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Indian Journal of Anatomy

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

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Indian Journal of Anatomy

Volume 11 Number 1
January – March 2022

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Original Article

Indian Journal of Anatomy
Volume 11 Number 1, January – March 2022
DOI: http://dx.doi.org/10.21088/ija.2320.0022.11122.1

Comparative Study of Foramen Magnum in Dry Cadaveric Skulls and Computerized Tomography Images in North Interior Part of Karnataka Region

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M K Qureshi, R S Bulagouda, Gavishiddappa A. Hadimani et al. /Comparative Study of Foramen Magnum in Dry Cadaveric Skulls and Computerized Tomography Images in North Interior Part of Karnataka Region./Indian J Anat. 2022;11(1):9-14.

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Received on: 04.04.2022

Accepted on: 27.04.2022

Abstract

The foramen magnum (FM) is a unique and complex anatomical opening in the base of the skull,which the posterior cranial fossa communicates with the vertebral canal. It is also related to a number of pathological conditions, including Chiari malformations, various tumours, and occipital dysplasias. The study aimed to compare and evaluate the foramen magnummorphology in dry skulls and CT scan images. ***Material and methods:*** The morphology of the foramen magnum was assessed in 118 adult non-pathological dry human skulls and 3D computer tomography images in 118 individuals (66 male, 52 female) aged 18–75 years. ***Result:*** the incidence of various shapes of the foramen magnum was observed the most common shape was oval (33.89%) in skulls, followed by round (15.25%), tetrahedral (13.55%), pentagonal (7.32%), hexagonal (16.94%) and irregular (12.71%). The mean anteroposterior 33.76 ±2.1mm & 28.09+ 1.9 mm transverse diameter of the foramen magnum. The minimum and maximum values for AP diameter were 31.78 & 39.13. Inthe CT scan study, the mean anteroposterior diameter of FM in the male 35.96± 3.7 and 33.85±3.5 in females. The transverse diameter in males 30.38±3.5 and 27.83±2.5 in females. The FMI was observed in males 85.48±9.1 and 83.26±9.0 in female. ***Discussion:*** Results provides baseline data for the anatomist and important information for neurosurgeons to approach the cranial base with maximum safety and minimum mortality and morbidity.

Keywords: Foramen magnum, morphological variation, Cervico-medullary junction, Transcondylar approach.

Introduction

The base of the skull presents the most conspicuous structure called the foramen magnum, which is formed in the occipital bone and separates the brain above from the spinal cord below. The foramen magnum is constructed by the fusion of four parts of the occipital bone (pars squama pars right and left lateralis and pars basilaris)[1]. The posterior part of the foramen magnum, known as the neurovascular compartment, contains the caudal portion of the medulla oblongata, meninges, cerebrospinal fluid, vertebral blood vessels, anterior and posterior spinal arteries and the spinal root of accessory nerves; the anterior part of it is known as Osseo-ligamental compartment.[2] The knowledge of the change in the anatomical configuration and shape of the foramen magnum disturbs the vital structures passing through it and emerges the surgical approach in foramen magnum brain herniation Foramen magnum meningioma achondroplasia, foramen magnum dermoid cyst and Aronld Chairi syndrome.[3-5]

Materials and Methods

The present study was conducted on 118 adult non-pathological dry human skulls of unknown ageprocured from the Bone bank Department of Anatomy, Shri B M Patil Medical college BLDE (Deemed to be University), Vijayapur, Karnataka, for the duration of one year. On the other hand, to compare morphometry of dry bone after taking approval from the institutional ethical committee, we examined 118 computed tomographic images of both sexes (Male 66, Female 52) aged between18-75. The CT images were collected from the Department of Radiology and Imaging, Shri B M Patil MedicalCollege, BLDE (Deemed to be University), Vijayapur, Karnataka, India. The different shapes of FM were noted and classified as oval, round, egg, tetragonal, pentagonal, hexagonal and irregular shapes.

Inclusion Criteria

Fully ossified, dried, macerated skulls.

Adult cranial CT scan with complete foramen magnum.

Exclusion Criteria

Skulls with gross deformity.

CT scans with damaged foramen magnum associated with pathological condition were excluded from the study

All the dry skull parameterswere obtained with the help ofa digital sliding calliper with an accuracy of 0.01 mm—statistical analysis made by using SPSS Anova Software. The following parameters were measured:

1. The anteroposterior (AP) diameter of the FM was defined as the distance from basion to opisthion and measured.
2. The transverse diameter (TR) of the FM was defined as the distance between the foramen's lateral margins at the point of greatest lateral curvatures and measured.
3. FM index (FMI) calculated using the following formula: Foramen Magnum Index ¼ Maximum transverse diameter Maximum AP diameter 100. The shape of the foramen magnum was assessed and classified oval round, pyriform, arrow pentagonal and hexagonal.

Results

In dry Skulls

In the present study, the incidence of various shapes of the foramen magnum was observed the most common shape was oval (33.89%) in skulls, followed by round (15.25%), tetrahedral (13.55%), pentagonal (7.32%), hexagonal (16.94%) and irregular (12.71%) (Table-1) (figure 1). The mean anteroposterior (Sagital) & transverse diameter of the foramen magnum was found to be 33.76 ±2.1mm (mean ± SD) & 28.09+1.9 mm, respectively. The minimum and maximum values for AP diameter were 31.78 & 39.13. The minimum and maximum transverse diameter of the foramen magnum was 21.07 & 30.82 mm. The minimum and maximum values for FMI were 73.88 & 97.98, respectively (Table-2).

In CT images

The various parameters of the foramen magnum of CT scans showed eight varying morphological shapes were identified and reported (Table 3). Oval, round, egg shape, tetrahedral, pentagonal, hexagonal and irregular. The most common shape of the foramen magnum identified in the CT image was the oval shape, found in (26.27%). The most diminutive shape of FM observed in irregular shape (9.32%). Egg shape in (12.71%), tetrahedral (10.16 %), round shape (11.01%), pentagonal (14.40%) hexagonal (15.25%) (Figure 2). For the present study, we observed the mean anteroposterior diameter of FM in the male subject was 35.96± 3.7 and in females was 33.85±3.5, respectively. The transverse diameter in males and females was 30.38±3.5 and 27.83±2.5, respectively. The FMI was observed in males and females as 85.48±9.1, 83.26±9.0 respectively (Table-4).

Table 1: Morphological variations of Foramen Magnum in dry skulls

Shape	Number	%
Round	18	15.25
Oval	40	33.89
Tetrahedral	16	13.55
Pentagonal	9	7.62
Hexagonal	20	16.94
Irregular	15	12.71

Table 2: Dimensions of Foramen Magnum in dry skulls

Total no (N)-118	Anteroposterior Diameter (mm)	Transverse Diameter (mm)	Foramen Magnum Index
Mean ±SD	33.76±2.1	28.09±1.9	84.65±6.3
Minimum	31.78	21.07	73.88
Maximum	39.13	30.82	97.98

Table 3: Morphological variations of Foramen Magnum in CT scan images.

Shape	No	%
Oval	31	26.27
Egg	15	12.71
Round	13	11.01
Tetrahedral	12	10.16
Pentagonal	17	14.4
Hexagonal	18	15.25
Irregular	11	9.32

Table 4: Dimensions of Foramen Magnum in CT scan images

Total no (N)-118	Male	Female
Anteroposterior Diameter (mm)	35.96±3.7	33.83±3.5
Transverse Diameter (mm)	30.38±3.5	27.83±2.5
FMI (mm)	85.48±9.1	83.26±9.0

CT is a reliable diagnostic tool for the accurate measurement of transverse and AP diameter of the foramen magnum

Discussion

The study of foramen magnum gained interest in the field of clinical science, anthropology, comparative anatomy and evolutionary biology.[6] The base of the skull presents an important anatomical opening called the foramen magnum, which communicates the posterior cranial fossa with the vertebral canal. During fetal development, the anterior and lateral aspects of the FM are formed from the basioccipital, the exoccipitals, and their respective interoccipital synchondroses anterior while the posterior boundary of the foramen is formed by the supraoccipital, the exoccipitals, and their corresponding interoccipital synchondroses posterior. The fetal growth centers do not fully ossify until approximately 10 years of age until which time both the size and shape of the FM are undergoing change. Between the 7th month in utero and birth, the rate of FM growth in its sagittal dimension is 5.4% greater than that of its transverse dimensions[7]. Between birth and 0.5 years, the opposite trend is observed – the rate of transverse growth is 7.6% faster than that of sagittal growth[7]. Mean adult sagittal lengths are attained by 5 years of age, whereas mean transverse lengths are not attained until 10 years of age.[7]

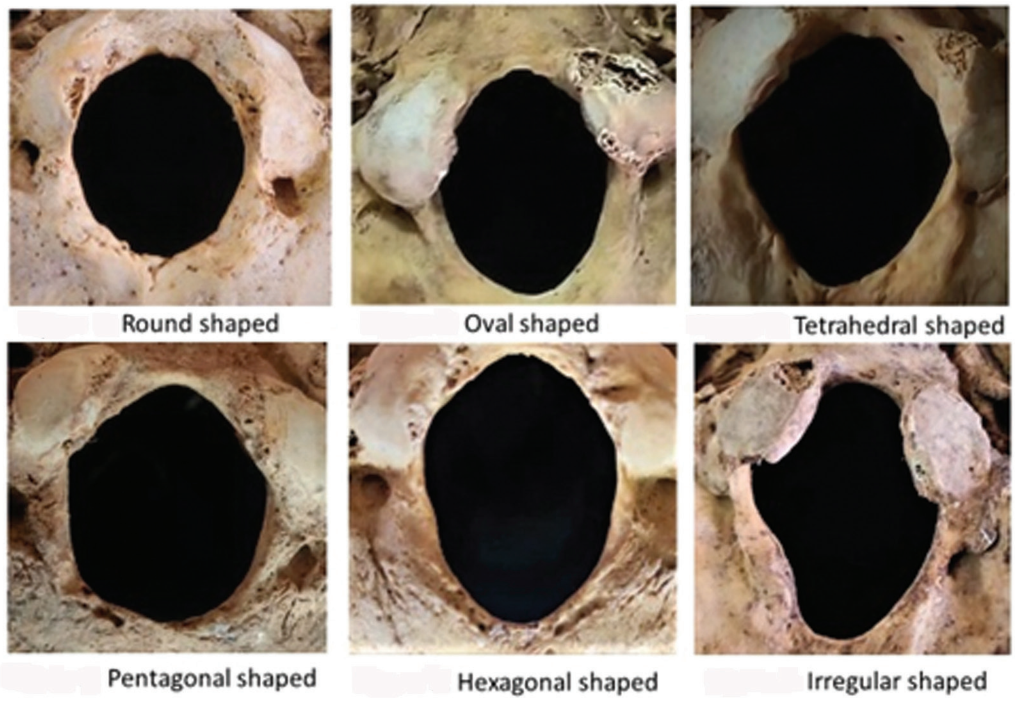

Figure. 1 Different shapes of the foramen magnum in dry skulls.

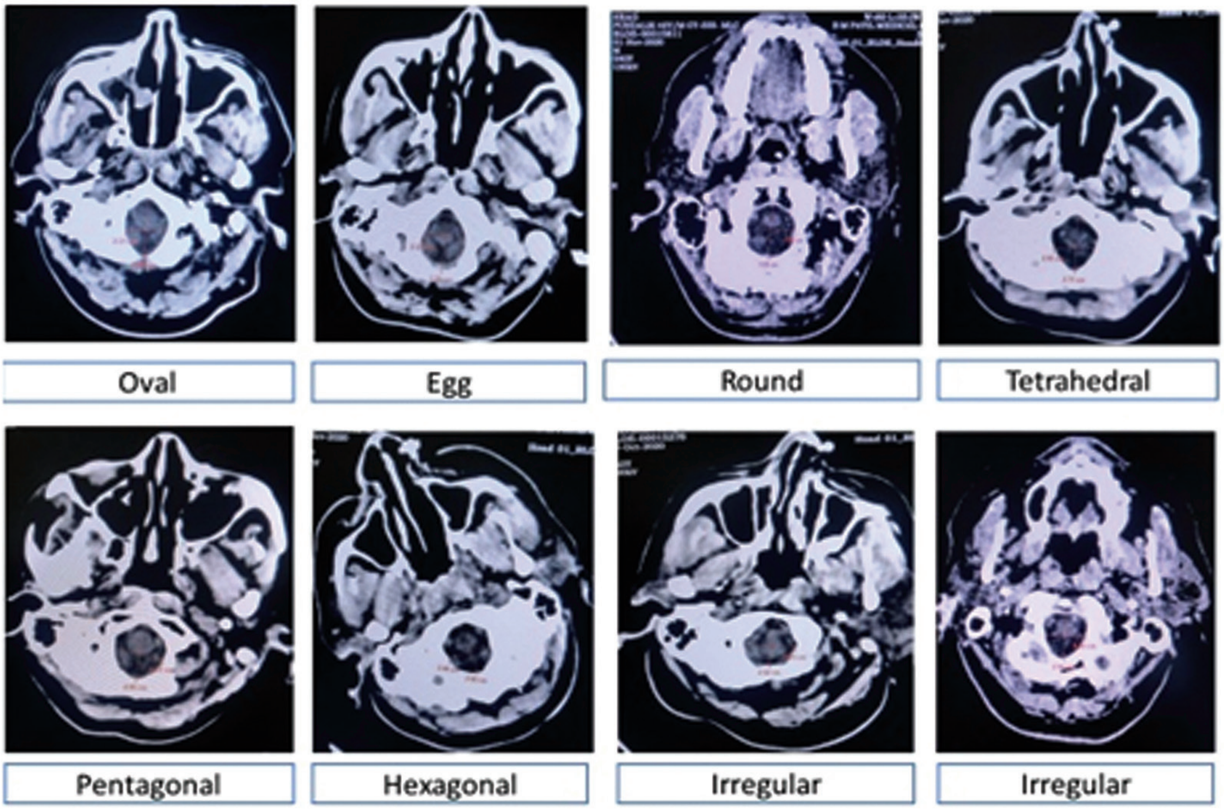

Fig. 2 Different shapes of foramen magnum as studied in CT scans

Biological and non-biological factors play an important role in the regulation of the development of foramen magnum. Genetical, hormonal, nutritional and muscles are the main biological factors, non-biological factors include abnormal fetal position in uterine cavity enhance the change in the muscle attachment this may be the cause for variation in the shapes of the foramen magnum.[8]

The literature of foramen magnum reports on the area of the foramen magnum and its variations. The most common shape of the foramen magnum in our study observed in both dry and CT images was oval shape (33.89 & 26.27%), while the least common shape found in the dry skull was pentagonal (7.62%) and in CT image irregular shape (9.32). Other variant shapes of FM observed both in the dry skull, and CT image were round (15.25%) & (11.01%). Pentagonal shape (7.62%) and (14.40%), the hexagonal shape (16.94%) and (15.25%). The round-shaped foramen magnum provides a larger operative angle for a better approach and requires less bone extraction for the neurosurgeons[9]. Thus, in the Indian population, the neurosurgeon has to go for osteotomy for a better transcondylar approach, as the shape of this foramen is oval in most of the subjects[10]. In an ovoid type of the FM, the ability of the surgeon to adequately expose the anterior portion of the FM might be difficult[10]. In our study, the shape of the FM varied and the ovoid FM was demonstrated in both dry skull and CT image (33.89% & 26.27%), of the specimens. Garcia et al.[11] have found 45% of oval shape FM in their CT scan study, which is higher than our CT scan study findings. Murshed et al. have found 8.1% of oval shape FM, which is much lower than our CT scan study values. Inastudy of 200 skulls, Zaidiand Dayal[12] reported that oval FMs were found in 128 (64%) skulls. Sindel et al.[13] and Langetal.[14] reported that this shapewas not found in more than 18.94% and 22.35%, respectively, of their samples. other types with their respective frequencies of occurrence have been found astetrahedral pentagonal and hexagonal and, in our study,the least irregular shape achieved (12.71%) (9.32%) in both dry skull and CT scans, similar findings were describedby many authors (ChethanPetal2012[15], NatsisKetal 2013[16]).The irregular shape of FM is highlighted by the developmentalcranialanomalies of the bone and soft tissues at the craniovertebral junction (FurtadoSVet al 2010). Murshed et al. have found 9.09% of irregular (B) shape in their study, which is almost similar to our results. However, Garcia et al[11].

have not classified the irregular shape further into irregular (A) and irregular (B). The sagittal diameter is generally larger than the transverse diameter, which was also observed in our study. In the present study,the anteroposterior and transverse diameter of FM in dry skull 33.76+ 2.1mm and 28.09+1.9mm & in CT scans 35.96+3.7mm and 30.38+3.5, which were consistent with the findings of Sampada PK etal[17].Catalia – Herrera[18] reported 35mm for the sagittal and 30.5 mm for the transverse diameters. Similar finding in CT scan reported in aseries Gruber et al[19] in 2009, Uthman, ATet al[20] In males themean area was greater (828.92±113.25 mm2) than in females (754.46±107.69 mm2). The FMI in dry skull 84.65+ 6.3 mm, and CT image in male 85.48+ 9.1mm and 83.26 + 9.0 mm. Kanodia G et al[21] evaluated the dimensions of FM in the dry skull as well as in living by CT scan, they reported AP diameter as 34.1±2.9 mm and transverse diameter as 27.5+2.5 mm in the dry skull while there was no significant difference, but AP diameter of the dry skull was larger than CT scan group. Results of this study provide a baseline useful data that enables surgeons to perform effective and reliable surgery in FM and in mastoid region[22] with maximum safety. A large foramen magnum usually results from chronic increased intracranial pressure or from direct effects of an expanding process within the foramen magnum (syringomyelia, Arnold-Chiari malformation). Asymmetry of the foramen magnum occurs with craniovertebral anomalies or premature synostosis of one or more of the occipital synchondroses. A keyhole shaped foramen magnum has been described in the hydrocephalus syndrome. Achondroplasia is the most common syndrome with a small foramen magnum, but other skeletal dysplasia's and disorders associated with sclerosis of the skull can also lead to a small foramen magnum.

Conclusion

The for amenmagnumisan importantl and mark of the base of the skull and is of particular interest to many fields of medicine. specific neuro anatomical structures and their lesions in foramen magnum, require particularly microsurgical intervention, choosing and establishing the most suitable surgical techniques need for accurate planning mainly based on the for amenmagnum morphometry to refrain from any neurological injury.

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Original Article

Indian Journal of Anatomy
Volume 11 Number 1, January – March 2022
DOI: http://dx.doi.org/10.21088/ija.2320.0022.11122.2

A Cadaveric Study of Variant Morphology of Gall Bladder and its Clinical Significance

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How to cite this article:

Sharad Kumar Pralhad Sawant, Shaheen Rizvi/A Cadaveric Study of Variant Morphology of Gall Bladder and its Clinical Significance/Indian J Anat. 2022;11(1):15-22.

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Received on: 08.03.2022

Accepted on: 09.04.2022

Abstract

Introduction: As gall bladder is often a common site of open and laparoscopic procedures, the aim of the study was to note the different congenital anomalies of Gall bladder in the adult cadavers which can provide relevant information to the surgeons and radiologists performing diagnostic and therapeutic interventions at this region. The embryological basis and clinical implications of variations are discussed.

Materials and Methods: Study was carried out on 75 gall bladders of formalin fixed cadavers in department of Anatomy at K.J. Somaiya Medical College, Sion, Mumbai. The studies were carried out in the period from July 2019 to August 2021. Following parameters were noted: 1) shape 2) external morphology 3) dimensions of gall bladder which included measurement of length and breadth. Transverse diameter at the level of body of gall bladder and length from the tip of fundus to the neck of gall bladder.

Observation and Discussion: In 48 specimens, gall bladder was pear shaped. Other shapes observed were Cylindrical, Hourglass, Flask shaped and Irregular. In 1 specimen, the gall bladder was partially intrahepatic. A very prominent Hartmann's pouch was observed in 22 specimens. Length of Gall bladder ranged between 5.3 cms to 10.2 cms and transverse diameter ranged between 2.8 cms and 5 cms. Different positions of the fundus in relation to inferior border of liver were also noted.

Conclusion: Anatomical variations of Gall bladder become vital during surgical settings. Congenital anomalies and anatomical variations related to the gallbladder and extra hepatic biliary tree though not common but can be of clinical importance as failure to recognize them during operative procedures may lead to inadvertent complications. It is of greatest importance to laparoscopic surgeons during cholecystectomy to prevent alarming consequences as failure to recognise them can lead to iatrogenic injuries and increase morbidity and mortality. Every surgeon should assess for these anomalies before any operative procedures.

Keywords: Gall bladder, fundus, intrahepatic, surgeons, radiologists, laparoscopic cholecystectomy.

Introduction

Extrahepatic Biliary apparatus comprises of gall bladder, cystic duct, hepatic ducts and CBD. As variations are so commonly encountered, it has led some eminent workers to mention that there is no normal anatomy of extra hepatic biliary tract, and the onus is on the surgeon to recognize the variations when present.[1] Gall bladder being a reservoir for bile is commonly pear shaped having a capacity of 30-50ml and is palpated in the Right hypochondrium. Extending from near the right end of the porta hepatis to the inferior hepatic border and being connected to the common bile duct by the cystic duct it is described as having a fundus, body and neck. The fundus, a blind ending diverticulum lies at the lateral end of the body and usually projects below the inferior border of the liver to a variable length. Its body is present in a fossa in the right hepatic lobe's inferior surface. Its upper surface is attached to the liver by connective tissue, elsewhere it is completely covered by peritoneum continuous from hepatic surface. It typically lies in close proximity to the duodenum, pylorus, and hepatic flexure of the right colon and right kidney. The body tapers towards the neck, which lies very close to the porta hepatis. The junction of the body and neck is sometimes straight, more often angular. The neck may show a pouch like dilatation called Hartmann's pouch towards the right. Its identification is useful in defining biliary anatomy when performing a cholecystectomy. The neck turns sharply downwards as it becomes continuous with the cystic duct and through the cystic duct drains into the right side of common hepatic duct. The mucus membrane of cystic duct is raised up into spiral folds comprising 5 to 10 irregular turns which are believed to serve the purpose of keeping the duct open so that bile can pass through it, both in and out of the gall bladder.[2] The gall bladder measures between 7-10 cm in length and maximum breadth is 3 cm. Variations in shape and size are not uncommon and are often debated by abdominal surgeons. Variations have been observed in the arrangements of ducts and even in the position of the gall bladder.[3] As gall bladder is often a common site of open and laparoscopic procedures, this study was done to observe the different congenital anomalies in the adult cadavers.

The present study aims to study the dimensions, variations of shape, external morphology and position of gall bladder which can provide the relevant information to the surgeons and radiologist performing diagnostic and therapeutic interventions at this region.

Material and Methods

The study was conducted on 75 gall bladders obtained from formalin fixed cadavers used for undergraduate students during a period of 2 years in the department of Anatomy of K. J. Somaiya Medical College, Sion, Mumbai. Ethical clearance was taken from institutional ethical committee prior to commencement of the study. The gall bladder was carefully dissected and cleaned to observe the variations in shape, its external morphology and position. Photographs were taken for proper documentation.

Following parameters were noted: 1) shape 2) external morphology 3) dimensions of gall bladder which included measurement of length and breadth. Transverse diameter at the level of body of gall bladder and length from the tip of fundus to the neck of gall bladder were measured with the help of sliding vernier callipers.

Results

Specimens were examined in situ by the naked eye and then removed and measured. According to shape gall bladder were classified as Pear shaped, Cylindrical, irregular, Hourglass shaped and Flask shaped. An intrahepatic gall bladder was also observed. Different shapes and external morphology of the gall bladder observed are summarized in Table 1.

Table 1: Showing different shapes of gall bladder

	Number	Percentage
Shape		
Pear shaped	48	64.1
Cylindrical	9	12
Hourglass shaped	4	5.4
Flask shaped	11	14.6
Irregular	2	2.6
Intrahepatic	1	1.3
External Morphology		
Folded fundus	5	6.7
Folded neck	12	16
Hartman's pouch	22	29.3
Position of Fundus		
Inframarginal Fundus	49	65.3
Marginal Fundus	14	18.6
Supramarginal Fundus	12	16.1

Length of Gall bladder ranged between 5.3 cms which was the minimum length to 10.2 cms which was the maximum length observed. Average length was 7.75 cms.

Maximum transverse diameter of gallbladder at the level of body of gall bladder ranged between 2.8 cms which was the shortest transverse diameter and 5 cms which was the largest. Mean diameter was 3.9 cm.

Length of fundus below inferior margin in inframarginal type of fundus ranged between 0.7 to 2.8 cm.

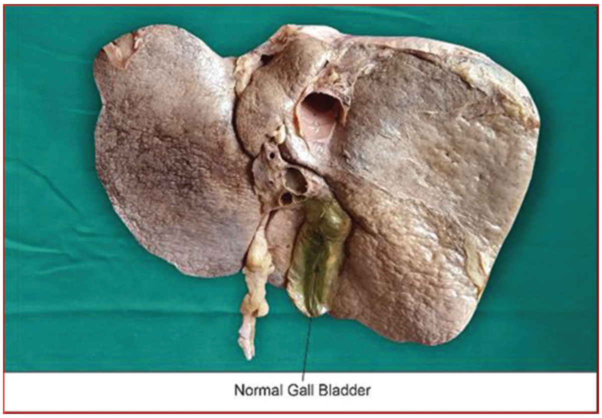

Fig. 1: Showing photographic presentation of Normal Gall Bladder.

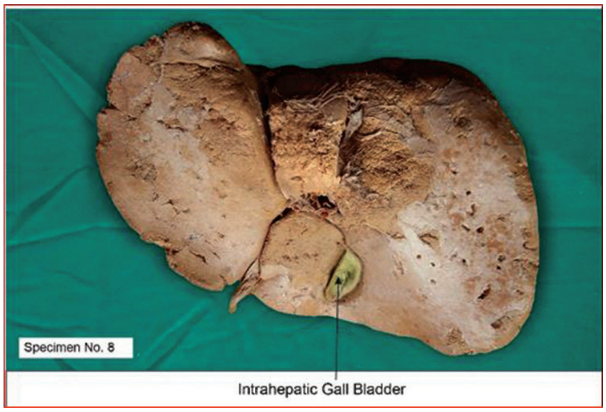

Fig. 2: Showing photographic presentation of Intrahepatic Gall Bladder.

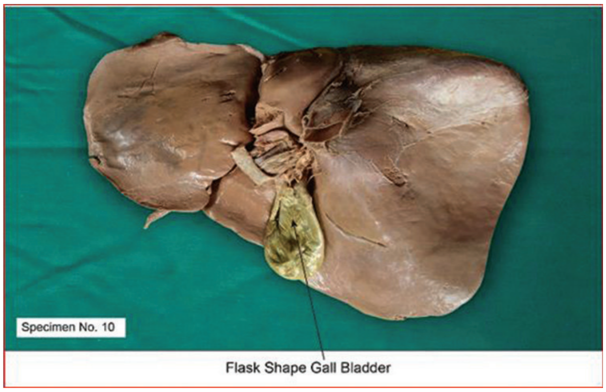

Fig. 3: Showing photographic presentation of Flask Shape Gall Bladder.

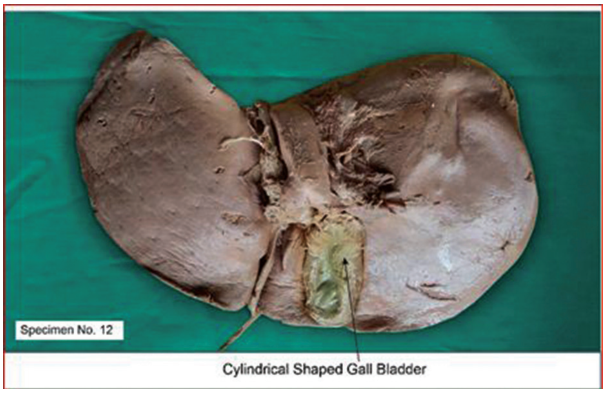

Fig. 4: Showing photographic presentation of Cylindrical Shaped Gall Bladder.

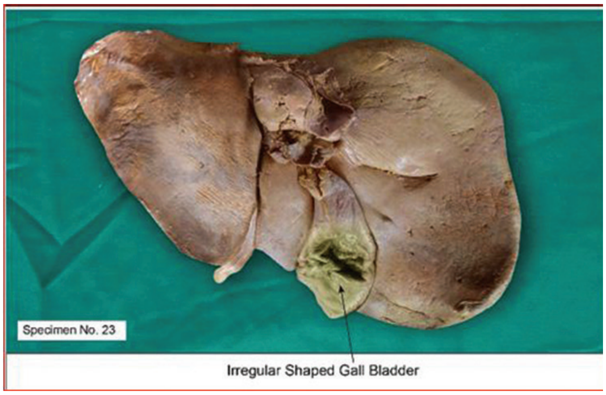

Fig. 5: Showing photographic presentation of Irregular Shaped Gall Bladder.

Fig. 6: Showing photographic presentation of Hour Glass Shaped Gall Bladder.

Fig. 7: Showing photographic presentation of Pear Shaped Gall Bladder.

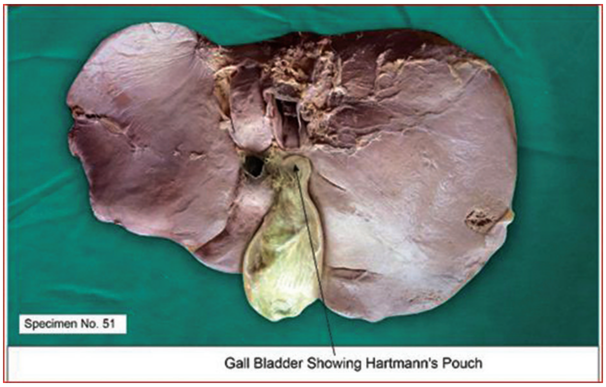

Fig. 8: Showing photographic presentation of Gall Bladder Showing Hartmann's Pouch.

Fig. 9: Showing photographic presentation of Gall Bladder Showing Folding of Neck.

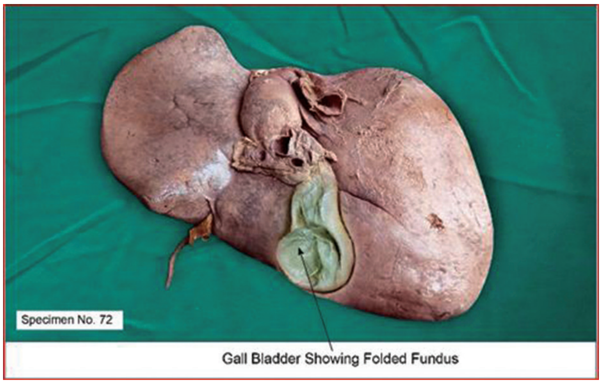

Fig. 10: Showing photographic presentation of Gall Bladder Showing Folded Fundus.

Fig. 11: Showing photographic presentation of Supra Marginal Gall Bladder.

Fig. 12: Showing photographic presentation of Infra Marginal Gall Bladder.

Discussion

Phrygian Cap or folded fundus is a triangular deformity where the fundus is folded on the body. It is of not pathological but sometimes is wrongly interpreted for layer of stones or hyperplastic cholecystosis.[4] According to Hollinshead, the gall bladder is relatively constant in its development and the Phrygian cap, could be due to a disproportion between the size of the gall bladder and that of the gallbladder bed, but without any pathological significance.[5] Bartel (1916) was the first who reported 43 cases of folded fundus at autopsy.[6] Later Boyden (1935) reported it in 7.5% of the 80 autopsy specimens.[7] The folded fundus was reported in 3-7.5% of GB by Lichtenstein & Nicosia.[8] Sreekanth et al studied 100 gall bladder specimens in 2016, and observed folded fundus in 2%, folded neck in 4% and both folded fundus and neck in 2%. Mishra et al observed 2 specimens of folded neck and 4 specimens of folded fundus in their study of 50 gall bladder specimens.[9] In the present study, the folded fundus of the gall bladder was seen in 5 (6.7%) specimens and folded neck in 12 (16%) specimens. The gallbladder varies greatly in size and shape and occasionally it becomes difficult to distinguish between various parts. There may be a contrast in the size of gall bladder in some physiological states and even in some diseases. It may increase in size (cholecystomegaly) due to obstruction of cystic duct or common bile duct, after vagotomy and in sickle cell disease. Increase in size has also been observed in diabetes, pregnancy and obesity. A very small gall bladder may be found in cystic fibrosis.[10] In present study the length of the gall bladder ranged between 5.3 to 10.2cms and was similar to the findings of Jaba Rajguru et al (2012), Rajendra R et al (2015) and J desai, et al (2015).[11,12,13] The breadth of the gall bladder in the present study was in the range of 2.8 to 5 cms and was similar to the findings of Chari & Shah (2008) Jaba Rajguru et al (2012), Prakash AV et al (2013), Rajendra R, et al (2015) and J desai, et al (2015).[14,15]

Pear shape is the most common shape of gall bladder observed by almost all authors during literature study followed by flask shape. Other shapes observed in the range of 2 - 6% by most authors have been cylindrical, Irregular and hourglass shape.[16,17,18] Hourglass gallbladder is a constriction at the junction of middle and lower third of gallbladder, which divides the gallbladder into a wider upper zone and a smaller lower portion. Courvoisier (1890) reported the first case of hourglass gallbladder and considered it to be a cicatrical contraction secondary to inflammation.[19] In the present study, hour glass gallbladder is seen in 4 specimens.

Some authors have observed shapes like elliptical.[20], bilobed[17] and retort shape[11] which were not observed in our study.

The different measurements and shapes of gall bladder reported by different authors have been summarized in Table 2.

Table 2 Showing measurements of gall bladder and shapes as reported by different authors

Author	No. of specimens	Length (cms)	Breadth (cms)	Shape
Rajguru J et al. (2012)	60	12-May	2.5 - 5	Pear (85%), flask (5%), cylindrical (3.33%), Irregular (1.67%), hourglass (3.33%), Retort (1.67%)
Sah et al (2013)	30	3.9 – 9.0	0.7- 5.2	Pear (60%), Flask (26.7%), Tubal (6.7%), Hourglass (6.7%).
Rajendra et al (2015)	78	11-Apr	2.5 - 5	Pear (53.2%), cylindrical (11.4%), hourglass (6.3%) oval (11.4%) others (16.5%).
J desai, et al (2015)	50	4.5 -11	2.8 - 5	Pear (84%), cylindrical (10%), hourglass (2%), retort (4%)
Nadeem (2016)	70	4.5 -11.6	2.7 - 5.2	Pear (82.85%), flask (2.86%), Cylindrical (2.86%), irregular (1.43%), Bilobed (1.43%), others (7.14%)
Tiwari (2018)	50	10-May	2.4 - 4.7	Pear (52%), flask (28%), cylindrical (12%), Irregular (4%) hourglass (4%)
Present study (2021)	75	5.3 - 10.2	2.8 - 5	Pear (64%), flask (14.6%), cylindrical (12%), Irregular (2.6%) hourglass (5.3%)

Hartmann's pouch is a widening at the lateral end of the neck of gall bladder which is considered a contrast finding by most authors like Hollinshead (1983)[5], McGregor (1986)[4], Keith Moore (2006)[21] and Standring (2008).[2] It is of two types namely congenital and acquired type. In congenital type all the three layers of gall bladder wall are present, whereas the acquired variety is a result of any disease process and has little or no smooth muscle in its wall. It is often associated with cholelithiasis and carcinoma of the gall bladder. Gall stones can get impacted here sometimes causing a rare complication called Mirizz's syndrome due to formation of Mucocoele which can compress the common hepatic duct or bile duct. The calot's triangle and cystic duct may not be discernible during surgeries due to a large Hartmann's pouch. Hence the existence of Hartmann's pouch should be ascertained preoperatively before any surgery to prevent intra operative and post operative complications.[23] Futura and Kinfu (2001)[22] observed a higher prevalence of Hartman's pouch in females than males. Sanjay Sah (2018)[16] observed Hartmann's pouch in 40% specimens.

Nadeem in his study observed Hartmann's pouch in 7.14% specimens[17] and Sreelekha et al[24] in 6.77% specimens. In the present study Hartmann's pouch is present in 22 (29.3%) of the specimens.

Intrahepatic gallbladder can be partial or complete, when the gall bladder projects out from the liver partly it is of partial type and if completely embedded within the liver parenchyma it is of complete type. Congenital arrest in the movement of gall bladder in intrauterine life from the intrahepatic position to its normal position is responsible for this anomaly. These gall bladders are more susceptible to cholelithiasis due to incomplete emptying of the gall bladder produced by stasis. Surgeries on such gall bladders are challenging and can cause complications.[25]

The fundus extending beyond the inferior margin is critical for surgeons during cholecystectomy. Lurje A et al., in 1937 studied 194 cadavers and was the first to classify the relation of fundus to the edge of the liver into supra marginal, marginal and infra marginal. He reported 33% to be supramarginal, 13.9% to be marginal, and 53.1% to be inframarginal type.[26] Rajguru J et al (2012)[11], in his study of 100 specimens reported 8% to be supramarginal, 5% to be marginal, and 87% to be inframarginal type. Sreelekha et al (2019)[24] in her study on 58 specimens reported 34.5% to be supramarginal, 22.4% to be marginal, and 43.1% to be inframarginal type. In the present study supramarginal was reported in 16.1% specimens, marginal in 18.6% and inframarginal in 65.3%. Their extension beyond the inferior margin as reported by Lurje et al ranged between 0.5 to 4 cm.[26] Other authors have reported the range to be between 0.4 and 2.5 cm (Anjankar) and (Sreekanth C) et al[27,9] and between 1.8 to 4 cm (Sreelekha).[24] In the present study, the length varied between 0.7 to 2.8 cm which was similar to the observations of Anjankar.

Embryological Basis

Between the third to fourth week of development around the 18th day, hepatic diverticulum of foregut develops and projects ventrally & cranially into surrounding mesoderm of septum transversum. By 25th somite stage the hepatic diverticulum enlarges and gets divided into a large cranial portion pars hepatica & a small caudal portion pars cystica, which give rise to liver, gall bladder and biliary duct system. The pars cystica gives rise to gall bladder & cystic duct. The connection between the hepatic diverticulum and the foregut narrows, forming the bile duct. An arrest during this normal development or any deviation from the normal can result in variations in the formation of gall bladder and biliary system.[28]

Clinical Considerations

Congenital biliary duct malformations can appear at any time and may catch the surgeon unaware during laparoscopic surgery, and hence should always be kept in mind in the presence of confused or poorly defined anatomy during preoperative imaging. In such cases an intraoperative cholangiography may sometimes become necessary in order to avert an accidental duct clipping or injury or bleeding resulting in future strictures.[29] Dharmendra kumar et al in his study concluded that congenital anomalies and anatomical variations of extra-hepatic biliary tree though are not common but can be of clinical importance.[30] The gall bladder and biliary tract are closely related to adjacent organs. Hence their anatomical variations become vital during surgical settings. Failure to recognize them during operative procedures may lead to inadvertent complications. Laparoscopic cholecystectomy for gallstone disease reveals a much clearer anatomy of the biliary tree as compared to open surgery and the extra-hepatic biliary system can be evaluated for its anatomical variations and congenital anomalies.[31] The surgeons should also be familiar with arterial anomalies during laparoscopic cholecystectomy to avoid iatrogenic injuries. A tortuous course of common hepatic artery or right hepatic artery running in front of the origin of cystic duct known as "Cater pillar turn or Moynihan's hump" are most vulnerable.[32] The short cystic artery arising from the looped right hepatic artery is also susceptible to trauma during cholecystectomy causing bleeding and leakage of bile. An awareness of extra hepatic biliary ductal and arterial anatomic relationships can avert a number of complications of laparoscopic cholecystectomy.[33] In patients with intrahepatic gall bladder, cholecystitis is difficult to diagnose as peritoneal inflammation is absent. In such patients cholelithiasis is treated with a cholecystostomy rather than a cholecystectomy.[34] Information regarding location of fundus of gall bladder and its peritoneal covering is important for surgeons as it is sometimes associated with torsion of gall bladder.[35]

Conclusion

Congenital anomalies and anatomical variations related to the gallbladder and extra hepatic biliary tree though are not common but can be of clinical importance. They are important for radiological studies, investigative procedures, surgical interventions and their clinical outcomes. It is of greatest importance to laparoscopic surgeons during cholecystectomy to prevent alarming consequences as failure to recognise them can lead to iatrogenic injuries and increase morbidity and mortality. Every surgeon should assess for these anomalies before any operative procedures. It is the duty of the anatomist to bring awareness about these anatomical variations.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

SPS drafted the manuscript, performed the literature review & SR assisted with writing the paper.

Acknowledgement

Authors are thankful to Dean Dr. Varsha Phadke Madam and teaching and non-teaching staff for their support and encouragement. Authors acknowledge the immense help received from the scholars whose articles are cited and included in references of this manuscript. The authors are also grateful to authors / editors / publishers of all those articles, journals and books from where the literature for this article has been reviewed and discussed.

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Review Article

Indian Journal of Anatomy
Volume 11 Number 1, January – March 2022
DOI: http://dx.doi.org/10.21088/ija.2320.0022.111-22.3

E- Learning: A New Method to Teach Anatomy

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How to cite this article:
Sharad kumar Pralhad Sawant, Shaheen Rizvi/E- Learning: A New Method to Teach Anatomy/Indian J Anat. 2022;11(1):23-26.

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Received on: 08.03.2022

Accepted on: 09.04.2022

Abstract

Today teaching and learning in medical curriculum have moved out beyond textbooks and classrooms into the digital world. According to Ellaway & Masters, "e-learning encompasses a pedagogical approach that typically aspires to be flexible, engaging and learner–centered; one that encourages interaction (staff–staff, staff–student, student–student), and collaboration and communication, often asynchronously (though not exclusively so)." E-learning should blend with, and complement didactic teaching learning methods. A blended learning environment compared with a traditional lecture setting is more fulfilling and gives a constant satisfaction as compared to traditional teaching methods. Medical students coming from varied backgrounds, find the study of Anatomy difficult, as there are a lot of new concepts and terminologies to be understood and memorized. Along with it the vast curriculum and the reduced duration of the course adds to their misery. Available resources like textbooks, workbooks or atlases do not allow accessing all anatomical structures or clinical inputs as well as the latest updates. With advances in technology, electronic learning can solve the insufficiencies experienced by such students and boost anatomy learning. The article traces an E-learning environment through various websites in the study of Anatomy and its advantages over traditional teaching methods.

Keywords: Teaching and Learning, Medical Curriculum, Textbooks, Classrooms, Digital World, E-learning, Traditional Lecture, Websites.

Introduction

The settings in which students of health care absorb information these days are much different than what it was even a decade ago. Back then the internet was not so predominantly utilised in medical education. But today more and more medical schools are employing E-learning platforms. Today teaching and learning have moved out beyond textbooks and classrooms into the digital world. According to Ellaway & Masters, "e-learning encompasses a pedagogical approach that typically aspires to be flexible, engaging and learner–centered; one that encourages interaction (staff–staff, staff–student, student–student), and collaboration and communication, often asynchronously (though not exclusively so)." The common denominator is the use of technology and electronic devices to enhance learning. The foundation for gaining proficiency and absorbing any skill is through communication and repetition.[1] Traditional learning methods in medical education involve learners, educators and also patients; hence repetition becomes difficult to avoid psychological anxiety to the patient. On the other hand E-learning comprises technology and simulation, which can be reiterated any time, to improve learning.

Learning can be didactive, active or interactive. When the learning material is passed on to the student passively, it is 'didactic', when the student has control over the learning process, it is 'active'. In the Interactive type, the learning content evolves during the study due to teacher student interaction; and instructors act as facilitators and assessors of competency.[2] E-learning lets students evolve beyond the course expectations, and inspires discovery and learning ahead of the curriculum.[3] E learning has also been approved by the UN and WHO as a useful tool in medical education.

E-learning should blend with, and complement didactic teaching learning methods. A blended learning environment compared with a traditional lecture setting is more fulfilling as compared to traditional teaching methods. Medical educators should employ novel and innovative e-learning methods in order to improve student concentration.[4] An E-learning environment facilitates the use of varied technologies which comprise multimedia applications through Web-based learning, Online learning, Distributed learning, Computer-assisted instruction, or Internet based learning. E learning also includes learning via links with other learners through e-mail, video-conferencing, and chat. This enables group discussions which are beneficial to learning.[5]

Discussion

Medical students coming from varied backgrounds, find the study of Anatomy difficult, as there are a lot of new concepts and terminologies to be understood and memorized. Along with it the vast curriculum and the reduced duration of the course adds to their misery. Available resources like textbooks, workbooks or atlases do not allow accessing all anatomical structures or clinical inputs as well as the latest updates. With advances in technology, electronic learning can solve the insufficiencies experienced by such students and boost anatomy learning.[6]

In the present study we examined some websites which impart medical education. 'TeachMe Anatomy' is one of the most comprehensive sites. It works like an encyclopaedia for medical students. It offers the significance of unfamiliar terms in an instant, so that students don't leave the site. Each article gets an aggregated score. It shows how many revisions a post has and how up-to-date it is with the current science. This is something books can't do! It has a classy design. Each page follows a similar formatting style; an introduction to the topic, a description of the structure anatomically with relevant and clear images, and finally a clinical relevance section that draws it back to medicine. The sidebar also features a few quick MCQ-style questions alongside references to related clinical research. The paid-for premium tier gives access to a larger question bank as well as a 3D model.[7]

'Innerbody Research' is a very simple medical education site which is extremely easy to use. In the anatomy section, you can just select a system and start reading. The pages cover just about everything including specific diseases relating to that system. A great feature of the site is a navigation point on each page. You can interactively click around the part of the body relevant to each category e.g. skeletal section and you'll be taken to the detailed information.[8]

'Get Body Smart' has one of the best visuals, highly recommended quizzes and excellent tutorial sites, although unlike other sites it is much less information-dense. The highlight of this site is to show rather than tell, it uses animations to teach rather than detailed text descriptions. A navigation bar takes you to an anatomical system. From there, you touch upon a short tutorial and start solving the questions related to the images. From here you head right to the quizzes to consolidate your learning.[9]

'Anatomy Zone' is a site started by two British doctors that displays 3D videos. An interactive site in which each video comes with a scannable text allowing a user to watch and take notes directly, using the information from the site. The videos are delivered in a lecture-style format by the doctors themselves. 'UMich Anatomy' is the website made by Anatomy Department of University of Michigan Medical School. They have put their whole syllabus online free for public use. It is best for gross anatomy. Each part is structured exactly as the real-life class would progress. It also includes downloadable supplementary materials like lab worksheets and lecture slides too. Each of the available courses is divided into blocks and anatomy is studied according to physiological importance. It binds all together so that a student knows why what they are learning is important. 'www.instantanatomy.net' – Is a website for anatomical education with numerous applications for training in anatomy.[10]

There are innumerable such sites which also include BioDigital - 3-D interactive models, BodyMaps - Allows users to explore the human body in 3-D, Muscle Atlas, The Visible Human Project - Complete 3D representations of male and female human bodies[11], Workshop Anatomy for the Internet - A collection of detailed image of human anatomical structures. Other computer projects available for students include 'Virtual Reality Brain Project' - a project consisting of images of various cross-sections of the human brain with interactive use. It allows altering the size of these cross-sections, their rotation, and selection of a specific region for observing its structure.[12]

Using various cross-sectional images of organs at different levels helps towards a better understanding and detailed knowledge of a number of anatomical structures with their connections, interconnections and spatial organization which are otherwise difficult to comprehend by students.[13] This is particularly important in the study of neuroanatomy and study of pleura and peritoneum and areas of skull which cannot be easily visualised. These can also be aptly visualised in computer programs using 3D technology.[14] Images of actual cadavers can further assist learning process. If a computer program follows criteria like free access, easy to use, zero downloading and clear explanations it is an excellent choice for medical students especially those who are hard-pressed for time. This type of proficiency will not be provided by textbooks or atlases and sometimes not even by physical assessment of the concerned structure. It also ends up being less costly than buying or preparing an anatomical model for study.[15] In view of the changing and the more clinically oriented curriculum, anatomical websites can now show clinical cases with an explanation of the disease, patient history, physical examination and diagnostic and imaging tests performed[16]. If the patient is deceased the autopsy results can be interpreted on the basis of dissection. This will go a long way in better understanding the clinical topics for a student of anatomy. The usage of cadavers and real specimens aids in longer lasting memory and acquisition of clinical diagnostic skills which is essential for clinical diagnosis of patients in later years.[17]

Books can at times be difficult to access maybe due to its cost, or being heavy to carry around or may just be out of stock; sometimes for conducting research one may have to spend hours in the library looking for references. All these are provided in the virtual space at a lesser cost and time. Bearing in mind the consistent scientific progress even in subjects like anatomy and histology, newer editions of books after updation, are usually done once every few years. Hence the use of trustworthy web sites in this field is essential.[18] A number of websites also offer continuous medical education which is a mandatory requirement for health science graduates including Anatomy. Another very important use of anatomical websites includes interactive videos depicting histology slide preparation, with the latest machinery and the latest techniques. It also includes details of the working of microscopes and slide visualisation, these are at times challenging to absorb from textbooks and are inadequately taught in many places.[19] Thus these technologies can be utilised in a cost effective manner for the continual training and also for keeping abreast of knowledge on anatomical sciences for both learners and educators.

E-learning technology can be used for growth of all 3 learning domains viz., cognitive, psychomotor and affective. In the cognitive domain virtual resources like audio-video clips, podcasts, animations, and web-links for self-directed learning can be provided to students. Psychomotor skills can be enhanced by technology, at least up to the 'knows how' level by Audio-visual demonstration of procedures, diagnostics and interventions. In the affective domain, videos portraying good and bad communication-skills, counselling sessions etc can be used to stimulate learning.[20,21]

Conclusion

There are several distinctive advantages of E-learning over traditional didactic teaching. E-learning has been established to be not only as student friendly as traditional didactic teaching but also incorporates self-directed learning. Learners can learn in a comfortable learning environment, they can learn at their convenience, there is flexibility over contents and over the pace of learning. As a result there is greater ability to concentrate. At the same time the learners are exposed to updated material with latest evidence-based content. Educators can also automate marking, digitally issue tests, track student progress and evaluate competencies accurately and effectively through online assessments.

Competing interests

The authors declare that they have no competing interests.

Authors' Contributions

SPS drafted the manuscript, performed the literature review & SR assisted with writing the paper.

Acknowledgement

Authors are thankful to Dean Dr. Varsha Phadke Madam and teaching and non-teaching staff for their support and encouragement. Authors acknowledge the immense help received from the scholars whose articles are cited and included in references of this manuscript. The authors are also grateful to authors / editors / publishers of all those articles, journals and books from where the literature for this article has been reviewed and discussed.

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

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