

Assessment of the Performance of ChatGPT in Human Anatomy of First Professional MBBS Competency Based Medical Education (CBME) Undergraduate Curriculum

Mahima Sophia Manavalan¹, Indumathi Sundaramurthi², Krishna Mohan Surapaneni^{3,4}

How to cite this article:

Mahima Sophia Manavalan, Indumathi Sundaramurthi, Krishna Mohan Surapaneni. Assessment of the Performance of ChatGPT in Human Anatomy of First Professional MBBS Competency Based Medical Education (CBME) undergraduate curriculum. *Ind J Anat.* 2023;12(4):17-26.

Abstract

Background: ChatGPT developed by OpenAI is a state-of-the art innovation and is leading the field of technology with its massive ability to generate any of information in human like conversational manner. The utility of this Artificial Intelligence (AI) based model is being tested in various domains and usability in education is certainly a topic of sensation. ChatGPT has been successful in clearing competitive medical exams and could possibly emerge as an ideal tool for advancing teaching learning methodologies in medical education once the accuracy in its content can be validated and affirmed.

Objective: In this study, we aim to evaluate the performance of ChatGPT Human Anatomy of first MBBS professional

Methods: This assessment was carried out using the university examination question paper of Human Anatomy paper 1. The question paper comprised of 2 essay, 10 short notes and 20 Multiple Choice Questions (MCQ). All the questions were entered on ChatGPT one after the other and the responses generated were saved and sent to our evaluation team in the department of anatomy.

Result: ChatGPT has provided brief explanations for all the questions. For the Multiple Choice Questions (MCQ), the option along with reasons were given. Out of 20, six answers were incorrect. Although ChatGPT has provided relevant answers for all the questions, there was no diagrammatic representation provided. The feedback from the faculties suggested that there were few incorrect explanations and content should be more elaborate with relations of the structures being explained in detail. Overall ChatGPT has passed the test with total of 56%.

Conclusion: From the results of our study, we emphasize that ChatGPT has the potential to be used as an effective learning tool with its humanoid conversation that can create a personalised learning experience. However, the accuracy and dependability of such tools is a cause of concern. Also, due to lack of its ability to produce pictorial illustration, learning and understanding of subjects like anatomy may not be very efficient.

Keywords: ChatGPT; Human anatomy; Medical education; Artificial intelligence.

Author's Affiliation: ¹Department of Anatomy, ²Department of Biochemistry, ³Vice principal & Professor, Department of Biochemistry, ⁴Department of Medical Education, Panimalar Medical College Hospital & Research Institute, Varadharajapuram, Poonamallee, Chennai 600123, Tamil Nadu, India.

Corresponding Author: Krishna Mohan Surapaneni, Vice principal & Professor, Departments of Biochemistry, Medical Education, Panimalar Medical College Hospital & Research Institute, Varadharajapuram, Poonamallee, Chennai-600 123, Tamil Nadu, India.

E-mail: krishnamohan.surapaneni@gmail.com

Received on: 14.02.2024

Accepted on: 30.03.2024

INTRODUCTION

ChatGPT is an enormous artificial intelligence (AI) based language model that has set the stage on fire ever since its release on 30th November, 2022.¹ The language model for ChatGPT (Generative Pretrained Transformer) was trained using a method called Reinforcement Learning from Human Feedback, making it highly conversational.²



This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0.

Recently, ChatGPT has created a sensation among educators worldwide after it cleared the United States Medical Licensing Examination (USMLE).³ Owing to its rapidity and ability to generate large amount of data, concerns abound on how ChatGPT will alter education.⁴

ChatGPT has several advantages in enhancing teaching and learning methods, such as encouraging individualised and interactive learning and formative evaluation techniques.⁵ In context to medical education, AI has the potential to completely transform the current educational practices and make a notable impact on different fields of medical sciences. However, these AI tools should be used with caution and checked for reliability of information.⁶ Several studies have been conducted to assess the performance of ChatGPT in various medical domains, medical examinations and clinical management.⁷ In regards to this, we intend to evaluate the knowledge of ChatGPT in Human Anatomy and the ability of ChatGPT to crack medical exams. This study would provide a comprehension on the accuracy and dependability of content generated by ChatGPT so that its utility as a fruitful learning modality for medical students in the coming years can be substantiated.

METHODS

Our evaluation was performed using the final university examination question papers of Phase I MBBS that was conducted in the month of January 2023. Human Anatomy in undergraduate medical curriculum has been divided into two parts. With Upper Limb, Lower Limb, Abdomen & Pelvis, Embryology & Histology, Osteology and General Anatomy in Paper I and Thorax, Head & Neck, Neuroanatomy, Genetics, Embryology and Histology in Paper II. We followed the exact

pattern of University Examination with 2 essays for 15 marks each, 10 short notes of 5 marks each and 20 Multiple Choice Questions (MCQ) counting to 100. For this evaluation we used the theory and Multiple Choice Questions (MCQ) of Paper I. All the questions were typed on ChatGPT separately and answers were generated. The same methods were followed to obtain answers for Multiple Choice Questions (MCQ). We did not mention any additional commands to the AI tool in terms of word count or inclusion of specific contents. All the responses were saved and evaluated manually by the faculties of Department of Anatomy.

RESULTS

ChatGPT has provided brief explanation for all the questions. The essays were direct questions and not case based. But it has multiple subdivisions for which ChatGPT has generated responses in short and concise manner. We did not find any difference in the wordcount or amount of information generated between essays and short notes. However, a main drawback is the ChatGPT could not generate illustrations for any of the questions. As human anatomy deals with the study of structures in human body, diagrams play an important role in understanding the structure and function of all organs. No diagrammatic representation is the major negative feedback that we have revised. Also, the faculties felt that more content should be added and relations should be explained more in detail. Marks were given as per the content generated by ChatGPT. With regards to Multiple Choice Questions (MCQ), ChatGPT generated the answers along with explanation for the same. Out of 20, ChatGPT has scored 14. Overall, the performance of ChatGPT in Human Anatomy was average. ChatGPT has managed to

Table 1: Evaluation Report – Theory

S. No.	Type of Question	Question	Maximum Marks	Allotted Marks	Remarks
1	Essay	Describe the boundaries and contents of Axilla. Write the origin, course, relations, termination and branches of the axillary artery in detail (Fig. 1).	15	7.5	<ul style="list-style-type: none"> No diagrams To be evaluated for an essay, this content is insufficient Relations should be mentioned in detail Branches of axillary artery should be mentioned in detail with diagrams

table cont...

		Describe the uterus in detail under the following headings: a) Position and parts b) Peritoneal and visceral relations c) Supports d) Microstructure e) Development f) Clinical Anatomy (Fig. 2)	15	6.5	<ul style="list-style-type: none"> No diagrams To be evaluated for an essay, this content is insufficient Relations and supports of uterus should be explained clearly with diagrams Position of uterus is not given
3	Short Note	Obturator nerve (Fig. 3)	5	3	<ul style="list-style-type: none"> No diagram Did not mention about the origin of obturator nerve Additional content about nerve should be provided
4	Short Note	Fascial spaces of hand (Fig. 4)	5	3	<ul style="list-style-type: none"> No diagrams Mid palmar and thenar spaces has to be explained in detail with extent, boundaries and communication Pulp spaces of fingers which is very important clinically is missing in the content
5	Short Note	Right supra-renal gland (Fig. 5)	5	3	<ul style="list-style-type: none"> No diagram External features and relations of adrenal gland are missing Venous drainage is missing
6	Short Note	Hamstring muscles (Fig. 6)	5	3.5	<ul style="list-style-type: none"> No diagrams Criteria for hamstring muscles is missing Short head of biceps femoris is not a hamstring muscle Origin and insertion should be more elaborate
7	Short Note	Neurulation (Fig. 7)	5	3.5	<ul style="list-style-type: none"> No diagram Content is good but should be more elaborate Anterior and posterior neuropore missing
8	Short Note	Inguinal canal (Fig. 8)	5	2.5	<ul style="list-style-type: none"> No diagram Content should be clear and elaborated more
9	Short Note	Histology of liver (Fig. 9)	5	2.5	<ul style="list-style-type: none"> No diagram Portal triad is missing Few other important points are missing
10	Short Note	Femoral triangle (Fig. 10)	5	2.5	<ul style="list-style-type: none"> No diagrams Content is more generalised Femoral she, femoral ring and femoral hernia not explained clearly
11	Short Note	Intra-capsular ligaments of knee joint (Fig. 11)	5	2	<ul style="list-style-type: none"> No diagrams Only cruciate ligaments explained Other intracapsular ligaments missing
12	Short Note	Erb's palsy (Fig. 12)	5	2	<ul style="list-style-type: none"> No diagrams Did not mention about Erb's point Content is more generalised
			80	41.5	

Table 2: Evaluation Report – Multiple Choice Questions

S. No.	Question	Answer Key	Answer generated by ChatGPT	Remarks
1	First carpometacarpal joint is a A) Pivot type of synovial joint B) Condylar type of synovial joint C) Saddle type of synovial joint D) Ellipsoid type of synovial joint	C	C	Correct
2	Structure which is not related to Calot's triangle is A) Hepatic duct B) Gastroduodenal artery C) Cystic artery D) Cystic duct	B	B	Correct

table cont...

3	Trochanteric anastomosis is formed by the union of all the following arteries except A) Descending branch of superior gluteal artery B) Ascending branch of medial circumflex artery C) Branch from inferior gluteal artery D) Transverse branch from lateral circumflex artery	D	D	Correct
4	Lymph capillaries are present in A) Cornea B) Dermis C) Inner ear D) Nervous tissue	B	B	Correct
5	The structures which do not pierce the clavipectoral fascia A) Thoraco-acromial vessels B) Medial pectoral nerve C) Cephalic vein D) Lateral pectoral nerve	B	D	Incorrect
6	Zona pellucida disappears at the end of A) 5th day of development B) 7th day after fertilization C) 3rd day after fertilization D) 9th day after fertilization	A	C	Incorrect
7	Sural nerve is a branch of A) Femoral nerve B) Sciatic nerve C) Common peroneal nerve D) Tibial nerve	D	D	Correct
8	Which of the following statements is not correct regarding the anatomical snuff box? A) Medially bound by extensor carpi radialis longus B) Laterally bound by abductor pollicis longus and extensor pollicis brevis C) Roof is crossed by superficial branch of radial nerve D) Content is radial artery	A	D	Incorrect
9	Stereocilia are found on the apical surface of the epithelium lining A) Testis B) Prostate C) Epididymis D) Seminal vesicle	C	A	Incorrect
10	Sustentaculum lienis is A) Phrenico-colic ligament B) Gastro-splenic ligament C) Phrenico-splenic ligament D) Lieno-renal ligament	A	B	Incorrect
11	Retraction of scapula is produced by A) Upper fibers of trapezius and levator scapula B) Middle fibers of trapezius and rhomboids C) Upper and lower fibers of trapezius and serratus anterior D) Lower fibers of trapezius and pectoralis minor	B	B	Correct
12	All of the following structures develop from septum transversum except A) Lesser omentum B) Falciform ligament C) Serous pericardium D) Central tendon of diaphragm	C	C	Correct
13	Content of adductor canal is A) Nerve to vastus medialis B) Nerve to vastus lateralis C) Nerve to vastus intermedius D) Nerve to rectus femoris	A	A	Correct
14	Left testicular vein terminates in to A) Inferior vena cava B) Inferior mesenteric vein C) Splenic vein D) Left renal vein	D	D	Correct

table cont...

15	Anal canal develops from A) Ectoderm and mesoderm B) Endoderm and ectoderm C) Mesoderm and endoderm D) Only from endoderm	B	B	Correct
16	All of the following statements are true about Peyer's patches except A) Aggregation of lymphatic follicles B) Help to maintain normal bacterial intestinal flora C) Found in mesenteric border of ileum D) Form a part of gut associated lymphatic tissue	C	B	Incorrect
17	The tarsal bone which does not have muscular attachment is A) Cuneiform bone B) Cuboid C) Navicular D) Talus	D	D	Correct
18	Muscle of deep perineal pouch is A) Ischiocavernosus B) Sphincter urethrae C) Bulbospongiosus D) Superficial transverse perinea	B	B	Correct
19	Gemellus inferior is supplied by A) Nerve to quadratus femoris B) Nerve to obturator internus C) Superior gluteal nerve D) Inferior gluteal nerve	A	A	Correct
20	Which part of the colon is more prone to volvulus? A) Ascending colon B) Transverse colon C) Descending colon D) Sigmoid colon	D	D	Correct

obtain a "Pass" in the subject with total of 56 marks out of 100. But it has not meet the expectations of faculties in terms of generating accurate answers being the most advanced conversational AI-based large language model. Table 1 and Table

2 represents the evaluation report of ChatGPT theory and MCQ questions of human anatomy. The pictorial evidence of the responses generated by ChatGPT are also represented in as Fig. (Figs. 1,2,3,4,5,6,7,8,9,10,11 & 12)

Describe the boundaries and contents of Axilla. Write the origin, course, relations, termination and branches of the axillary artery in detail.

Axilla, also known as the armpit, is a pyramidal space located between the upper thoracic wall and the upperlimb. The boundaries of the axilla are as follows:

- **Anteriorly:** Pectoralis major and minor muscles
- **Posteriorly:** Subscapularis, teres major, and latissimus dorsi muscles
- **Medially:** The serratus anterior muscle and the thoracic wall
- **Laterally:** The intertubercular groove of the humerus and the coracobrachialis muscle

The contents of the axilla include the axillary artery and vein, the brachial plexus, and lymphnodes.

The axillary artery is a continuation of the subclavian artery and begins at the lateral border of the first rib. It terminates at the inferior border of the teres major muscle, where it becomes the brachial artery. The axillary artery gives off several branches along its course, including:

1. **Superior thoracic artery:** the first branch of the axillary artery, which supplies the upper thoracic wall.
2. **Thoracoacromial artery:** This branch arises from the axillary artery at the level of the pectoralis major muscle and divides into four branches: deltoid, acromial, clavicular, and pectoral.
3. **Lateral thoracic artery:** This branch arises from the axillary artery at the level of the lower border of the subscapularis muscle and supplies the serratus anterior muscle and the lateral thoracic wall.
4. **Subscapular artery:** This is the largest branch of the axillary artery, which arises at the lower border of the subscapularis muscle and divides into the circumflex scapular and thoracodorsal arteries.
5. **Anterior and posterior circumflex humeral arteries:** The set of branches arise from the axillary artery near the surgical neck of the humerus and supply the shoulder joint and the muscles that move the humerus.

In terms of relations, the axillary artery is located posterior to the pectoralis minor muscle and anterior to the subscapularis muscle. It is crossed by the cords of the brachial plexus and accompanied by the axillary vein. The axillary lymph nodes are located along the course of the axillary vessels.

Overall, the axilla is an important region of the body that contains several vital structures and serves as a passage way for the upper limb's neurovascular bundle.

Fig. 1: Response generated by ChatGPT-1

2. Describe the uterus in detail under the following headings:

- a. Position and parts
- b. Peritoneal and visceral relations
- c. Supports
- d. Microstructure
- e. Development
- f. Clinical Anatomy.

a. Position and Parts:

The uterus is a pear-shaped muscular organ located in the pelvis between the urinary bladder and the rectum. It is divided into three parts: the fundus, the body, and the cervix. The fundus is the rounded upper part of the uterus, the body is the central part, and the cervix is the narrow lower part that protrudes into the vagina.

b. Peritoneal and Visceral relations:

The uterus is located within the pelvic cavity and is covered by a layer of peritoneum. The peritoneum covers the anterior and posterior surfaces of the uterus, but not the cervix. The bladder is located anterior to the uterus, while the rectum is posterior to the uterus. The broad ligament of the uterus attaches the uterus to the lateral pelvic walls.

c. Supports:

The uterus is supported by various ligaments, including the broad ligament, the round ligament, the uterosacral ligaments, and the cardinal ligaments. The ligaments help to maintain the position and stability of the uterus within the pelvic cavity.

d. Microstructure:

The uterus is composed of three layers: the endometrium, the myometrium, and the perimetrium. The endometrium is the innermost layer and is composed of glandular and stromal tissue. The myometrium is the middle layer and is composed of smooth muscle fibers that are responsible for the contraction of the uterus during labor. The perimetrium is the outermost layer and is composed of a serous membrane that covers the uterus.

e. Development:

The uterus develops from two Müllerian ducts, which fuse during embryonic development. The upper parts of the Müllerian ducts form the fallopian tubes, while the lower parts form the uterus, cervix, and upper part of the vagina.

f. Clinical Anatomy:

The uterus is an important organ in female reproductive health and can be affected by various conditions such as fibroids, endometriosis, and cancer. The position and size of the uterus can also impact fertility and pregnancy outcomes. In addition, the uterus is the target organ for various forms of contraception, such as intrauterine devices (IUDs) and hormonal contraceptives.

Fig. 2: Response generated by ChatGPT-2

1. Obturator nerve

The obturator nerve is a mixed nerve that arises from the anterior divisions of the second, third, and fourth lumbar spinal nerves. It courses through the pelvis and supplies the muscles of the medial thigh.

The obturator nerve enters the thigh by passing through the obturator canal, which is formed by the obturator foramen of the hipbone. Within the thigh, the obturator nerve divides into anterior and posterior branches.

The anterior branch of the obturator nerve supplies the adductor longus, adductor brevis, and gracilis muscles. The adductor magnus muscle is supplied by both the anterior and posterior branches of the obturator nerve.

The posterior branch of the obturator nerve supplies the obturator externus muscle and the adductor magnus muscle.

The obturator nerve also provides sensory innervation to the skin of the medial thigh. In terms of clinical significance, damage or injury to the obturator nerve can result in weakness or paralysis of the adductor muscles of the thigh, causing difficulty with walking and lower limb stability. This may occur due to trauma, surgery, or nerve compression. Damage to the obturator nerve may also result in sensory deficits in the medial thigh.

Fig. 3: Response generated by ChatGPT-3

2. Fascial spaces of hand

The fascial spaces of the hand are potential spaces between the fascial layers that surround the muscles, tendons, and bones of the hand. These spaces can provide pathways for infection to spread from one area to another and can have serious clinical implications if left untreated.

There are four main fascial spaces in the hand:

1. **The thenar space:** Located on the radial side of the palm, between the adductor pollicis muscle and the thenar muscles. Infections in this space can spread to the wrist and forearm.
2. **The mid palmar space:** Located in the center of the palm, between the palmar aponeurosis and the flexor tendons. Infections in this space can spread to the fingers and wrist.
3. **The hypothenar space:** Located on the ulnar side of the palm, between the abductor digiti minimi muscle and the hypothenar

fig. cont...

muscles. Infections in this space can spread to the wrist and forearm.

4. **The deep palmar space:** Located deep to the midpalmar space, between the interosseous muscles and the adductor pollicis muscle. Infections in this space can spread to the forearm and elbow.

In addition to the superficial spaces, there are also several smaller spaces and compartments in the hand that can become infected and cause serious complications. These include the dorsal subcutaneous space, the carpal tunnel, and the flexor tendon sheaths. Treatment of fascial space infections typically involves drainage of the affected area and antibiotic therapy. In severe cases, surgery may be necessary to remove infected tissue and prevent the spread of infection.

Fig. 4: Response generated by ChatGPT-4

3. Right supra-renal gland

The right supra-renal gland, also known as the right adrenal gland, is one of two triangular-shaped endocrine glands located on top of the kidneys. The right adrenal gland is smaller than the left adrenal gland and is shaped like a pyramid, with the base located superiorly and the apex pointing inferiorly.

The right adrenal gland is composed of two main parts: the outer cortex and the inner medulla. The cortex is responsible for producing and secreting steroid hormones, including cortisol, aldosterone, and androgens. The medulla is responsible for producing and secreting catecholamines, including adrenaline (epinephrine) and noradrenaline (norepinephrine). The right adrenal gland is supplied by several arteries, including the superior and middle suprarenal arteries, which are branches of the inferior phrenic artery, and the inferior suprarenal artery, which is a branch of the renal artery.

The right adrenal gland is also innervated by sympathetic nerve fibers that originate in the thoracic and lumbar spinal cord. These nerve fibers stimulate the medulla to produce and secrete catecholamines, which help to regulate blood pressure, heart rate, and other physiological responses to stress.

In terms of clinical significance, tumors of the adrenal gland can cause excessive production of hormones and lead to a variety of symptoms and conditions, including Cushing's syndrome, Conn's syndrome, and pheochromocytoma. Surgical removal of the adrenal gland may be necessary in some cases to treat these conditions.

Additionally, imaging studies of the adrenal gland may be performed to evaluate for tumors or other abnormalities.

Fig. 5: Response generated by ChatGPT-4

4. Hamstring muscles

The hamstring muscles are a group of three muscles located at the back of the thigh. They include the biceps femoris, semitendinosus, and semimembranosus muscles.

1. **Biceps femoris:** This muscle is located on the lateral (outer) side of the back of the thigh. It has two heads—the long head and the short head. The long head originates from the ischial tuberosity (a bony prominence in the pelvis), while the short head originates from the linea aspera of the femur (a bony ridge on the back of the thigh). The biceps femoris muscle flexes the knee joint and also helps to rotate the leg laterally.
2. **Semitendinosus:** This muscle is located on the medial (inner) side of the back of the thigh. It originates from the ischial tuberosity and inserts on the tibia (a bone in the lower leg) via the pes anserinus (a tendinous insertion on the medial aspect of the tibia). The semitendinosus muscle flexes the knee joint and also helps to extend the hip joint.
3. **Semimembranosus:** This muscle is located on the medial side of the back of the thigh, deep to the semitendinosus muscle. It also originates from the ischial tuberosity and inserts on the tibia via the pes anserinus. The semimembranosus muscle flexes the knee joint and also helps to extend the hip joint.

All three hamstring muscles are innervated by the sciatic nerve, which is the largest nerve in the body and originates from the lower lumbar and sacral spinal cord. In terms of function, the hamstring muscles play an important role in running, jumping, and other activities that involve bending and straightening the knee joint. They also help to stabilize the hip joint and control the movement of the pelvis.

Injuries to the hamstring muscles, such as strains or tears, are common in athletes and can cause pain and weakness in the back of the thigh.

Fig. 6: Response generated by ChatGPT-6

5. Neurulation

Neurulation is the process by which the neural plate, a flat sheet of ectodermal cells in the early embryo, folds inward and gives rise to the neural tube, which later develops into the brain and spinal cord. The process of neurulation begins during the third week of embryonic development and is a critical step in the formation of the nervous system.

The process of neurulation can be divided into three stages:

1. **Formation of the neural plate:** During the first two weeks of embryonic development, the blastula (a hollow ball of cells) undergoes several rounds of cell division and differentiation to form the three germ layers: ectoderm, mesoderm, and endoderm. The neural plate arises from the ectoderm, and it is formed by the proliferation and elongation of a specialized group of cells called the neural

ectoderm.

2. **Formation of the neural folds:** At the beginning of the third week of embryonic development, the neural plate begins to fold inward, forming two longitudinal ridges called the neural folds. The neural folds gradually move toward each other and fuse in the midline to form the neural tube. The closure of the neural tube occurs first in the cervical region and then progresses in both rostral (head) and caudal (tail) directions.
3. **Differentiation of the neural tube:** The neural tube gives rise to the entire central nervous system, including the brain, spinal cord, and associated structures. The neural tube also gives rise to the neural crest, a group of cells that migrate and differentiate into various cell types, including sensory neurons, sympathetic neurons, and chromaffin cells.
Disorders that result from defects in neurulation can have serious consequences, including neural tube defects such as spina bifida and anencephaly. These conditions are caused by failure of the neural tube to close properly during embryonic development, leading to malformations of the brain and spinal cord.

Fig. 7: Response generated by ChatGPT-7

6. Inguinal canal

The inguinal canal is a passage in the lower abdominal wall that allows structures to pass from the abdominal cavity into the external genitalia and the upper thigh. The inguinal canal is important for the passage of the spermatic cord in males and the round ligament of the uterus in females.

The inguinal canal is located just above the inguinal ligament, which is a band of connective tissue that stretches from the anterior superior iliac spine (ASIS) to the pubic tubercle. The canal is approximately 4 cm long and runs obliquely from the deep inguinal ring, which is an opening in the transversalis fascia, to the superficial inguinal ring, which is an opening in the external oblique aponeurosis.

The inguinal canal is surrounded by several layers of muscle and fascia. The internal oblique muscle forms the roof of the canal, while the transversus abdominis muscle forms the floor. The anterior wall of the canal is formed by the external oblique aponeurosis, and the posterior wall is formed by the transversalis fascia.

In males, the inguinal canal contains the spermatic cord, which includes the vas deferens, testicular artery, testicular vein, and genital branch of the genitofemoral nerve. In females, the inguinal canal contains the round ligament of the uterus, which attaches the uterus to the labia majora. The inguinal canal can be a site of herniation, which occurs when a portion of the intestine or other abdominal contents protrudes through the canal and into the scrotum or labia majora. Inguinal hernias are more common in males than females and are often the result of a weakness in the abdominal wall or increased pressure in the abdomen due to lifting or straining.

Fig. 8: Response generated by ChatGPT-8

7. Histology of liver

The liver is an important organ that performs several functions, including detoxification of the blood, metabolism of carbohydrates, fats, and proteins, and synthesis of bile. The liver is composed of functional units called lobules, which are arranged in a hexagonal pattern around a central vein. Each lobule is composed of several different types of cells, including hepatocytes, Kupffer cells, and stellate cells.

Hepatocytes are the most abundant cells in the liver and are responsible for most of the liver's metabolic functions. They are polygonal in shape and have a characteristic hexagonal pattern when viewed under a microscope. Hepatocytes have a central nucleus and numerous mitochondria, which are responsible for energy production. They also contain smooth and rough endoplasmic reticulum, which are involved in the synthesis of proteins and lipids, respectively.

Kupffer cells are specialized macrophages that are found in the sinusoids, which are blood vessels that run through the liver lobules. Kupffer cells are responsible for phagocytosis of bacteria, viruses, and other foreign particles that are present in the blood. They also play a role in the regulation of inflammation in the liver.

Stellate cells are located in the space of Disse, which is the area between the sinusoids and hepatocytes. Stellate cells are responsible for the storage of vitamin A and the synthesis of extracellular matrix components, which are important for the maintenance of liver structure.

The liver is also characterized by a complex system of blood vessels. The hepatic artery supplies oxygenated blood to the liver, while the hepatic portal vein delivers nutrient-rich blood from the gastrointestinal tract. These blood vessels run through the liver lobules and drain into the central vein, which then drains into the hepatic vein and returns blood to the heart. Overall, the histology of the liver is characterized by the presence of hepatocytes, Kupffer cells, and stellate cells arranged in a complex network of blood vessels. This complex organization allows the liver to perform its important metabolic functions and maintain the homeostasis of the body.

Fig. 9: Response generated by ChatGPT-9

8. Femoral Triangle

The femoral triangle is an anatomical region located in the upper thigh, bounded by the inguinal ligament superiorly, the sartorius muscle laterally, and the adductor longus muscle medially. The femoral triangle is an important anatomical landmark because several important structures pass through this region.

The femoral triangle contains several structures, including the femoral nerve, femoral artery, and femoral vein. The femoral nerve is the largest nerve in the thigh and supplies sensation to the skin of the anterior thigh and medial leg. The femoral artery is a major artery that supplies blood to the lower extremity, and the femoral vein is a large vein that returns blood from the lower extremity to

the heart.

The femoral triangle can be subdivided into three compartments, which are separated by the fascia lata, a layer of connective tissue that surrounds the thigh muscles. The lateral compartment contains the femoral nerve, which passes through the muscle to reach the anterior compartment. The middle compartment contains the femoral artery and vein, which are separated from each other by a layer of connective tissue called the femoral sheath. The medial compartment contains lymph nodes and lymphatic vessels.

Several important structures are located around the femoral triangle. The femoral nerve arises from the lumbar plexus and passes through the psoas major muscle before entering the femoral triangle. The femoral artery and vein pass beneath the inguinal ligament and into the femoral triangle. The saphenous nerve, which is a branch of the femoral nerve, passes through the femoral triangle and supplies sensation to the skin of the medial leg. The femoral triangle is an important anatomical landmark for clinical procedures, including femoral artery catheterization, venous access, and nerve blocks. It is also an important landmark for surgical procedures, including groin hernia repair and femoral artery bypass surgery. Understanding the anatomy of the femoral triangle is essential for safe and effective clinical practice in this region of the body.

Fig. 10: Response generated by ChatGPT-10

9. Intra-capsular ligaments of knee joint

The knee joint has two intra-capsular ligaments: the anterior cruciate ligament (ACL) and the posterior cruciate ligament (PCL).

The ACL originates from the anterior intercondylar area of the tibia and inserts on to the posterior aspect of the lateral condyle of the femur. Its main function is to prevent anterior translation of the tibia on the femur and to provide rotational stability to the knee joint.

The PCL, on the other hand, originates from the posterior intercondylar area of the tibia and inserts on to the anterior aspect of the medial condyle of the femur. Its main function is to prevent posterior translation of the tibia on the femur and to provide rotational stability to the knee joint. Both the ACL and PCL play an important role in stabilizing the knee joint during activities such as running, jumping, and cutting. Injuries to the ACL or PCL result in significant knee instability and can require surgical intervention to repair or reconstruct the ligament.

Fig. 11: Response generated by ChatGPT-11

10. Erb's palsy

Erb's palsy, also known as Erb-Duchenne palsy, is a condition that results from damage to the brachial plexus, a network of nerves that runs from the neck to the shoulder and arm. Erb's palsy specifically affects the upper brachial plexus, which controls movement and sensation in the shoulder, arm, and hand.

The most common cause of Erb's palsy is a difficult childbirth, especially when the baby's head and neck are pulled to the side during delivery. This can cause stretching or tearing of the nerves in the brachial plexus, leading to weakness or paralysis of the affected arm.

Symptoms of Erb's palsy include weakness or paralysis of the arm, decreased or absent reflexes in the affected arm, and a limp or paralyzed appearance of the arm held against the body. In some cases, there may also be a loss of sensation in the affected arm.

Treatment for Erb's palsy depends on the severity of the injury and may include physical therapy, occupational therapy, and, in some cases, surgery. With early and appropriate treatment, many children with Erb's palsy can regain normal use of their affected arm.

Fig. 12: Response generated by ChatGPT-12

DISCUSSION

Based on the results of our study, it is evident that ChatGPT has good knowledge on human anatomy and can interpret the answers well. But, the extent of dependability is a cause of concern as discrepancies in the answers are possible. One of the main drawbacks of ChatGPT is that, it cannot generate diagrams. Subjects like anatomy, require deep understanding of the location and relations of different structures in the body. Thus pictorial representation is highly crucial in order to appreciate these structures well. Therefore, the ChatGPT cannot be accepted as an effective learning tool in human anatomy with its existing ability to generate only descriptive content.

Similar studies have been conducted to test the performance of ChatGPT in anatomy. A multiple-choice test with 40 items made up the assessment. According to the results of the test, ChatGPT fared better than the health science students in Turkey.⁸ The findings of our study is also consistent with another attempt that checked the knowledge of ChatGPT about the branches of facial nerve in middle ear in anatomy. The response generated by ChatGPT was not anatomically accurate and has failed to provide a comprehensive explanation. There were also mistakes identified in the functions provided for the respected branches.⁹ Thus, the answers generated by ChatGPT may not be highly accurate always and essential requires validation of content before it could be used practically.

The implementation of AI based tools like

ChatGPT in medical education raises many concerns with respect to academic integrity, unfair learning assessments, erroneous information, and excessive dependence on AI.¹⁰ These technological advancements should be used with extreme caution along with considering the difficulties and restrictions of ChatGPT, including moral dilemmas and possibly negative outcomes.¹¹ It is imperative for medical educators to stay up with the quickly evolving world of technology and take into account the consequences for curriculum design, assessment techniques, and educational needs while such AI-based systems are used for medical education and research.¹²

CONCLUSION

ChatGPT can revolutionise medical education if used appropriately and with caution. As AI tools are also prone to generating incorrect information at times, proper validation of the information generated is crucial before learners can depend on such artificial platforms. ChatGPT has emerged the most highly advanced AI tool that mimics human conversation. With this ability, it can provide an inclusive and personalised learning environment for students. However in regards to effectiveness of teaching, ChatGPT may still not be suitable to be relied upon completely for providing a profound understanding of subjects with intricate details like anatomy, which requires practical demonstration and pictorial representation to make the content easier to understand and reciprocate.

Acknowledgements:

Authors would like to extend their gratitude to the OpenAI, an American artificial intelligence research laboratory for providing free access to ChatGPT.

Conflicts of Interest: Nothing to declare

Funding: This study did not receive funding in any manner from any source.

REFERENCES

1. Introducing ChatGPT.,OpenAI; Accessed on 19.03.23; <https://openai.com/blog/chatgpt>
2. ChatGPT: Reinforcement Learning from Human Feedback., Accessed on 19.03.23., <https://botbark.com/2023/02/05/chatgpt-reinforcement-learning-from-human-feedback/>
3. Kung, T. H., Cheatham, M., Medenilla, A., Sillos, C., De Leon, L., Elepaño, C., ... & Tseng, V. . Performance of ChatGPT on USMLE: Potential for AI-assisted medical education using large language models. *PLOS Digital Health*, 2(2), 2023, <https://doi.org/10.1371/journal.pdig.0000198>
4. Thorp HH. ChatGPT is fun, but not an author. *Science*. 2023 Vol 379, Issue 6630, p. 313, DOI: 10.1126/science.adg7879
5. Baidoo-Anu, David and Owusu Ansah, Leticia, Education in the Era of Generative Artificial Intelligence (AI): Understanding the Potential Benefits of ChatGPT in Promoting Teaching and Learning (January 25, 2023). Available at SSRN: <https://ssrn.com/abstract=4337484> or <http://dx.doi.org/10.2139/ssrn.4337484>
6. Khan RA, Jawaid M, Khan AR, Sajjad M. ChatGPT - Reshaping medical education and clinical management. *Pak J Med Sci*. 2023;39(2):605-607. doi: <https://doi.org/10.12669/pjms.39.2.7653>
7. Khan, R. A., Jawaid, M., Khan, A. R., & Sajjad, M. (2023). ChatGPT - Reshaping medical education and clinical management. *Pakistan Journal of Medical Sciences*, 39(2). <https://doi.org/10.12669/pjms.39.2.7653>
8. Talan, T. & Kalıncara, Y. The Role of Artificial Intelligence in Higher Education: ChatGPT Assessment for Anatomy Course. *Uluslararası Yönetim Bilişim Sistemleri ve Bilgisayar Bilimleri Dergisi*, 7 (1), 33-40, 2023. DOI: 10.33461/uybisbbd.1244777
9. Mogali, S.R. Initial impressions of ChatGPT for anatomy education. *Anat Sci Educ*. 2023., <https://doi.org/10.1002/ase.2261>
10. Sok, Sarin and Heng, Kimkong, ChatGPT for Education and Research: A Review of Benefits and Risks (March 6, 2023). Available at SSRN: <https://ssrn.com/abstract=4378735> or <http://dx.doi.org/10.2139/ssrn.4378735>
11. Han Z, Battaglia F, Udaiyar A, Fooks A, Terlecky SR. An Explorative Assessment of ChatGPT as an Aid in Medical Education: Use it with Caution. *medRxiv*. 2023., doi: <https://doi.org/10.1101/2023.02.13.23285879>
12. Lee, H. The Rise of ChatGPT: Exploring its Potential in Medical Education. *Anat Sci Educ*. 2023; Accepted Author Manuscript. <https://doi.org/10.1002/ase.2270>

