

Medical Embryology and its Importance in the 21st Century Curriculum: A mini review

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Abstract

Embryology is an essential tool in clinical practice especially for managing various medical disorders. As a course in medical schools, it is neither easy nor straightforward to understand and teach in the 21st century curriculum, as such, it is easy to overlook. As a discipline, embryology has entered a phase of unparalleled transition in its understanding base. This translates to a phase of abundant modification in the medical curriculum. A main critical issue of learning embryology is how extensively newer molecular medical embryology can be paired with the traditional approach to developmental of anatomy. Another issue would be which venue to be considered most effective in embryology instruction. The medical curriculum in during 21st century have different objectives, as well as different educational approach. As a consequence, this paper outlines a variety of aspects in which embryology could be presented as well as how it may be incorporated within the medical curriculum.

Keywords

Medical embryology, Clinical embryology, Medical education, Approaches to learning, Medical curriculum.

Introduction

Embryology as a discipline in the West originated from researches conducted by Ancient Greek Philosophers. The philosophers had struggled to answer the foremost metaphysical query “What is man? And “What is the Universe?” Anaximander and Empedocles (611-547 BC and 504-433 BC respectively) had tried to compare the different stages of embryonic development as well as cosmos development (Needham & Hughes, 1959). Studies on medical embryology as an philosophical discipline was initially perceived in the Hippocratic Corpus. However, *On the Generation of Animals* by Aristotle (383 – 322BC) became the maiden scientific edition that gave a comprehensive theory of embryology (reproduction and development in various organisms) – a theory that remained unchallenged until the Renaissance, and which greatly influenced later theories in philosophy and embryology (Bury, 1911). The vital role played by human embryology in human’s understanding of himself, and in medicine cannot be overlooked. It is worth noting that the knowledge of embryology has greatly contributed to the advancement in medical science. Several investigations have also shown that learners who consider embryology as a beneficial aspect of their universi-

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ty education are doing it because they believe it helps learners to enhance their clinical skills (Scott, Charles, and Holland, 2013). Other than studying the evolutionary nature of different anatomy of the body, the analysis of a variety of scientific topics, including the foundation of gametogenesis as well as fertilization, congenital abnormalities, and the consequence of intrauterine incidents like congenital disease and the growth of the foetus, that are clearly important to a range of specialities like obstetrics and paediatrics (Alfalah et al., 2019).

Like other disciplines, embryology must justify its position in the present-day medical curriculum, one that is overcrowded. Curriculum committees in schools are most likely to ask questions such as “why this subject should be taught?” and “what should be taught?”. In this paper, the viewpoint on the role or importance of embryology in medical education is presented. Educational programs, as well as curricular objectives, differ and there is no correct answer to explain how embryology classes should be performed. What is emphasized in a particular program may be marginalized in another program? This paper does not prescribe a one-fit-all model. Rather, it presents options that will facilitate the effective contribution of embryology within the medical education.

Modern embryology curriculum

In most cases, justice is done to content in a particular course, however it is not much constraint to change the subject to “what the student should be taught during their medical education?” If this is resolved, then more focus is channeled to coordination, timing, and packaging. Recently, content regarding embryology has been described in vague phrases, old versus new. The phrase old here refers to developmental phase, while the phrase new is thought to be referred to as molecular aspect. Frankly, there are not many instances where the entire information in a particular area has been transformed or improved as rapidly like medical embryology, all within a decade. But then, it has been shown a seemingly a large decrease in time allocation to embryology in the curriculum of medical schools. Thus, one has to select what material to present to the students.

Neither “old” nor “new” knowledge is adequate for a comprehensive learning of embryology. Restricting oneself to growth-related anatomy limits adequate comprehension of causation. In the same vein, an understanding of molecular events without a comprehending the knowledge of the morphologic contextual in how they’re occurring could cause misconceptions. The problem, subsequently, is which vast information in this area is the learner supposed to master as well as what must be the level of exposure?

Presently, most medical institutions within USA as well as Australia, are gradually shifting from the classroom-based study of embryology, preferring to impart the knowledge during the student’s clinical years (Muller et al., 2008; Drake et al., 2009). One, therefore, wonders if the subject is accorded the same value to the same level. Al-Neklawy (2017) showed that teaching embryology via online classes might constitute a successful additional tool while performing embryology classes. The results of this study showed that the majority of Egyptian medical students (90%) were satisfied with embryology classes performed online (Al Neklawy, 2017). Moreover, the

wide availability of embryology resources online might facilitate online learning (Hill, 2018). The bone of contention is the problem-based approach used in the modern medical curriculum, which encourages the teaching of embryology as a basic medical science (Drake, Lowrie and Prewitt, 2002). It is important to note that over 64% of medical schools in the United States combine embryology with gross anatomy. It is also worth noting that 22% of medical schools teach embryology alongside human structure, human function, and histology (Drake, Lowrie and Prewitt, 2002). American Medical Schools are mostly graduate schools that offer fast-track programs with many subjects condensed together. And so, students can retain information by comprehending the physiological and anatomical relationships between both subjects.

Allowing medical students to learn multiple subjects simultaneously helps them to acquire a comprehensive understanding of each subject. For instance, students in their first years must have a working knowledge of the early development of the fetus, development of the organ system as they occur in stages, genetics, and how embryology is applied in the clinic. The goal is to make embryology clinically relevant while in the classroom (Hamilton and Carachi, 2014). It is important to note that a problem-based approach will hasten the student's understanding of complex diseases, as well as its treatment. It will also ease the learning process (Scott, Charles, and Holland, 2013). As such, even though there may be a reduced focus on embryology as an independent subject, its integration with physiology and anatomy is of great benefit, and implicitly recognizes the value of embryology.

Learning approaches to embryology

The pedagogical strategy to embryology do not vary significantly with those which are employed in academic education for other topics, but the source material does raise certain particular difficulties. Of course, embryology is introduced at a majority of medical schools as a lecture-based subject, usually without a laboratory, albeit with differing numbers of material hand-outs. The amount of allocated hours assigned to a formal embryology teaching ranges greatly. Thus, the forms and quantities of content officially discussed differ similarly. Regarding institutions adopting the problem based learning (PBL) method, there are no standardized classes, and much of the learning is conducted through the study of specific clinical cases. Several institutions often dedicate conventions to address the divide between basic science teaching and clinical practice of the basic science portion of the medical curriculum. Such workshops, which can require attendance from both fundamental science and physicians, may be very helpful to introduce students to content that is not extensively discussed in classes or books on embryology. The science of conception, birth abnormalities, the foetus as a patient and childbirth are subjects that have proved to be well suited for such venues. Textbooks prove to be a mainstay with several classes in academic embryology. Two of the field's longstanding texts Moore & Persaud, 1998, and Sadler (2000) were originally largely anatomically focused as well as used commonly among conventional courses. More over, two other textbooks also combined biological and molecular approaches (Carlson 1999; Larson 2001). Web-based instruction is rapidly being used in nearly every medical school in the USA. Placing the outlines of whole classes, including still images, on safe websites for the benefit of the students

is becoming more popular. If the ability to hold the Internet grows, so do the volume and sophistication of the text-related statistics. Animations developed throughout the years for chosen embryological developments like embryo transfer, fertilization, gamete, embryo folding, intestine rotation, and heart septation, but due to the complexities and cost, there is currently no broad scope for standard animation. Nonetheless, these animations can be extremely efficient for individual use.

Team based learning

Team-based learning (TBL) is an educational business training technique (Michaelsen et al., 1997), and this approach has been implemented increasingly by medical schools (Searle et al., 2003). There is increasing proof that team-based learning (TBL) is a productive way to integrate collaborative peer instruction in small groups and learning engagement. Progressively, classes in both undergraduate and graduate medical school are conducted using TBL. During the preclinical years, when medical schools develop comprehensive and interdisciplinary classes, TBL is especially valuable because of its focus on collaboration, material mastery, and problem solving for clinical use. For medical gross anatomy and medical embryology, TBL is an appealing approach to follow since it allows the student to study anatomical details on which they improve anatomical principles important for skills in clinical practice (Nieder et al., 2005; Vasan et al., 2009). Multiple medical schools have implemented TBL in fundamental science implementation in recent years (Nieder et al., 2005), clerkships (Levin et al., 2004), and internship opportunities (Haidet et al., 2002). As several medical schools in the preclinical years are developing comprehensive and multidisciplinary classes, TBL is incredibly beneficial because of its focus on collaboration, topic competence and clinical practice problem-solving skills. TBL is an appealing technique for anatomical education, as it allows learners to study anatomical details upon which to acquire anatomical principles regarding the solution of medical symptoms (Nieder et al., 2005). A reasonable planning and attendance is also needed. TBL offers more constructive learning for students as opposed to passive education often linked with conventional lectures (Nieder et al., 2005).

The importance of embryology in anatomy

Embryology is very important in the present-day medical curriculum. It sounds trite, but pregnancy conditions for the birthing of each individual remain true. Consequently, it is of utmost significance that while an infant develops from a zygote (which is in turn formed from the union of a sperm and an oocyte), a lot of things can go wrong. Whether it is traced to environmental or genetic factors, it results in premature births, and several birth defects such as maldevelopment, spina bifida, congenital heart problems, abnormal positioning of the kidneys, etc. Research has shown that at least 7.9 million infants globally are born with some form of congenital defects each year (Christianson, Howson, and Modell, 2006). A study conducted at the Centres for Disease Control and Prevention (2006) concluded that *"Birth defects affect 1 in every 33 babies (about 3% of all babies) born in the United States each year."*

This accounts for over 20% of neonates. Doctors must be able to trace the root causes before diagnosis, treatment, and possibly prevention can be made. This explains why it is more than important to study the abnormalities of physiological development, a discipline known as teratology while doing anatomy courses. For instance, it is important that obstetricians and gynaecologists have a working understanding of anatomy as well as physiology to provide optimal prenatal care as well as postnatal care, and for paediatricians treating students who have been affected by these congenital defects.

There are various explanations why embryology is a fitting part of the traditional medical syllabus. Since multiple classes or people might not possess the same academic habits, nor do they have the same technical requirements, such factors cannot really be favored or described in rank order. The basic philosophical rationale for researching embryology is to consider how our bodies originated. Like in many other basic science fields, for its own sake this can be seen as gaining information, but beyond that there are many explanations why this information is essential. Birth deformities appear to rate higher in the disorders that their physicians offer to patients. While the recorded occurrence of birth defects ranges based on the screening severity, any identifiable form of birth defect may eventually be assigned to approximately 5 percent of live-born individuals. Recognizing the origin of birth defects has proved to be amongst the hardest to break diagnostic notions. Traditional embryology offered morphological clues as to where trends of pathological morphological development vary from ordinary, but the origin of most birth defects has scarcely been derived from that information solely. Modern molecular technology has highlighted the roots of numerous genetically engineered defects occur at birth, and has presented some hints about the genesis of other. A course in embryology must deliver a theoretical foundation for understanding processes that underlie both normal as well as abnormal developments. Thus, embryology is a very important field in medicine and its associated disciplines.

The advantage of combining embryology with anatomy

Having a working knowledge of developmental embryology allows medical students to understand better, the anatomy. Students, for example, will be familiar with the nervous system and the venous system, because embryology explains in detail the development of the veins in the vertebra, arrangement of plexus, and of course, embryology of the cranium and the caudal regions. Knowing the embryology regarding the venous structure greatly aids with understanding the arrangement of the transverse foramen's venous system (Magro et al., 2013). When the student understands the development of organs in embryology, such as the urogenital and cardiovascular systems, their understanding of anatomy will be reinforced. For example, knowing how the lungs are segmented, how the heart is formed, and where the dermatomes are located makes it easier to visualize their development. More so, Carlson (2002) identifies the "formation of heart chambers, the development of gross vascular patterns, lung segmentation, gut rotation, and development of major parts of the urogenital system" as aspects of anatomy for which learning is approached through developmental anatomy. Frankly, developmental anatomy is a foremost aspect of

embryology, considering that it focuses on the changes undergone by the body, cells, organs, and germ cells during development (Leonard et al., 2000).

Embryology plays a very vital role in understanding how birth defects relate to genetics, for instance, the *sox* and *hedgehog* genes for development of the limbs, *situs inversus* where there is a transposition of the heart and other vital organs to the opposite side of the body during embryological development. The development of the pancreas is another example. Here, the head, the body, and the tail undergo separate developments, and then unite, leading to a higher risk of defects (Sadler et al., 2007). If there is an abnormality in pancreatic development, food substances, especially lipids, will remain undigested. It is important that healthcare professionals understand the causes of these defects to be able to handle the rising conditions, and also prevent them. This explains why it is important to study and understand the normal and abnormal formation of organs.

Clinical application: treatment

Understanding embryology creates a strong foundation for other aspects of medical knowledge. Both – descriptive and experimental embryology – provides an opportunity to investigate the etiology of particular congenital malformations. Studying embryology is crucial to understand the etiology of congenital anomalies and possibly evaluate the possibilities for their prevention. As stated by Carlson (2002), *“understanding the developmental stages that a structure or region undergoes during its embryogenesis gives important clues not only to its normal structure but also to reasons why anatomical variation can occur (e.g., the pattern of the major veins of the trunk and abdomen)”*. The fact is, one cannot fully lay claim to understanding anatomy when one doesn't understand embryology. Congenital defects of the heart like aortic coarctation can be used as a case study. By having a working knowledge of embryology, the medical student will know that this disorder can be treated at birth by interventional cardiac catheterization or prevented via alteration or eradication of the medications or environmental factors responsible for its development (Stark, De Leval, and Tsang, 2006). Imperforate anus is another common congenital defect. Understanding how the cloaca develops in the human embryo, as well as the occurrence of imperfect fusion, helps with the treatment of this condition. Treatment may be done at birth if it has not reached the advanced stage. A surgical procedure may be done later on (Hosokawa et al., 2017). While these treatments are common, their existence is attributed to embryology. Thus, they continually serve as a testimony of the importance of embryology in the modern clinical curriculum.

Conclusion

Embryology is considered an increasingly vital aspect of the medical curriculum. An understanding of embryology translates to an understanding of the human anatomy. Medical students will be able to make sense of the variation in organ structure in humans after they have had a perfect understanding of the organ embryology. Understanding the embryology helps with treatment and even prevention of abnor-

mal development of organs. But then, it is important to note that there is no “all-round” correct way of presenting this subject in the modern medical curriculum. The watchword in the modern curriculum is basing the content and presentation of the course in relation to desired results. As such, medical schools must tailor the teaching of embryology to match with their curricular objectives. Instructors also have the responsibility of creating a platform that is effective for presenting the subject.

References

- ALFALAH, S.F.M., FALAH, J.F., MUHAIDAT, N., ELFALAH, M., FALAH, O (2019) Investigating Learners' Attitudes Toward Virtual Reality Learning Environments in Embryology Education. *Modern Applied Science*, 13:1.
- AL-NEKLAWY AF (2017) Online Embryology teaching using learning management systems appears to be a successful additional learning tool among Egyptian medical students. *Annals of Anatomy - Anatomischer Anzeiger*. 214:9–14.
- BURY R (1911) Aristotle de Generatione Animalium - Aristotle de Generatione Animalium. Translated by A. Platt. 8vo. Oxford: Clarendon Press, 1910. 7s. 6d. net. *The Classical Review*. 25(1):23-24.
- CARLSON BM (1999) Human embryology and developmental biology. 2nd ed. St. Louis: Mosby.
- CARLSON BM (2002) Embryology in the medical curriculum. *The Anatomical Record*. 269(2):89–98.
- CHRISTIANSON A, HOWSON C, MODELL B (2006) March of Dimes global report on birth defects. White Plains, NY: March of Dimes Birth Defects Foundation.
- DRAKE RL, LOWRIE D, PREWITT CM (2002) Survey of gross anatomy, microscopic anatomy, neuroscience, and embryology courses in medical school curricula in the United States. *The Anatomical Record*. 269(2):118–22.
- DRAKE RL, McBRIDE JM, LACHMAN N, PAWLINA W (2009) Medical education in the anatomical sciences: the winds of change continue to blow. *Anat Sci Educ*. 2(6):253-259.
- HAIDET P, O'MALLEY KJ, RICHARDS BF (2002) An initial experience with “team learning” in medical education. *Acad Med* 77 (1):40-4.
- HAMILTON J, CARACHI R (2014) Clinical embryology: is there still a place in medical schools today? *Scottish Medical Journal*. 59(4):188–92.
- HILL MA (2018) Two Web Resources Linking Major Human Embryology Collections Worldwide. *Cells Tissues Organs*. 205(5-6):293–302.
- HOSOKAWA, T., YAMADA, Y., TANAMI, Y., HATTORI, S., SATO, Y., & TANAKA, Y. et al (2017) Sonography for an Imperforate Anus: Approach, Timing of the Examination, and Evaluation of the Type of Imperforate Anus and Associated Anomalies. *Journal Of Ultrasound In Medicine*, 36(9), 1747-1758. doi: 10.1002/jum.14228
- LARSEN WJ (2001) Human embryology. 3rd ed. New York: Churchill Livingstone.
- LEONARD RJ, HOOS PC, AGUR A, GILROY AM, LOZANOFF S, NELSON ML, NEWMAN LM, PETTERBORG LJ, ROSENHEIMER J (2000) A clinical anatomy curriculum for the medical student of the 21st century: Developmental anatomy. Educational Affairs Committee, American Association of Clinical Anatomists (AACA). *Clin Anat*.13:17–35.

- LEVINE RE, O'BOYLE M, HAIDET P, LYNN DJ, STONE MM, WOLF DV, PANIAGUA FA (2004) Transforming a clinical clerkship with team learning. *Teach Learn Med.* 16:270–275
- MAGRO E, SENECAILB, GENTRIC J-C, ALAVI Z, PALOMBI O, SEIZEUR R (2013) Contribution of embryology in the understanding of cervical venous system anatomy within and around the transverse foramen: a review of the classical literature. *Surgical and Radiologic Anatomy.* 36(5):411–8.
- MOORE KL, PERSAUD TVN. (1998) *The developing human.* 6th ed. Philadelphia: Saunders.
- MULLER JH, JAIN S, LOESER H, IRBY DM. (2008) Lessons learned about integrating a medical school curriculum: perceptions of students, faculty and curriculum leaders. *Medical Education.* 2008;42(8):778–85.
- NEEDHAM J, HUGHES A (1959) *A history of embryology.* Cambridge: [Cambridge] University Press.
- NIEDER GL, PARMELEE DX, STOLFI A, HUDES PD (2005) Team-based learning in a medical gross anatomy and embryology course. *Clin Anat* 18: 56-63.
- SADLER T. *Langman's essential medical embryology* (2005) Philadelphia, Pa.: Lippincott Williams & Wilkins.
- SCOTT, K.M., CHARLES, A.R. and HOLLAND, A.J.A. (2013) Clinical embryology. *ANZ J Surg,* 2013: (83) 709-712.
- STARK E. *Surgery for Congenital Heart Defects* (2006), 3rd Edition. John Wiley & Sons.
- VASAN, N. S., DEFOUW, D. O., & Compton, S (2009) A survey of student perceptions of team-based learning in anatomy curriculum: Favorable views unrelated to grades. *Anatomical Sciences Education,* Volume 2(4).