anatomy of the dilated biliary system, to plan placement of drainage tube. Procedures were done at the interventional radiology suit with all precautions of sterility. Intravenous sedation and local anaesthesia were used. Patients were monitored continuously. In all patients external drains were placed via the left lobe of liver. Ultrasound and fluoroscopy were used to identify ductal anatomy while placing. With ultrasound guidance, appropriate segmental duct is punctured. Site of puncture is kept peripheral as possible as more central puncture has higher risk of major vascular injury.

After successful puncture, a guide wire is passed through the puncture needle. During the procedure, check cholangiograms are done periodically to follow the biliary anatomy. Then the external drainage catheter is left in the biliary system for its decompression.

Results

A total number of 38 patients underwent the procedure. 22 males and 16 females. The age distribution was 32 to 84 years.

The procedure was performed for following indications (Table 1).

All patients with malignancies following PTBD were treated by definitive surgery, two to three weeks later. The patient with failed PTBD had a peri-ampullary carcinoma and peripheral duct dilatation was inadequate for successful puncture. He underwent pancreatico-duodenectomy early.

Two with common bile duct stones presented with acute cholangitis and required PTBD as EBS failed. The patient with a choledochal cyst was a thirty two year old lady in the first trimester of pregnancy. To bridge until delivery decompression EBS failed and required PTBD. Pregnancy continued until 34 weeks when she had a pre term delivery and was subjected to resection of choledochal cyst and Roux-N-Y hepatico-jejunostomy. Two patients

Table 1: number of patients undergoing PTBD for different indications

Indication	Pre-operative	Palliative	Number of patients
Hilar cholangiocarcinoma	5	3	8
Head of pancreas carcinoma	8	1	9
Peri-ampullary carcinoma	15(with 1 failure)	1	16
Common bile duct stone	2		2
Common bile duct stricture	2		2
Choledochal cyst	1		1
Total	33	5	38

with bile duct strictures underwent reconstruction after two weeks from the placement of PTBD. The five patients needing palliative PTBD were after failed EBS. One of them with a pancreatic head neoplasm developed a bile leak in to the peritoneal cavity and was managed with laparotomy and cholecysto-jejunostomy.

Discussion

PTBD is used as pre-operative decompression or for palliation in malignancies as discussed in the introduction[1,2,3,4]. The use in benign pathologies are limited. In our series it has been in used two patients with acute cholangitis with stone disease and another two with a benign stricture and a choledocahal cyst respectively. Two with stones and one with choledochal cyst underwent PTBD as endoscopic stent insertion failed. The two with bile duct strictures had elective placement of EBS for pre-operative decompression.

The need for pre-operative biliary decompression is a matter of debate[2,3]. In a recent systematic review, it has been shown to reduce complications following resections[3]. The length of hospital stay and mortality rates have not shown a statistically significant difference[3]. EBS is associated with an inflammatory reaction more than PTBD[4]. In our unit all patients planned for curative resections are referred for PTBD except in few patients showing minimal duct dilatation.

For palliation in malignancy EBS is preferred to PTBD[1]. In case of EBS failure PTBD and later internalization is performed. This happens more often in hilar occlusions than in distal obstructions[1]. In our series five patients required PTBD after failed EBS and three of them were hilar cholangiocarcinomas.

In PTBD access in to ducts is possible from left or right side and often happens on personal preference(1). But when advantages and disadvantages are compared left approach is more beneficial(1).

Conclusion

PTBD is useful for pre-operative decompression and palliation whenEBS fails. The anatomy of the obstructed duct system as well as related surface and internal anatomy are important for successful placement.

Conflict of interest

None declared.

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Prevalence of primary basilar invagination among asymptomatic Sri Lankan adults - computed tomographic study

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Abstract

Objective: To evaluated the prevalence and some associated factors of basilar invagination (BI) in a group of Sri Lankan adults.

Material and methods: Brain computed tomographic images (CT) of adults admitted to Teaching Hospital Rathnapura, Sri Lanka were studied, excluding subjects with craniofacial syndromes, cerebral or spinal pathologies. The distance between Chamberlain's line (CL) and odontoid process (OP) measured in sagittal CT images (bone window). BI is defined when the OP is 2mm above CL.

Results: The study group (n=135; male=67; female=68) was in 20-97 years age range (mean-56±18 years). BI was present in 11.8% (n=16), of which the mean position of OP was 2.33±1.06 cm above CL (range=0.6-4.7 mm). In 13.4%, OP was at the same level as CL. When BI is absent, the mean position of OP was 2.1±1.9 cm below CL. The OP was below CL in 86.6% (n=58) of males and 75% (n=51) of females demonstrating no significant (X2=2.904;p=0.088) gender variation in BI. Internal cranial height (OR=0.823; 95%CI=0.678-0.990; p=0.044) was negatively associated with the incidence of BI. However, age (OR=1.015; 95%CI=0.984-1.047; p=0.341), gender (OR=0.707; 95%CI=0.226-2.218; p=0.553), posterior fossa height (OR=0.912; 95%CI=0.808-1.030; p=0.136), or Klaus' height index (OR=1.099; 95% CI=0.874-1.383; p=0.419) had no significant influence on BI.

Conclusion: Current study, for the first time, documents the incidence of BI among asymptomatic Sri Lankans. Since ethnic variation in the incidence of BI is reported, such population-specific data would be invaluable in diagnosing the asymptomatic BI cohort, which in turn, will facilitate to prevent permanent disability and life-threatening emergencies.

Keywords: basilar invagination, prevalence, asymptomatic patients, computed tomography

Introduction

The anatomy of craniocervical junction attracts great attention considering the vital neural structures clustered in this sophisticated region, in which the relationship of the odontoid process of the second cervical vertebra to the

upper cervical spinal cord, cerebellar tonsils and the brain stem are critical (1,2,4,5). Under normal conditions, the odontoid process does not compress or impinge on any of the adjacent neural structures. However, the possibility of the brain stem or spinal cord impingement by the odontoid process can be increased by many factors, such as developmental abnormalities, variations in normal positional or altered position due to a pathological process (1,2,4-6). Basilar invagination (BI) or the superior migration of the odontoid process and Chiari malformation are the most frequent of the craniocervical region abnormalities causing neural compression, commonly resulted from a developmental defect of the occiput (7).

The majority of patients with BI are asymptomatic and develop symptoms following a trivial injury or infection in the head and neck region (2,3,6). The symptomatic minority (BI patients) require substantial medical care to prevent adverse squeal of neural compression. Unless treated, the majority of symptomatic BI patients may end up in permanent disability or even succumbed to death (2,4,8-10). Importantly, even a certain proportion of asymptomatic patients have shown the potential of developing permanent disability following trivial trauma.

Therefore, diagnosing BI is essential before the complications manifest (2,6)

Since the clinical diagnosis of BI is challenging due to the non-specific presentation in the majority; investigations, particularly the imaging investigations play a pivotal role. In the radiological diagnosis of BI, violation of the Chamberlain's line by the tip of the odontoid process is considered. Many authors used different thresholds to define BI: the tip of odontoid process 2, 3, 5 and 6mm above the CL (2,5,8,9). The lateral view of the X-ray cervical spine has been used in diagnosis before the dawn of the era of computed tomography (CT) (6,8,11). The CT cervical spine with sagittal reconstruction is more sensitive and specific than X-ray in diagnosing BI due to several reasons. Firstly, the measurement accuracy of the electronic measurement calliper system is high. Secondly, with multi-planner image reconstruction ability, the CT offers a high resolution of the imaged structures (1,10). Compared to CT, magnetic resonant imaging (MRI) offers similar or higher sensitivity in detecting BI; however, its value limited due to restricted availability in many low affluent countries (9).

The aetiology of BI can be varied: primarily a developmental bone anomaly or secondarily acquired in bone pathologies such as osteomalacia, Paget's disease or local bone destruction as seen in rheumatoid arthritis (1,4,6). Additionally, BI is associated with many other neurological problems such as Chiari malformation (inferior migration of cerebellum and brain stem) and syringomyelia of the cervical spinal cord (6).

The prevalence of BI is known to vary with the age, ethnicity, and morphology of the posterior fossa and the

craniocervical junction (5). Further, the incidence of BI known to be higher in some nationalities and among different ethnic groups (2). Similar ethnic or geographical variation can be expected from Sri Lankan populations as well. Hence, the projected prevalence of BI for Sri Lankans could be either an under or overestimate of the actual values. Therefore, the knowledge on the population-specific prevalence of BI would of great value in establishing relevant guidelines to manage the asymptomatic cohort of a particular population. Thus, our study aimed to evaluate the prevalence of BI in a group of Sri Lankan adults and to assess some associated factors of BI.

Material and methods

This cross-sectional, observational study recruited all the subjects (n=915) presented for computed tomographic (CT) of the brain under investigation of headache, to the Radiology department of the Teaching Hospital Rathnapura, Sri Lanka, from June 2019 to November 2019. The subjects were screened using medical records and already stored CT images to identify eligibility. The exclusion criteria included; a history of epilepsy, craniofacial syndrome, cervical spinal deformity, craniocervical surgery, known craniocervical junction instability, any disease process with bone deformity (such as rheumatoid arthritis, osteomalacia, Paget's disease), head injury, cervical spine injury, brain or spinal tumours, hydrocephalus or meningoencephalitis, neuropathy, and positive neurological signs. Any subject aged less than 18 years, with incomplete CT brain study or CT image degradation for any reason or not consented subjects were also excluded from the study. Informed written consent obtained before the data collection. Patients' privacy and anonymity maintained throughout the study. The ethical clearance for the study was obtained from the Ethical Review Committee, Kothalawala Defense University, Sri Lanka.

CT measurement procedure

All the brain CT scans were performed in the same CT scanner (Toshiba Alexion, Tochigi, Japan, released to the market in 2013), evaluated by same experienced Radiologist. The measurements were obtained under adequate magnification from the sagittal reconstructed CT images of the brain in bone and soft tissue window settings, using the electronic calliper of the image processing software, to the nearest 0.1 mm.

The Chamberlain's line was defined as the line joining the posterior edge of the hard palate and the opistium (6). To define the subjects with basilar invagination (BI) the perpendicular distance between the tip of the odontoid process and the Chamberlain's line was obtained. The BI was defined using three predetermined criteria as used in previous studies (8): BI is present if the odontoid tip is 2mm, 5mm or 6 mm above the Chamberlain's line (Figure 1a). The prevalence of BI was calculated under each diagnostic criterion.

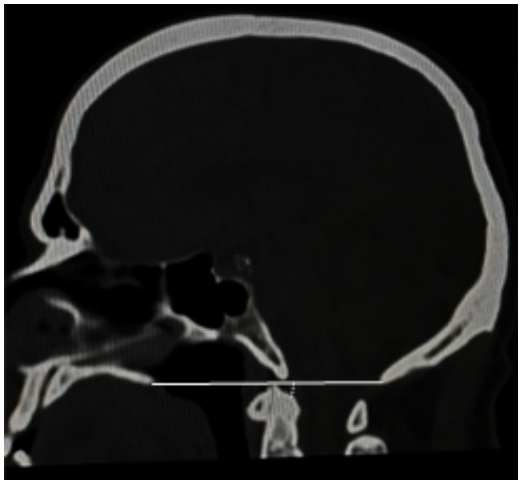

Fig 1a. Sagittal reconstructed CT image of the brain demonstrating the measurements taken to define basilar invagination. (Solid line: Chamberlain's line; dotted line: measurement obtained from the tip of the odontoid process to the Chamberlain's line).

The posterior fossa height was measured from the foramen magnum to the highest point of the tentorium, using a sagittal image of the brain in soft tissue window image settings (Figure 1b).

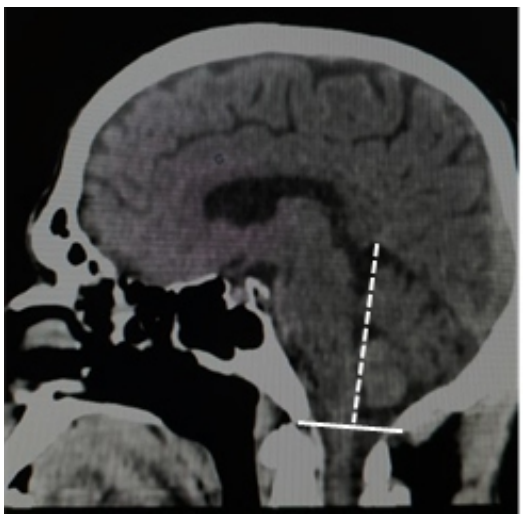

Fig 1b. Sagittal reconstructed CT image of the brain demonstrating measurement of the posterior fossa height. (Dotted line: height of the posterior fossa; solid line: line defining the position of foramen magnum).

Internal cranial height was measured from the foramen magnum to the highest point of the inner aspect of the calvarium, using a sagittal image of the brain in bone window image settings (Figure 1c). Klaus' height index was defined as the height between the tip of the odontoid process and the highest point of the tentorium (12) (Figure 1d).

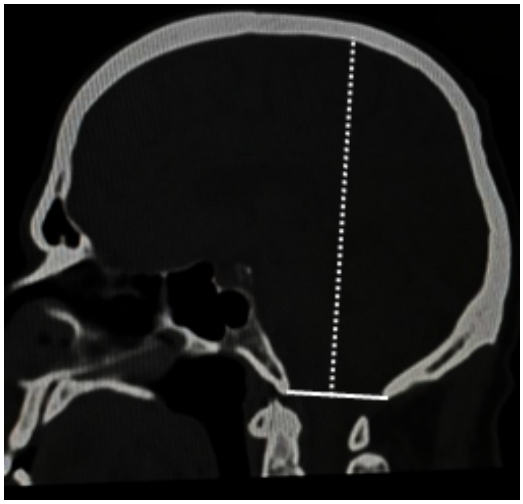

Fig 1c. Sagittal reconstructed CT image of the brain demonstrating the procedure of obtaining the measurement of internal cranial height. (Dotted line: internal cranial height measurement; solid line: the line defining the position of foramen magnum).

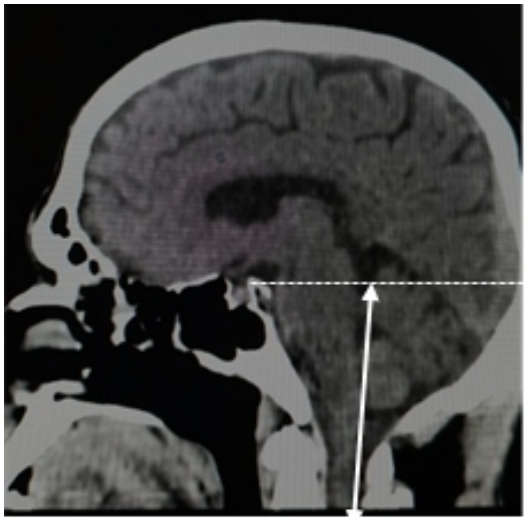

Fig 1d. The procedure of obtaining the measurement of Klaus' height index in a sagittal reconstructed CT image of the brain. (Dotted line: the line defining the highest point of the posterior fossa; arrowed line: the measurement obtained from the tip of the odontoid process to the highest position of the posterior fossa).

The position of the cerebellar tonsils to the foramen magnum delineated the criteria for diagnosing the Chiari malformation (Figure 2): the tonsillar position up to 3mm below the foramen of magnum was considered normal; the tonsillar position 3-5mm below the foramen of magnum was considered abnormal for symptomatic patients; the tonsillar position 5mm below the foramen of magnum was considered abnormal for asymptomatic patients (6). Since our study population was asymptomatic, to define the cases of Chiari malformation, we considered the tonsillar position below 5mm as abnormal.

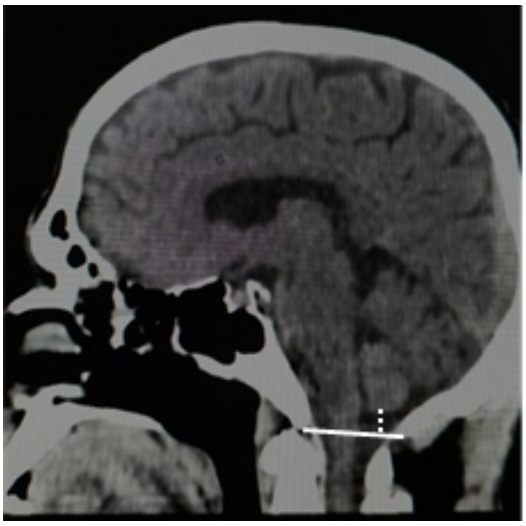

Fig 2. Sagittal reconstructed CT image of the brain demonstrating the procedure of obtaining the measurements to define the cerebellar tonsillar position. (Solid line: the line defining the position of the foramen magnum; dotted line: the measurement obtained from the foramen magnum to the lower border of the cerebellar tonsil).

Statistical analysis

Statistical analysis performed using SPSS 25 IBM statistical software. Categorical variables expressed as percentages and continuous variables as means, standard deviations and ranges. The differences between variables compared for significance using paired sample T-test and Qi-square tests, and the relationships between the variables evaluated using binary logistic regression analysis. The P values of less than 0.05 considered statistically significant.

Results

The study recruited 135 subjects, consisted of 49.6% (n=67) males and 50.4% (n=68) females, in the mean age of 56±18 years, and the age range of 20 to 97 years. The mean age of the males was 57±17.9 years, and the females was 55±19.0 years, with no significant age difference between them (p=0.633).

The position of the tip of the odontoid process to the Chamberlain's line was evaluated. In 80.1% (n=109), the odontoid process positioned below the Chamberlain's line keeping a mean distance of 2.43±1.96 mm and a range of 0 to 9.7 mm. In 19.1% (n=26), the tip of the odontoid process was above Chamberlain's line; the mean distance was 2.33±1.06 with a range of 0.6 to 4.7 mm. The gender variation on the position of the odontoid process was assessed. The odontoid process was below the Chamberlain's line in 86.6% (n=58) of males and 75% (n=51) of females demonstrating no significant (X2=2.904; p=0.088) gender variation.

The mean internal cranial height of the study population was 128.69±5.5 mm; males' 132.03±4.8 mm; females' 125.79±4.3 mm. The internal cranial height of males was significantly higher than the female counterpart (T=6.81; p<0.001). The mean posterior fossa height was 64.81±4.72 mm; males' 66.36±4.4 mm; females' 63.26±4.5 mm. The mean Klaus' height index was 66.23±5.7 mm; males' 68.2±5.3 mm; females' 64.39±5.9 mm. The posterior fossae height (T=4.016; p<0.001) and Klaus height index (T=4.125; p<0.001) of males were significantly higher than the female counterpart.

Table 1 depicts the distribution of basilar invagination in the study population. The incidence of basilar invagination calculated considering three cut off values: 2mm; 5mm and 6 mm above the Chamberlain's line. When the tip of the odontoid process 2mm above the Chamberlain's line considered abnormal (2mm as the cut off value), the incidence of basilar invagination was 11.8%. However, for this population, the incidence of BI was 0%, for both 5mm, and 6 mm cut of values.

(the cut of values used to identify basilar invagination by considering the position of the tip of odontoid process: 2mm, 5mm and 6 mm above the Chamberlain's line as abnormal (basilar invagination) in respective cases; BI: basilar invagination; CL: Chamberlain's line; OP: odontoid process)

Table 1: The distribution of basilar invagination in the study population for different diagnostic thresholds

	BI - present	BI - absent
OP 2mm above CL	11.8% (n=16)	88.2% (119)
OP 5mm above CL	0% (n=0)	100% (135)
OP 7mm above CL	0% (n=0)	100% (135)

Table 2 describes the gender distribution of basilar invagination. There was no significant difference (X2=1.068; p=0.301) in the incidence of basilar invagination among males (9%) and females (14.7%). Binary logistic regression analysis performed to analyze the factors associated with the occurrence of basilar invagination (Table 3). Though the internal cranial height negatively associated with basilar invagination (OR=0.823, p=0.044), none of the other evaluated factors such as age, gender, Klaus' height index or the posterior fossa height of the subject was significantly associated with the incidence (Table 2).

Table 2: The gender distribution of basilar invagination

	Male (n=67)		Female (n=68)	
	BI present	BI absent	BI present	BI absent
2 mm above CL	9% (n=6)	91% (n=16)	14.7% (n=10)	85.3% (n=58)
5 mm above CL	100% (n=67)	0% (n=0)	0% (n=0)	100%(n=68)
6 mm above CL	100% (n=67)	0% (n=0)	0% (n=0)	100%(n=68)

(the cut of values used to identify basilar invagination by considering the tip of the odontoid process 2mm, 5mm and 6 mm above the Chamberlain line.

The mean position of the cerebellar tonsils was 4.19±2.42 mm above the foramen magnum. The tonsilar position ranged from 14mm above to 3mm below the foramen of magnum. However, the majority (97.8%; n=131) had cerebellar tonsils placed above the foramen of magnum. Despite having three patients (2.2%; n=3) who were with the cerebellar tonsils placed below the foramen of magnum, none (0%) fulfilled the diagnostic criteria of Chiari malformation.

Discussion

The value of diagnosing asymptomatic patients with basilar invagination (BI) underscore the possibility of developing neurological symptoms at any age, upon which surgical intervention often needed to prevent permanent neurological disability (4,6,10,13). This pioneering study from a Sri Lankan population, reports an 11.8% incidence of primary BI among asymptomatic adults. Additionally, we found that the incidence of primary BI has a negative association with the internal cranial height. The clinical prediction of asymptomatic BI renders difficult due to lack of influence on age, gender, posterior fossa height or Klaus' height index.

The general examination findings of patients with BI are non-specific, would present with a short or deformed neck (for example, torticollis) that share with many other congenital and acquired neck disorders (14). The majority of BI patients are asymptomatic when they are symptomatic often present with non-specific symptoms while hiding the

real potential of progressing into neurological disabilities. Therefore, a high degree of suspicion is essential in case detection. Knowing the prevalence of BI in the general population would facilitate case detection and disability prevention that may be triggered upon a minor trauma (2,5,8,9). Further to this, the reported ethnic variations observed in prevalence devalue the use of references from other populations (2) and highlight the need to have population-specific prevalence values of asymptomatic BI.

Proving the hypothesis, we found an ethnic variation in the prevalence of BI by reporting (11.8% prevalence of asymptomatic BI) lower values than Brazilians (37.5%, n=40) (8). The Brazilian study has employed three different protocols to define the cases of BI (8). The standard protocol uses the tip of the odontoid process 2mm above the Chamberlain's line as abnormal (5,8). In the other two protocols, the odontoid tip placed 5mm and 6mm above the Chamberlain's line were considered abnormal (8). Our population showed different prevalence values in all criteria: while asymptomatic Brazilians were having 10% (5mm above the Chamberlain's line) and 5% (6mm above the Chamberlain's line), we found none fulfilling the same criteria in our sample. Data regarding the true incidence of BI among the general population scares, some stated it as low as 1% (13). Importantly, data on the incidence in the Indian subcontinent is yet to discover. Hence, the findings of this study would be considered as the references for the Indian subcontinent.

Among many associations of BI, small posterior fossa volume, platybasia (abnormal angle between the anterior skull base and the clivus), clival hypoplasia, condylar hypoplasia, hypoplastic Atlas, Chiari malformation and syringomyelia were frequent (2,4-6,14,15). However, we found that the indicators of posterior fossa volume, such as Klaus' height index, and posterior fossa height were not associated with BI of this cohort. Interestingly, it was observed that the reduced internal cranial height have a positive association with BI. This fact may also represent ethnic influence on anthropometry.

A positive association has been established among BI, reduced posterior fossa height and Chiari malformation (6). Though a high incidence (90%) of Chiari malformation reported among BI patients, none of our patients (0%) diagnosed to have Chiari malformation (6,16,17). The observed discrepancy in the incidence of Chiari malformation may partly represent the differences in methodology; this study assessed asymptomatic individuals, while the other studied symptomatic patients. The neurological symptoms classically associated with the compression of vital structures in the craniocervical region (such as cerebellar tonsils, brainstem and or the cervical spinal cord); the possibility of compression probably aggravated by the low posterior fossa volume (6,15). The present study cohort being asymptomatic possibly explains the lower incidence of Chiari malformation.

Since the clinical prediction of BI is difficult, the mainstay of diagnosis is with imaging, for that different modality contribute uniquely (6). The plain radiograph is less sensitive in delineating bone landmarks such as the posterior edge of the hard palate and the opistium than cross-sectional imaging -the measurements from the Chamberlain's line more accurately taken with CT images (9,10). The associated soft tissue abnormalities such as Chiari malformation and syringomyelia are better evaluated with MRI than with CT. Improved imaging technologies such as CT and MRI enhance the yield of assessing associated bone abnormalities and neural compression (1,4). Additionally, dynamic evaluation of the craniocervical junction enables diagnosing functional craniocervical junction instability; though there are different degrees of sensitivity, almost all the imaging modalities allow the dynamic assessment (1,4,8,9,14). Craniocervical junction instability said to be the critical most factor in developing many symptoms and disabilities of BI (2,4,6,8,9). Symptomatic frequency of BI is high in severe degrees of superior odontoid migrations, particularly when associated with atlantoaxial facet dislocation (5). Both abnormalities - the degree of odontoid migration and atlantoaxial facet dislocations - are reliably evaluated using cross-sectional imaging modalities such as CT and MRI.

The surgical intervention being the cornerstone of management in BI is generally offered for symptomatic patients, particularly those who are with an unstable craniocervical junction. Pain, restricted movements and hyper-lordosis of the neck are recognized features of the unstable craniocervical junction (15). Rather than restoring the anatomy, surgery primarily aimed to realign and stabilize the craniocervical junction by fixing the atlantoaxial junction (14). A screening imaging procedure would be of value to identify craniocervical junction instability among asymptomatic patients and those who are with non-specific external appearances such as short or deformed necks. The lateral view of the X-ray cervical spine obtained in neck flexion and extension is a readily available, cheapest imaging modality, which has the ability to indicates the craniocervical junction instability reliably. However, CT and MRI provide a dynamic assessment with a much higher sensitivity (14).

The reliability of the findings of the current study is confirmed because the diagnostic accuracy of BI with sagittal reconstructed CT of the craniocervical junction is high (5). Despite, this being a pioneer study to document the prevalence of basilar invagination for a Sri Lankan population, it suffers from several limitations. Firstly, being a single centre study limits generalizing the findings to the Sri Lankan population, which could be better achieved in the multi-centric study. Secondly, though it is vital to know the prevalence of BI in asymptomatic individuals, clinical implications would be enhanced if combined with

functional assessment, such as assessment of the atlantoaxial instability.

In conclusion, the high asymptomatic prevalence (11.8%) of basilar invagination reflects the need for having a high degree of suspicion to detect patients with non-specific symptoms.

Conflict of interest

None declared.

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CASE REPORTS

A unique case of brachial plexus form lateral to the axillary artery: a case report

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Abstract

Anatomical variations of the formation and distribution of the brachial plexus are fairly common and it is related to the embryological development of upper limbs. The present report describes an unusual variation of the brachial plexus in which the cords are arranged lateral to the 1st and 2nd parts of the axillary artery. Therefore, some of the main terminal branches show different relationship to the 3rd part of the axillary artery and the brachial artery. Awareness of such variations of the formation, relations and distribution of main branches of brachial plexus is of remarkable clinical importance for clinicians who carry out surgical, interventional radiological and anaesthetic procedures in the axillary region.

Keywords: Brachial plexus, cords variation, anatomical variations, median nerve, ulnar nerve

Introduction

Brachial plexus is essentially a network of nerve fibres which provide motor and sensory innervation for the upper extremity. It is comprised of ventral rami of lower cervical segments C_5 to C_8 and the first thoracic segment (T_1) which form the roots of the plexus[1]. For the descriptive purposes, this neve plexus is divided into roots, trunks, divisions, cords and branches. Its five roots are located in between the anterior and middle scalene muscles within the posterior triangle of the neck. Roots join to form the trunks as follows. The C_5 and C_6 unite to form the upper trunk, C_8 and T_1 unite to form the lower trunk and the C_7 continues alone as the middle trunk.

Each trunk divides into anterior division and posterior divisions behind the middle third of the clavicle. These six divisions link up again to form cords behind the 1st part of the axillary artery and arranged around the second part of the axillary artery according to their respective positions; lateral, medial and posterior. Each of these cords acquires their name from the position around the second part of the axillary artery.

At the lower border of Pectoralis minor muscle, the brachial plexus is divided into its main branches which are having a similar relation to the third part of the axillary artery as their parent cords (Fig 1).

We have encountered an unusual case in which the cords of the plexus are arranged on the lateral side of the axillary artery during routine educational dissections of the cadavers in the Department of the Anatomy Faculty of Medicine University of Ruhuna, Sri Lanka.

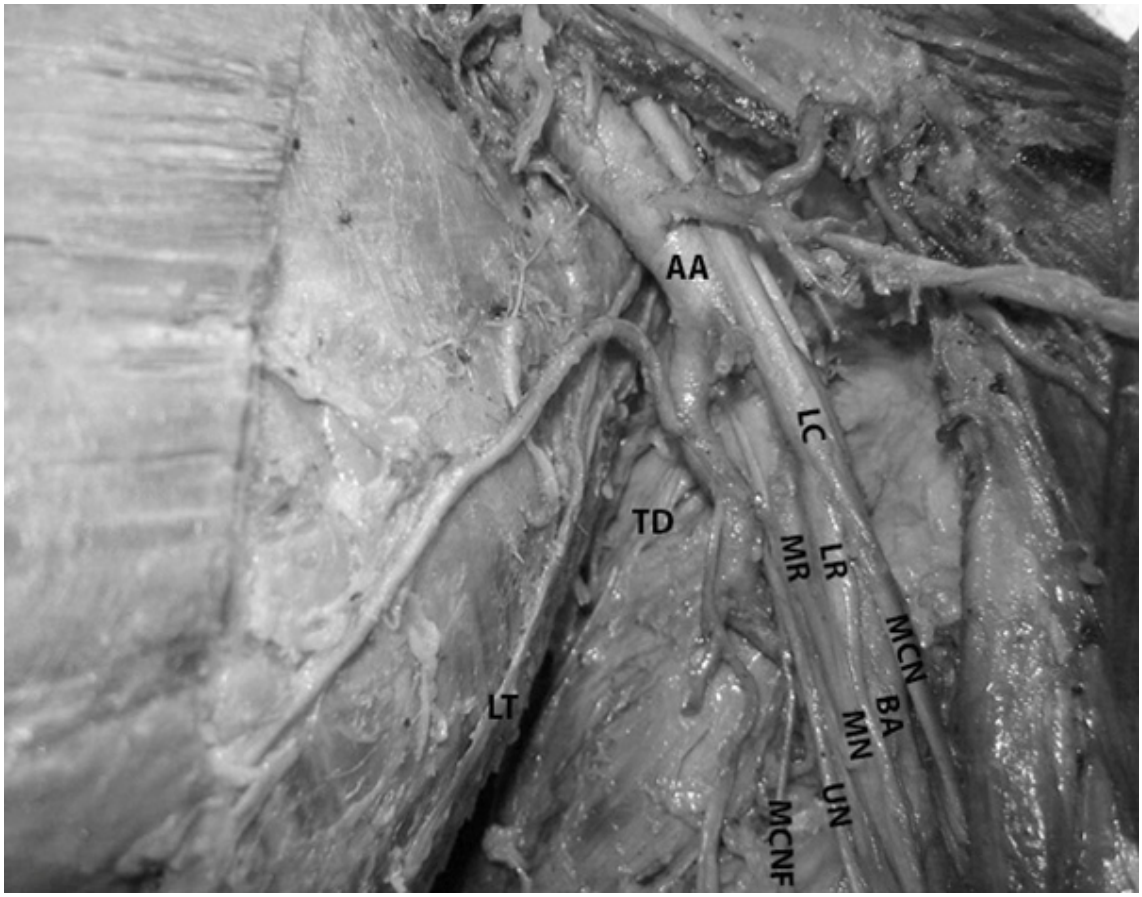

Figure 1: Normal anatomical relation of brachial plexus to the axillary artery and brachial artery.
(AA - Axillary artery, BA - Brachial artery, LC - Lateral cord, LR - Lateral root of median nerve, MR - Medial root of median nerve, MN - median nerve, MCN - Musculocutaneous nerve, UN - Ulnar nerve, MCNF - Medial cutaneous nerve of the forearm, TD - Thoracodorsal nerve, LT - Long thoracic nerve)

Case report

On routine dissection of the axilla of an adult male cadaver of Sri Lankan origin, we encountered that the all three cords (medial, lateral and posterior) of the brachial plexus were positioned lateral to the axillary artery throughout its course. Although the main branching pattern of the brachial plexus noted to be normal, their anatomical relations to the axillary artery are altered.

The nerves of the medial cord; (ulnar, medial cutaneous nerve of the forearm (MCNF) and arm) begin lateral to the artery. The ulnar nerve and the MCNF cross the 3rd part of the axillary artery from lateral to medial. The median nerve forms anterior to the ulnar nerve by joining its lateral and medial roots. Median nerve continues medial to the brachial artery up to the cubital fossa. Both roots of the median nerve noted to be on the lateral side of the axillary artery (Fig 2). Therefore, neither the roots nor the median nerve crosses the axillary or brachial artery throughout its course. Branches of the lateral cord

take normal pathway thus musculocutaneous nerve enters the coracobrachialis muscle. The posterior cord lies in between and posterior to the medial and the lateral cords (Fig 3). Therefore, the radial nerve does not relate posterior to the axillary artery. Radial nerve exits the axilla through the lower triangular space to pass behind the spiral groove of the humerus along with the profunda brachii vessels.

However, the upper part of the left brachial plexus above the level of the clavicle and its relations were normal. The right-side brachial plexus was also carefully inspected subsequently and it was found to be normal.

Discussion

Anomalies of the brachial plexus that relate to the formation and distribution of its main nerves are not uncommon and have been widely documented[2]. These abnormalities include variations of roots[3], trunks[4], different combinations of formation of cords[5-6], variations of its branches[6-7] and different relations to the axillary artery[8-9].

According to the available literature, the formation of the whole brachial plexus lateral to the axillary artery is very rare. However, Satyanarayana et al in Nepal report a case where all three cords of the brachial plexus form lateral

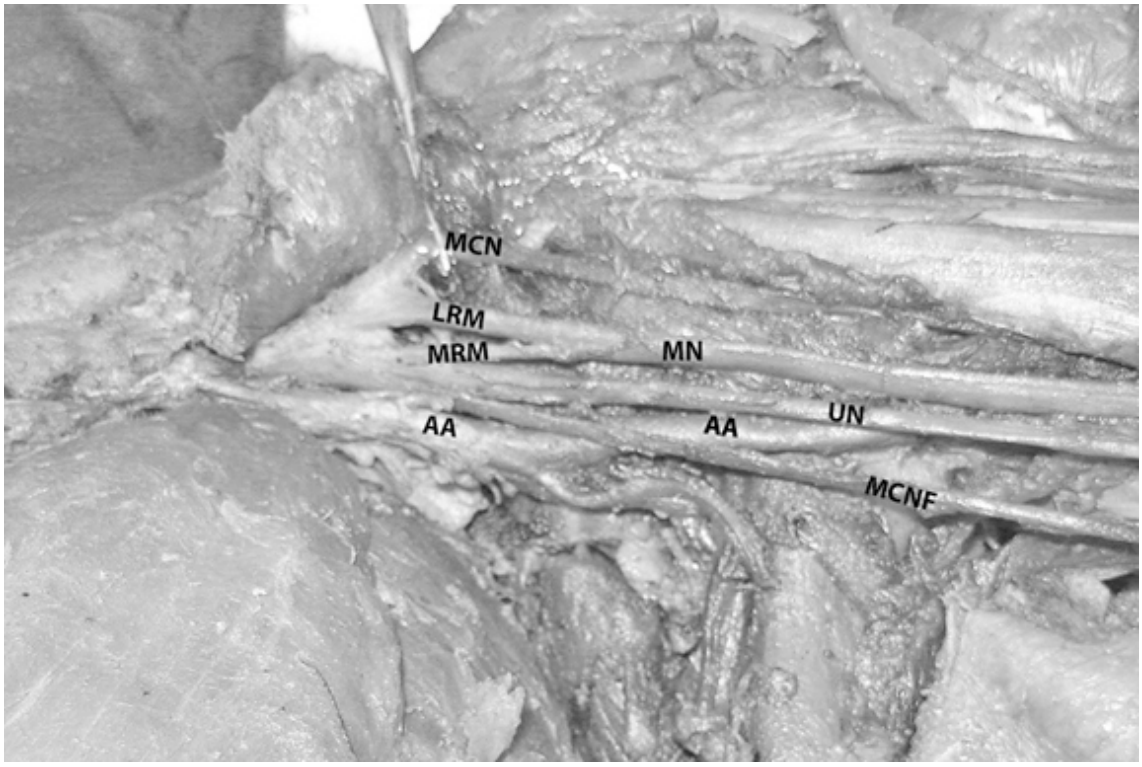

Figure 2: Abnormal relation of cords of brachial plexus and its main terminal branches to the axillary artery in the left upper limb (AA - Axillary artery, MCN - Musculocutaneous nerve, LRM - Lateral root of the median nerve, MRM - Medial root of the median nerve, MN - Median nerve, UN - Ulnar nerve, MCNF - Medial cutaneous nerve of the forearm, MC - Medial cord, LC - Lateral cord)

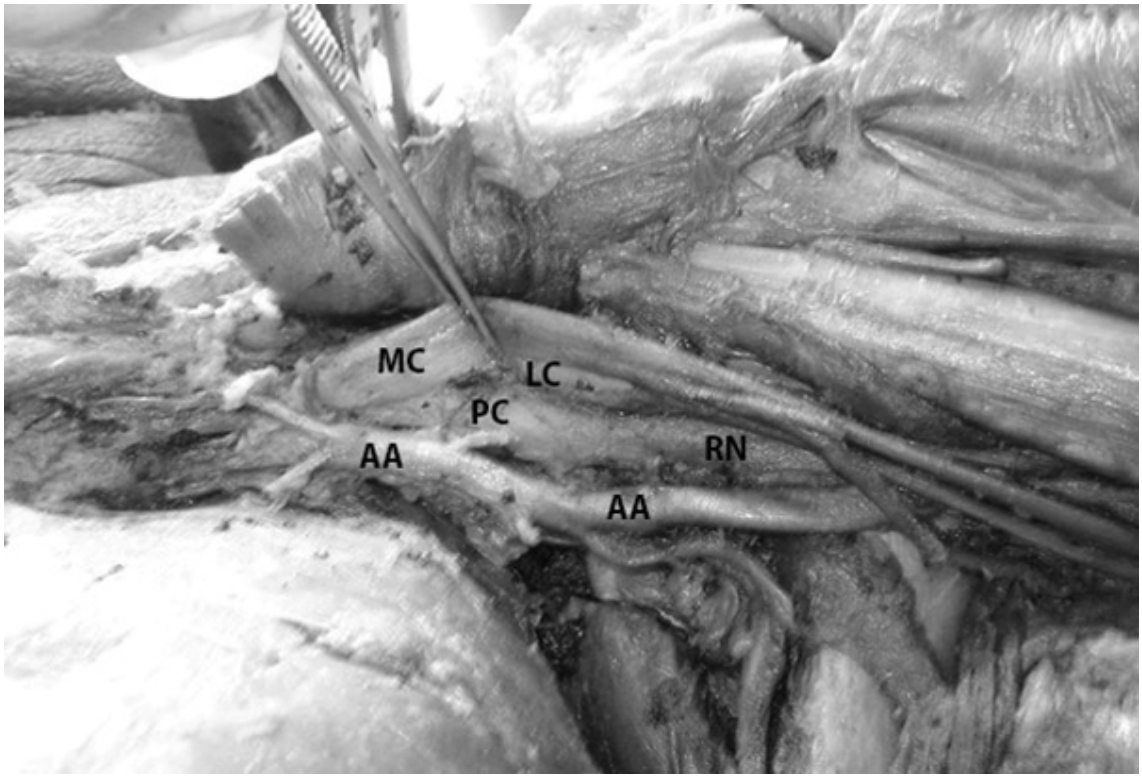

Figure 3: The posterior cord lies behind the other two cords (lifted up) - (AA - Axillary artery, MC - Medial cord, LC - Lateral cord, PC - Posterior cord, RN - Radial nerve)

to the axillary artery[10]. But his case is different from ours by having a different relationship in the formation and course of the main nerves. In our case, the median nerve forms lateral to the 3rd part of the axillary artery and anterior to the ulnar nerve. The case reported in Nepal, the median nerve forms around the profunda brachii artery. On the other hand, the ulnar nerve in our case forms at the usual level and crosses the 3rd part of the axillary artery along with the MCNF anteriorly from lateral to medial and pass medial to the artery. In the case reported in Nepal the ulnar nerve begins at a lower level close to the formation of the median nerve and continue to pass on the lateral side of the brachial artery.

There are other cases where the brachial plexus form lateral to the axillary artery. But in those cases, the brachial plexus itself is reported to have variations[11].

This means that our case is unique in keeping the lateral relation of cords to the 1st and 2nd part of the axillary artery and forming the branches lateral to the 3rd part of the axillary artery in normal pattern without any variation of the plexus itself. Therefore, our case is the first-ever case of this nature report in the literature.

The anatomical variations of the brachial plexus can be explained based on its embryogenic development. The upper limb buds are formed in the seventh week of development and they

first lie opposite the lower five cervical and upper two thoracic segments. Ventral primary rami from the corresponding spinal nerves infiltrate into the mesenchyme establishing an intimate contact with the mesodermal condensations[12].

After that, the finding of the pathway of the nerve fibres depends on various factors like surface receptors and cell adhesions which involve in cell-cell and cell-matrix interactions. Over or under expression of these factors might be responsible for the variations in the formation and relations[10].

A sound knowledge of the variations of the cords of brachial plexus and its terminal branches are imperative for clinicians especially surgeons and anaesthetists. Such anatomical variations may predispose patients to certain pathological conditions like thoracic outlet syndrome and may alter surgical approaches to the brachial plexus[13].

Elective neurosurgeries in the axillary region require comprehensive knowledge on the anatomy of brachial plexus and a good awareness of these variations[14]. Additionally, the structures might be misidentified during surgeries of the cervical spine, particularly in the case of nerve sheath tumours such as schwannomas[15].

Furthermore, the brachial plexus and its branches are susceptible to injury during surgical procedures done in the axillary region, such as emergency axillary exploration following a traumatic upper limb injury[3]. The plexus may be also vulnerable to injury during oncological surgical procedures like radical neck dissection and axillary lymph node clearance[10].

Regional anaesthetic procedures such as infraclavicular nerve blocks may be unsuccessful and sometimes damage important nerves of the plexus in complicated cases with anatomical variations[16-17].

When considering the present case where the plexus show different relationship to the axillary and the brachial artery is at high risk in damaging during vascular interventional procedures of the axilla or open vascular surgery in the axillary or brachial artery. Therefore, it is very important to know the presence of such variations even though it is rare.

Conflict of interest

None declared.

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Common peroneal nerve schwannoma, a rare cause of sciatica - Case report & review of literature

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Introduction

Schwannoma typically a slow-growing tumour that bears the reputation of the most common benign peripheral nerve sheath tumour. Sciatic nerve schwannoma is rare (1%) tumour that can manifest with symptoms of sciatica (1). Diagnosis of schwannoma is often delayed, notably when presents with symptoms of sciatica (1- 4).

Keywords: common peroneal nerve shwannoma, sciatica, neurofibroma, malignant peripheral nerve sheath tumours.

Case presentation

We report a case of common peroneal nerve schwannoma in a 53-year-old man presented with left leg pain for two years duration. He complained of severe and intermittent pain in the posterior aspect of the left calf, which progressed over the time. Though the pain was more apparent on walking, the characteristic claudication distance was not elicited. He experienced a shooting pain when squatting down or sits on a high chair. However, the pain was not exaggerated on coughing or trunk movements. He was apparently well before and was a non-smoker and a teetotaler.

On examination, he was average built; general and systemic examination was unremarkable with no definite neurological signs. The tendon reflexes were normal, and the movement range of the affected lower limb was normal. The straight leg raising test was negative. No chronic ulcers or trophic changes were found in the lower limbs.

In the process of investigations, to exclude a vascular pathology, he referred to the Radiology department for lower limb arterial and venous doppler studies. The arterial and venous doppler studies were not diagnostic of an arterial or venous pathology. However, a well-defined spindle-shaped mass in the left popliteal fossa was detected incidentally, which measured 3 x 2 x 1.5 cm in maximum craniocaudal, transverse and anteroposterior diameters respectively. The mass had a hypoechoic periphery with a relatively echogenic centre; minimal internal vascularity and posterior acoustic enhancement (Fig.1).

Medial to the mass was the left posterior tibial nerve that maintained normal morphology and thickness. Posteromedial to the mass were the popliteal artery and the vein, which were not compressed by the mass (Fig.3).

Fig. 1: Target sign

Eccentrically, it continued with the left common peroneal nerve (Fig.2).

Fig. 2: Eccentric peripheral nerve continuity of the lesion

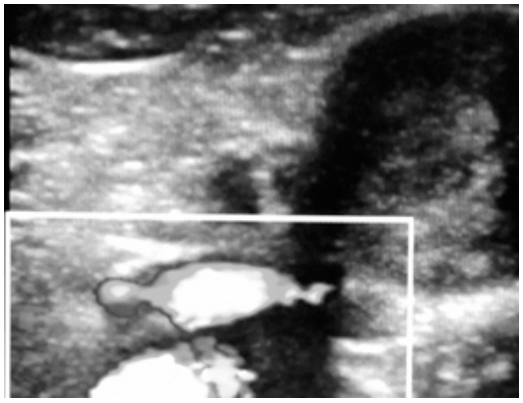


Fig. 3: Relationship of popliteal artery, vein and posterior tibial nerve to the lesion

(Artery and veins are indicated in the white box, nerve is indicated by the white arrow)

A peripheral nerve sheath tumour (PNST) of the left common peroneal nerve, causing sciatica-like symptoms was diagnosed, considering the location, ultrasound features and the relationship to the nerve. Once the diagnosis was made, the patient examined further to elicit specific signs such as the "Tinnel sign". The "Tinnel sign" was positive, which is a radiating pain along the left leg when percussing on the mass, confirming the neural origin.

A few weeks later, the mass excised surgically, upon which the symptoms disappeared. The histopathological report confirmed the diagnosis as a schwannoma of the left common peroneal nerve.

Discussion

Chronic leg pain is a common symptom that usually attributed to neural/ vascular origin or loco-regional pathologies. Detecting the aetiology of pain in our patient was tricky owing to non-specific symptoms; the symptoms were not compatible with neither the typical intermittent claudication pain of arterial origin nor the radicular type of pain of neurogenic origin. The radicular type of leg pain is typically attributed to a degenerative spinal pathology, hence even in the presence of typical pain, diagnosing a schwannoma is often delayed. Therefore, a whole limb imaging study, preferably an MRI scan

recommended for patients, who are having the characteristic symptoms of neural pathology while the preliminary investigation findings rule out any degenerative spinal pathology (5,6). Nevertheless, in our case, the benign peripheral nerve sheath tumour (PNST) was incidentally diagnosed during a vascular doppler study.

Schwannomas are tumours of Schwann cells, which form the myelin sheath around the nerve axons. Schwannomas are known to occur in cranial & peripheral nerves. However, the sympathetic nervous system involvement is rare (1- 4). The nerve sheath tumours could be solitary or multiple; benign or malignant. Schwannoma and neurofibroma recognized as a common benign solitary nerve sheath tumour (7) - the schwannoma considered to be the commonest benign PNST. The common peroneal nerve schwannoma reported earlier in the literature (8).

Differentiation between benign PNST from a malignant PNST is difficult with cross-sectional imaging, particularly with sonography (USS). Superficial PNST are amenable to USS assessment than the deep-seated PNST. The USS features of PNST are variable; commonly a low homogenously echogenic solid mass with posterior acoustic enhancement and positive "target sign". The continuity to a peripheral nerve is the pathognomonic feature of neural origin, can be demonstrated sonographically. Schwannomas are eccentrically related to a peripheral nerve. However, sonographic differentiation of PNST from a cystic lesion such as uncomplicated ganglion cyst is often tricky, hence misdiagnosis is frequent. Both PNST and cystic lesions are low echogenic lesions with posterior acoustic enhancement; the internal vascularity is a feature (in a colour doppler imaging) of a solid lesion, while avascularity is typical in the cystic masses (9).

Differentiating neurofibroma from schwannoma is possible only to a certain extent when imaged with USS & MRI; neurofibroma shows a central communication to the nerve while the schwannoma is eccentrical. However, the differentiation between benign from malignant PNST is not successful even with MRI. Usually, with MRI, the benign entity is homogeneous, iso-intense to the muscles in T1 and hyper-intense in T2-weighted images. In contrast, the malignant entity is inhomogeneous bearing haemorrhagic and necrotic areas. Presence of aggressive imaging features such as indistinct margins, infiltration and invasion of the surrounding tissues, favours the diagnosis of a malignant lesion.

MRI is better than USS to delineate imaging features of PNST such as

'"target sign", "fascicular sign" and "split fat sign". The "split fat sign" is the presence of a thin rim of fat around the nerve sheath tumour (Fig. 4).

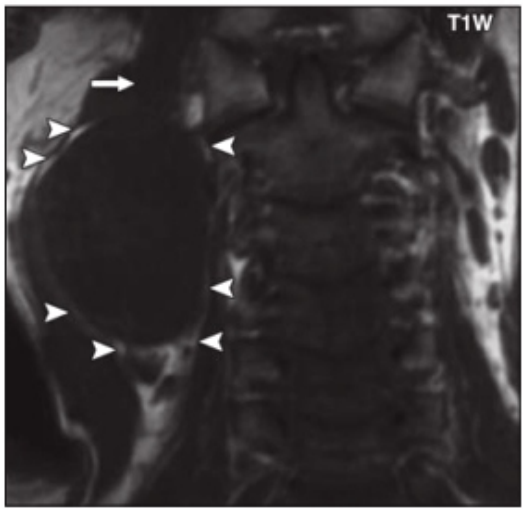
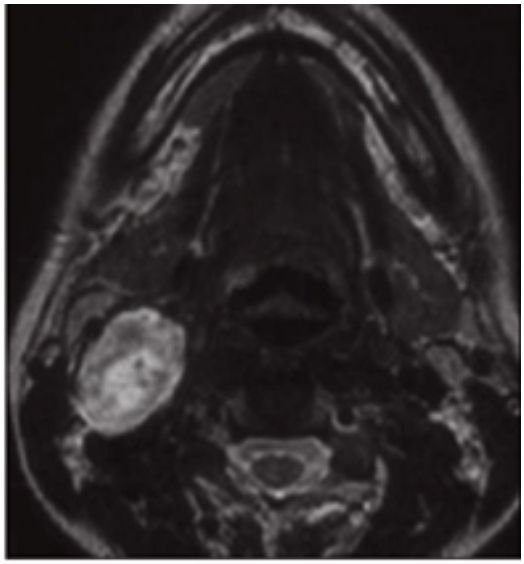


Fig. 4: Split fat sign (11)

(Thin fat rim around the lesion is indicated with arrow heads)

The "fascicular sign" (Fig. 5) described in T2 weighted images as multiple low signal intensities surrounded by a hyperintense rim, which probably represents nerve fascicles (10,11).



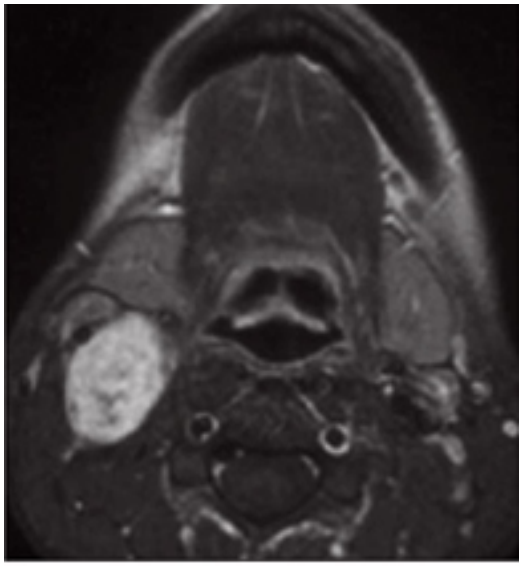


Fig. 5: Fascicular sign (11)

(multiple low signal intensity surrounded by hyper intense rim in T2 weighted images)

The "target appearance" of PNST is due to concentrically arranged Antony type A & B bodies: Antony type-A bodies are peripheral, and Antony type-B bodies are central. Computed tomography (CT) does not provide an added advantage over MRI in differentiating schwannoma from neurofibroma; in fact, the MRI is better than CT. The CT appearances of PNST often include uniformly low-attenuated tumour mass with the "target appearance" that is a hypoattenuating centre with a hyperattenuating periphery (11).

Malignant transformation of benign PNST said to be rare. Benign and malignant imaging features and basic demographic features of PNST are described in Table 1 (10).

Table 1: Typical demographic and radiological features of nerve sheath tumours (10)

Feature	**Tumour type**		
	Shwannoma	Neurofibroma	Malignant PNST
Demography			
Prevalence	5% of all benign soft tissue tumours	5% of all benign soft tissue tumours	6% of all sarcomas
Affected patients			
Age (Y)	25-65	20-55	20-65
Male:female ratio	1.3:1	1.2:1	1:1
Multiplicity and association with NF1	Rarely multiple; 5-18% of patients with multiple lesions have NF1	Typically solitary, but multiple when associated with NF1	Solitary, about 50% occurs in patients with NF1
Malignant change	Extremely rare	Extremely rare, except in NF1	Seen in <5% of patients with NF1 (range 2- 29%)
Lesion location	Most often in lower limbs, followed by torso, upper limb and retro peritoneum	Most often in head and neck, lower limbs and torso followed by upper limb	Seen in major nerve trunks (commonly in proximal extremities and torso)
Radiologic features			
Relationship of mass to the nerve	Eccentric, relative to the nerve & inseparable from nerve	Central, relative to the nerve	Central, relative to the nerve & infiltrates the nerve
Capsule	70% 0f cases	30% of cases	Rare
Target sign	50% of cases	50-70% of cases	Absent
Fascicular sign	Common	Common	Occasional, focal
Intra-tumoral cysts	Common	Rare	Not applicable
Margins	Well circumscribed	Well circumscribed	Most often well circumscribed than irregular

(Nf1- Neurofibromatosis 1)

Conclusion

Peripheral nerve sheath tumours can present as sciatica. For patients with characteristic symptoms but with negative spinal imaging studies, a whole limb MRI scan would facilitate the diagnosis of PNST. The continuation of the mass with a nerve is the pathognomonic imaging feature of neural origin. Lack of specific imaging features renders the differentiation difficult, between neurofibroma from schwannoma and benign from malignant tumour, with routine imaging such as ultrasonography and CT. Hence, MRI or biopsy remains the gold standard.

Conflict of interest

None declared.

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Case report: An adult presenting with congenital radio-ulnar synostosis

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Introduction

Congenital radioulnar synostosis is a rare condition with multi factorial aetiology due to developmental abnormality of upper limbs during early gestation. It results in abnormal osseous fusion between proximal radius and ulna bones leading to fixed pronation deformity of the forearm. This can cause great difficulty in daily activities depending on the extent of the deformity. Congenital radioulnar synostosis is diagnosed during childhood, when abnormal positioning of the forearm is noticed by the parents or teachers. Rarely, this could go undiagnosed till adulthood. Most of these adult patients are diagnosed incidentally when they present to the health care provider for a different reason. The possible reasons for delay in presentation is because this condition is painless and the patient learns to compensate for the deformity using the wrist and the shoulder joints. Congenital radioulnar synostosis is diagnosed by x ray of the elbow joint and forearm. Corrective surgery is the treatment of choice when severe limitations of hand functions occur especially affecting day to day essential activities in children. Adults often managed conservatively as they have already adjusted to live with minimal disability. Here, we are reporting a female patient diagnosed with congenital radioulnar synostosis presenting with features of rheumatoid arthritis.

Case report

A 32 yr old mother of two children presented to the Rheumatology unit, District General Hospital - Hambantota with multiple joint pain for 3 months' duration. The symptoms were gradual in onset involving bilateral elbow, wrist and small joints of the hands. The pain was associated with early morning stiffness lasting more than thirty minutes. The shoulder joint and the lower limb joints were not affected. She has also noted intermittent swelling of the small joints of the hand and the wrist joints. No features such as skin rash to suggest connective tissue disorder. There was no history of trauma. She did not have any significant medical or surgical history nor she had any episodes similar to the current presentation. On examination she had clinical features of active synovitis involving the metacarpophalangeal, proximal interphalangeal and bilateral wrist joints. Her movements of these joints were restricted due to pain hence, unable to make a fist or flex the wrist.

In addition, she had a significant reduction in supination and pronation at the proximal radioulnar joint. She kept her both forearms in fixed pronated position and further inquiry revealed that she is used to keep her forearms in this position since she could remember. Further to, she has not had any effect on her normal day to day life with this restriction in pronation and supination. Investigations revealed high inflammatory markers with elevated rheumatoid factor titers. Full blood count, thyroid functions and the bone profile were normal. Considering the history, examination and investigations, she was diagnosed to be having sero (+) rheumatoid arthritis and started on Methotrexate and Hydroxychloroquin. X ray of bilateral elbow joints (Figure 1,2,3) were done to investigate for her long term forearm disability and it revealed bilateral radioulnar synostosis of congenital origin. Even though this is unrelated to her present diagnosis of rheumatoid arthritis, we arranged for occupational therapy with activity modification to aim of improving her upper limb functions.

Figure 1: Lateral x ray of right elbow joint with abnormal articulation between proximal radius and ulna.

Figure 2: Lateral x ray of left elbow joint with abnormal articulation between proximal radius and ulna.

Figure 3: X rays of bilateral elbow joints

Discussion

The forearm consists of two long bones namely radius and ulna. Proximal radial head articulates with the ulna's radial notch to form the superior radio ulna joint. Distally the head of the ulna articulates with the medial side of the distal end of radius to form the inferior radioulnar joint. In between these two joints the two bones are connected with each other by a fibrous interosseous ligament. The main movements at these joints are pronation and supination, where the radial head rotates against the ulna's radial notch in the superior radioulnar joint. This allows radial shaft to rotate around the relatively fixed ulnar shaft. During pronation and supination about 140-180 degrees of rotation occurs at the radioulnar joints which results in rotatory movements of the forearm.

In radioulnar synostosis there is osseous fusion (bony bridge) between the proximal radius and ulna. Radioulnar synostosis can be divided in to two types.

- Congenital radioulnar synostosis
- Post traumatic radioulnar synostosis

The radioulnar synostosis affects supination and pronation of the forearm with minimal impact on the extension and flexion of the forearm at the elbow joint. Post traumatic radioulnar synostosis is a rare complication after forearm or elbow injury that can result in loss of movement and disability. (2) In contrast congenital radioulnar synostosis is a rare condition which result from failure of the normal embryological development of upper limbs. Radius and ulna develop from a common cartilaginous anlage which separates by six weeks of gestation. The failure of this longitudinal segmentation between radius and ulna results in a persistent bridge of tissue (3) which will ossify in to an osseous synostosis. Some authors have reported that there is genetic basis with autosomal dominance inheritance for congenital radioulnar synostosis; associated with chromosomal abnormalities such as duplication of sex chromosomes; congenital syndromes such as Klienfelter's syndrome. (4) Radioulnar synostosis is frequently bilateral and more commonly seen in male patients. (5)

A person with congenital radioulnar synostosis can remain unnoticed as it is asymptomatic and painless. During childhood it can be detected by the health professionals, parents or teachers. Normally the forearm is fixed in an average position of 30^0 of pronation but with time a person with this condition learns to compensate for the elbow restriction by other movements such as shoulder abduction and adduction. Most of the time elbow flexion is preserved so a person with radioulnar synostosis may ignore his or her limited movements of the forearms until it is detected accidently like in our patient. Once radioulnar synostosis is suspected it can be diagnosed by performing antero-posterior and lateral x rays of the forearm and elbow joint.

Radiographically, there are four types of congenital radioulnar synostosis.

1. Type I - Synostosis with no osseous bridge. Size of the radial head is reduced.

2. Type II - Synostosis has visible osseous bridge with otherwise normal anatomy.

3. Type III - Long osseous synostosis with hypoplastic and posteriorly dislocated radial head.

4. Type IV - Short osseous synostosis with anteriorly dislocated and mushroom shaped radial head.

Once diagnosed management of congenital radioulnar synostosis depends on several factors including the degree of deformity, impact of the deformity on daily activities and patient's expectations. When this is diagnosed during adulthood; the patient is asymptomatic and leading a normal life with minimal impact on day to day activities, patients tend to opt for conservative management. Conservative treatment includes occupational therapy focusing on activity modification. Corrective surgery is the other option for patients who have bilateral radioulnar synostosis with very limited forearm movements. Especially if the patient has great difficulty in performing activities such as washing, bathing, brushing to maintain good hygiene, occupation and recreational activities. Surgery is best performed in early adulthood and it is not recommended for older patients with mild deformity.

The patient discussed above had bilateral congenital radioulnar synostosis. However, she has learnt to compensate for the limited range in movements by using her wrists and shoulders. Hence, we educated her regarding the condition and explained that it does not relate to her recent diagnosis of rheumatoid arthritis. She opted for conservative management with counselling, activity modification and occupational therapy.

Conflict of interest

None declared.

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Journals
Standard journal article
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