RESEARCH ARTICLE

Teaching Variant Anatomy Students Attitude and Knowledge

Sven Schumann*

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ABSTRACT

Anatomical variations are deviations from the most common arrangement of anatomical structures in the human body. In contrast to malformations, anatomical variations do not result in an impairment of function. Nevertheless, variations are of high clinical interest, since variations can mimic pathologies leading to wrong diagnoses and interfere with therapies. In most anatomical curricula, anatomical variations are not included systematically. In this pilot study, German medical students in the pre-clinical phase of study were asked to answer questions about their attitude towards variant anatomy and name three anatomical variations. 46 students completed the online survey. Approximately two-third of the students agreed (n=25) or strongly agreed (n=4) that anatomical variations should play a more important role in anatomical education. Most frequently, variations associated with a situs inversus and the dominance type of arterial supply of the heart were mentioned. Pre-clinical students are aware of the importance of variant anatomy knowledge. Anatomical variations should be integrated systematically into pre-clinical medical education. This study might motivate anatomy teachers to develop and evaluate curricula which include variant anatomy.

Keywords: Anatomical Education; Anatomical Variation; Clinical Anatomy; Evolutionary Medicine; Medical Education

INTRODUCTION

Anatomical variations are deviations from the typical (most common) arrangement of anatomical structures as presented in anatomical textbooks (e.g., Gray´s anatomy [1]).

Anatomical variations are likely the result of a combination of genetic and environmental factors interfering with the individual embryological development. The prevalence of variations is different in different populations und changes with time [2]. Additionally, humans seem to have a higher degree of anatomical variation than most other known species [3].

In contrast to malformations, anatomical variations are no pathological condition, since variant anatomy does not result in an impairment of function. Nevertheless, variations are of high clinical interest. Variations may mimic pathologies, thereby leading to wrong diagnosis [4] or overtherapy [5]. Variations can also negatively impact surgical outcomes. About 10% of clinical malpractice might be due to ignorance of anatomical variations [3]. Due to improved technology like radiologic imaging and intraoperative microscopy a plethora of variations have come to anatomists´ and clinicians´ attention [6]. Unfortunately, new discovered anatomical variations are primary presented in anatomical case reports, often lacking a systematic approach [7, 8]. Additionally, a simple, clear, and exactly defined nomenclature for these structures is missing [9].

Besides new variations, several putative new human organs have been described or defined and were discussed even in popular media in the last years. For example, the existence of a great salivary gland at the pharyngeal ostium of the Eustachian tube or a new meningeal membrane in the subarachnoid space (SLYM, subarachnoid lymphatic-like membrane) were proposed [10, 11]. Additionally, some authors claim that structures like the mesentery or the aorta deserve to be classified as organs [12 - 14].

In most anatomical curricula, anatomical variations are not included systematically [15]. In this pilot study, the general knowledge and interest of German medical students about anatomical variations was investigated.

MATERIALS AND METHODS

In this prospective single centre study (University Medical Center Mainz, Germany), we requested a total number of 220 students of human medicine to fill in an online survey. This survey was performed in winter term 2023/2024. The participation was anonymous and voluntary. Students were asked to answer questions about variant anatomy (on a five-point Likert scale) and name three anatomical variations **[Table 1]**. All participants were in the pre-clinical phase of medical studies (before first state examination, "Physikum") and have completed a hands-on dissection course (66 hours of practical training on body donors). A group of 20 medical students dissected one body donor under the supervision of one anatomist.

RESULTS

A number of 46 students completed the survey (response rate 20.9%). Approximately half of the students (47.8%) agreed (n=15) or strongly agreed (n=7) to the statement that anatomical variations were addressed in medical education, pointing out a high heterogeneity in teaching **[Figure 1A]**.

Approximately two-third of the students (63%) agreed (n=25) or strongly agreed (n=4) to the statement that anatomical variations should play a more important role in anatomical education **[Figure 1B]**. In contrast, students were barely interested in the controversy about newly discovered organs **[Figure 1C]**. 10 students were unable to name just a single anatomical variation (21.7%, **[Table 2]**). In several cases, students did not mention

Table 1) Questions of the online survey.

I have completed the dissection course	**Yes** **No**
Anatomical variations were addressed in medical education	Strongly agree Agree Neutral (neither agree nor disagree) Disagree Strongly disagree
Anatomical variations should play a greater role in medical education	Strongly agree Agree Neutral (neither agree nor disagree) Disagree Strongly disagree
I followed the discussion about new discovered human organs in public media	Strongly agree Agree Neutral (neither agree nor disagree) Disagree Strongly disagree
Please name three anatomical variations in humans	

[1]*Institute of Anatomy, University Medical Center of the Johannes Gutenberg University Mainz, Mainz, Germany*
[2]*Institute of Anatomy, Brandenburg Medical School, Neuruppin, Germany*

Correspondence: Sven Schumann, Institute of Anatomy, Brandenburg Medical School, Fehrbelliner Straße 38, D-16816, Neuruppin, Germany; E-mail: sven.schumann@mhb-fontane.de

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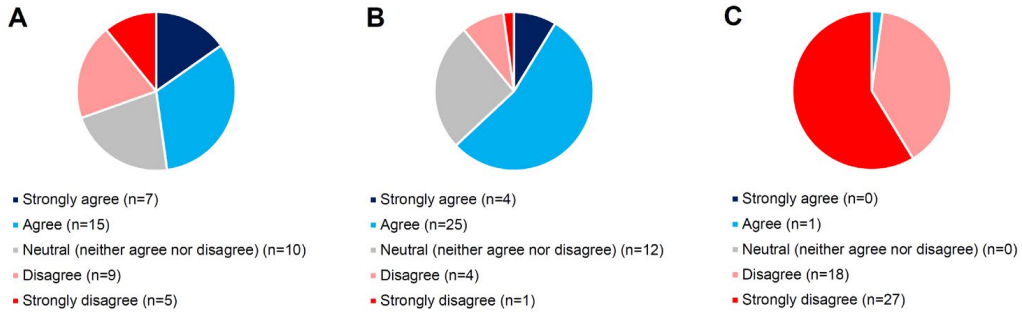

A) Anatomical variations were addressed in medical education

B) Anatomical variations should play a greater role in medical education

C) I followed the discussion about new discovered human organs in public media

Figure 1) Students´ responses to three different statements on a five-point Likert scale

Table 2) Anatomical variations named by students. English translation by the author. Dominance type of arterial supply of the heart refers to the German term "Versorgungstyp des Herzens". No answer is indicated by "/". Answers associated with a situs inversus are marked with [a], answers associated with variations of the arterial supply of the heart with [b]

Student no.	Answer
1	/
2	1. Situs inversus[a], 2. Ductus pancreaticus accessorius
3	1. Arteria thyroidea ima, 2. Persisting foramen ovale, 3. Topographical variants of the maxillary artery, 4. Arteria stapedia, 5. Situs inversus[a]
4	1. Dominance type of arterial supply of the heart[b], 2. Musculus pyramidalis, 3. Topography of the vermiform process (intraperitoneal or extraperitoneal)
5	1. Musculus pyramidalis, 2. Arteria thyroidea ima, 3. Situs inversus[a]
6	1. Course of the right recurrent laryngeal nerve, 2. Papilla duodeni minor
7	1. Different course of arteries
8	1. Celiac trunk, 2. Vermiform process, 3. Vasa privata of the heart[b]
9	1. Branching of the brachial plexus, 2. Branches of the celiac trunk, 3. Tilts of the uterus
10	1. Situs inversus[a]
11	1. Tendons of forearm muscles, 2. Accessory nipples
12	1. Vascular variations (e.g., two renal arteries), 2. Variations in topography (pelvic kidney), 3. Morphological variations (horseshoe kidney)
13	1. Musculus sternalis, 2. Musculus pyramidalis, 3. Arteria brachialis superficialis
14	1. Vascular supply of hand and kidney, 2. Dominance type of arterial supply of the heart[b]
15	1. Situs inversus[a], 2. Corona mortis, 3. Dominance type of arterial supply of the heart[b]
16	1. Situs inversus[a], 2. Nervus recurrens [sic!], 3. Topography of the kidney
17	1. Situs inversus[a]
18	1. Accessory ribs, 2. Right-dominant coronary circulation[b], 3. Musculus pyramidalis
19	1. Musculus sternalis, 2. Dominance type of arterial supply of the heart[b]
20	1. Variations in course and branching of arteries and veins, 2. Size of organs, 3. Number of teeth
21	/
22	1. Situs inversus[a], 2. Ectopic testis in babies
23	/
24	1. Ureter duplex, 2. Single kidney, 3. Pancreas anulare
25	1. Course of the recurrent laryngeal nerve
26	1. Single kidney, 2. Heart on the right side[a]
27	1. Recurrent laryngeal nerve, 2. Dominance type of arterial supply of the heart[b], 3. Vermiform process
28	/
29	/
30	/
31	1. Three kidneys, 2. Variations of the pancreatic duct, 3. Horseshoe kidney, 4. Accessory nipples, 5. Situs inversus[a]
32	1. Lumbar ribs, 2. Musculus sternalis, 3. Coronary arteries[b]
33	/

34	1. Musculus palmaris longus, 2. Pelvic position
35	1. Different shapes of the xiphoid process, 2. Two venae cavae inferiores due to uncomplete fusion during development, 3. Situs inversus in different grades[a]
36	1. Dominance type of arterial supply of the heart[b], 2. Aberrant course of nerves, 3. Missing wisdom teeth
37	1. Celiac trunk, 2. Musculus sternalis, 3. Brachiocephalic trunk
38	1. Musculus sternalis, 2. Musculus pyramidalis, 3. Arteria thyroidea ima
39	1. Topography of the thyroid gland, 2. Course of the recurrent laryngeal nerve, 3. Vessels
40	1. Sinus coronarius, 2. M. plantaris longus, 3. Part of the thyroid gland
41	1. Accessory bones of the foot, 2. Aberrant and accessory renal arteries, 3. Dominance type of arterial supply of the heart[b]
42	1. Skin colour, 2. Body height, 3. Genetic disposition
43	/
44	/
45	1. Course of different vessels
46	/

specific variations but common types (e.g., "variant course of blood vessels"). In two cases, more than three variations were listed. Most frequently, variations associated with a total or partial situs inversus (11 times) and the dominance type of arterial supply of the heart (vasa privata, "Versorgungstyp des Herzens",10 times) were mentioned.

DISCUSSION

Accurate knowledge of anatomy is a prerequisite for successful diagnosis and therapy [16]. Therefore, variant anatomy not only belongs to the portfolio of knowledge and skills of anatomists, but also of clinicians [9]. A lack of familiarity with anatomical variations is a central factor of a multitude of diagnostic and therapeutic errors. This makes the knowledge of anatomical variation essential to medical education. In this study, we analysed the attitude towards and knowledge about anatomical variations of medical students in the pre-clinical phase. To the authors´ knowledge, this study is the first study from a German speaking country about this topic. Most studies about anatomical variations in medical education were performed in English speaking countries (USA, UK, Australia) and in only three studies students were included [17].

A survey from 2020 demonstrated that 88.6% of anatomy faculty in the US agreed or strongly agreed that pre-clinical medical education is the optimal time to introduce variant anatomy. In contrast, 38.6% indicated that knowledge of variant anatomy was not assessed [18]. Both students and teachers tend to minimize the importance of variations during teaching and learning. Additionally, even major variations are ignored in exams [15].

There are several reasons why anatomical variations are not included in the curriculum. In Germany, the number of physicians in Anatomy departments, who know the relevance of variations from own clinical experience, is decreasing [19, 20]. Additionally, the duration of dissection course and anatomy lectures is shortened, so students and anatomists must focus on basic anatomy [20].

HOW TO TEACH ANATOMICAL VARIATIONS

When anatomical variations are presented a non-systematic way, there is a high chance to confuse students [7]. Therefore, a simple, clear, and exactly defined nomenclature for variations is needed to gain and retain this knowledge [9]. Additionally, it could be helpful not only to name and show, but also explain the origin of anatomical variations (ontogenetically and phylogenetically). There is no consensus, which variant structures are most important to teach.

For example, Kiss shortlisted nine anatomical variations worth to teach, including variations of the circulus arteriosus cerebri (of Willis), a missing dorsalis pedis artery, an internal carotid artery, pseudoaneurysm inside the sphenoidal sinus, cervical ribs, a linguofacial trunk, an arteria lusoria (aberrant right subclavian artery), variations of coronary artery branches, variations of liver anatomy, and variations of cecum and appendix [15].

It would be important to create an evidence-based list of clinically important anatomical variations; nevertheless this list must be updated periodically, since the prevalence of variations is not constant over time. For example, the prevalence of the median artery in the forearm is increasing during the 20th century [2]. In contrast, the prevalence of the thyroid im artery is reduced in a South Australian population of European descent [21]. Several factors might influence these changes (e.g., acceleration of prenatal development, ethnic mixture, reduced selective pressure due to therapeutically intervention). Additionally, new surgical techniques might require a changed focus on variations.

STUDENTS' AWARENESS

Obviously, pre-clinical students are already aware of the importance of variant anatomy knowledge. In contrast, they are less interested in "new" organs and the associated discussion [22, 23]. Thus, the positive attitude towards anatomical variations in this survey seems not to be a result of social-desirability bias and "novel organs" are only of academic interest. Most frequently, the situs inversus was mentioned as an example of an anatomical variation. Despite its association with Kartagener syndrome (primary ciliary dyskinesia) the development of a situs inversus in humans is not fully understood yet. Its prevalence reported to be 1:6500 to 1:25000 [24]. In dissection course, situs inversus is a rare event, but provides an interesting learning opportunity [25].

Another frequently mentioned variation is the dominance type of arterial supply of the heart. In right dominance, the posterior interventricular artery derives from the right coronary artery, in left dominance it is a branch from the left coronary artery. In the so-called balanced pattern, branches of both the right and left coronary artery run in or near the posterior interventricular groove [1]. Here, mnemonic devices might be amended [26].

FURTHER REASONS TO TEACH VARIANT ANATOMY

Since anatomical variations often represent evolutionary old patterns (e.g., Arteria ischiadica [27]), they can generate direct links to comparative and evolutionary anatomy. Basic knowledge of comparative anatomy might become important when teaching One Health concepts [28].

Within the concept of evolutionary medicine, a better understanding of evolutionary mechanisms and human evolution is leading to improved healthcare. Interestingly, learning about evolutionary medicine seems to be a more effective way to understand principles of evolution than learning pure evolutionary biology [29].

In the novel field of "forensic clinical anatomy", individuality of the body, which includes anatomical variations, acquires specific relevance, for example in the analysis of medical malpractice or identification of humans [30]. Like fingerprints, sinus patterns are unique for a person [31]. So, morphology of frontal sinuses can be used for forensic identification of humans

LIMITATIONS OF THE PRESENT STUDY

There are several limitations of this study. The number of participants was very low. This is because only students were asked who completed a full practical dissection course on body donors (no restrictions due to corona pandemic). The author is convinced that learning on corpses directly shows variability of the human body and helps students to recognize anatomical variations [32]. Additionally, the number of students in a dissecting group may influence the dissection experience and the recognition of variations. Therefore, this study might be repeated at different universities.

There could also be a bias due to low response rate. Students with low

knowledge about or interest in anatomy might not have participated in this survey. Due to the small sample size, sociodemographic characteristics of the participants were not considered. Additional studies might analyses the influence of educational background, gender and age. Additionally, typical bias of Likert scales should be taken into account.

CONCLUSION

Taken together, anatomical variations should be integrated systematically into pre-clinical medical education. This study might motivate anatomy teachers to develop and evaluate curricula which include variant anatomy.

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CONFLICTS OF INTEREST

The author declares that there is no conflict of interest.

ETHICAL STATEMENT

According to the Ethics Committee of Rhineland-Palatine no ethics approval was necessary for the present study, as it is not a biomedical research project in the narrower sense of the Declaration of Helsinki.

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