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Review

Perspective on a Vertical Integration Using Electives—Not with a Bang, but a Whimper

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Abstract: Following the current trends in medical-curriculum development with an important but poorly represented course in forensic medicine is a rather challenging quest. Given the exceptional opportunity of teaching forensic medicine and anatomy, the author's experience is shared, bearing in mind the harsh academic-workload standards. In that context, the introduction of (clinically oriented/problem-solving-based) curriculum-specific electives (CSEs) is suggested as a means of vertical integration of medical education. Moreover, it may be time to transfer learning (at least in part) to some other environment, possibly a virtual one. The body of knowledge expected to be learned by all students, the core curriculum, should be alleviated, and all too-specific topics should be transferred to the CSE. Keeping the curriculum attractive to clinicians and interesting for students should be an idea aiming for a fully integrated course. Balance of the core curriculum and CSEs aims to bring forth interaction with clinics and bonds with clinicians. In addition, students' affinities would be met more adequately.

Keywords: anatomy; curriculum; curriculum-specific elective; elective; forensic medicine; vertical integration

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1. Introduction

Referring to TS Elliot's poem in the title [1] suggests the true state of affairs in the medical curriculum. Though most medical schools do gradually shift toward integrated curricula, gross anatomy remains taught predominantly in the first undergraduate year [2,3]. As the clinical courses are taught during the final years (fourth, fifth, and sixth), they come as a whimper, an anti-climactic contrast to the bang of anatomy. In the customary curriculum, the forensic-medicine course is arranged for sixth-year students. They are two extremes of the same continuum.

This author's personal experience as a now-anatomist and former forensic-medicine teacher offers an idea of how to traverse the traditional boundaries and implement teaching activities focused on students, giving an idea of how to engage students in activities that may facilitate them to appreciate learning. Appropriate literature was scoped, being attentive not to disturb the flow of the paper with excessive referencing.

A basic ("gross") anatomy course is designed to teach general anatomical knowledge, and an elective course in clinical anatomy focuses on human anatomy as it relates to clinical practice [4–6], studying specific structures and issues in a clinical setting [7,8]. Just like this, a basic course on forensic medicine is defined as the application of medical and paramedical scientific knowledge to certain branches of law [9]. However, unfortunately, the current traditional subject-based curriculum is unlikely to go through a smooth, successful transition. Introducing curriculum-specific electives (CSEs) covering clinical courses from years four and five might help vertical integration of medical education (Table 1), similar to Kennedy et al. [10]. This means shifting forensic-medicine education towards specific clinical needs. It offers an opportunity to customize learning experiences (Table 2). Students would be permitted to select, direct, and organize the curricula that best meet their individual needs and/or interests so they may differentiate early [11–14].

Table 1. Prospect topics for integrated teaching—curriculum-specific electives (CSEs) (fourth- and fifth-year electives). Creating electives covering clinical courses from years four and five to provide an integrated approach towards allied disciplines.

Suggested Topics for Curriculum-Specific Electives (CSEs)	
Year lV	• Death and dying in the cardiology unit • Ethical and medico-legal issues in clinical practices • Alcoholism • Drug abuse • HIV/AIDS and COVID-19
Year V	• Death and dying in the ICU • Organ transplantation • Migrations • Abortion, contraception, pregnancy, and birth • Child abuse

Table 2. TOWS analysis for curriculum improvement. Basically an extension of the SWOT analysis framework that identifies your strengths, weaknesses, opportunities, and threats after curriculum improvement with curriculum-specific electives. Later, it looks to match up the strengths with opportunities and the threats with weaknesses.

		External	
		External Opportunities (O) Integrating the curriculum Interaction with clinics/binding with clinicians Meeting student's affinities Opportunity to introduce the specialistic Topic Broadening interests	**External Threats (T)** anatomical dissection "Learning material shortage" legislative changes clinicians' interest too narrow in scope/too specialistic for the audience the surgery" scenario
Internal	**Internal Strengths (S)** Core curriculum Academic workload Students' interests Clinical-preclinical reflections Clear application of any research	**Strategies using (S) to exploit (O)** Ballance core curriculum and meeting academic workload by introducing CSE!	**Strategies using (S) to mitigate (T)** Keeping the curriculum attractive to clinicians.
	Internal Weaknesses (W) Core curriculum Reduced flexibility Must be long-term curricular reform Organizational ineffectiveness No one is familiar with it and there are no easy exits	**Strategies using (O) to reduce (W)** Mitigate organizational ineffectiveness and look "out of the box" in suggesting CSE!	**Strategies Defensive to reduce (T)** Avoid organizational issues!

Although there has been a change in the integrated curricula in past decades [2,5,15], no specific efforts have been made to vertically integrate the forensic-medicine course because of, among other issues, the constant struggle with the shortage of teaching materials and the academic-workload guidelines [16–19]. Then again, anatomy, though fully integrated—except for the robust course at the beginning of preclinical education—offers several handy courses in the clinical-learning environment, as well as lifelong education programs [3,15,19,20].

2. Rationale—Questions Addressed

The main message of this review is to deepen the core subject areas in the curriculum through curriculum-specific electives (CSE) [10] from my experience as a former forensic-medicine teacher, enhanced with an anatomist's know-how in teaching skills. This should help my former colleagues deliver a course that is oriented towards specific clinical needs, considering specialty specificities [4,15,21,22]. However, I am not motivated only by this idea. Modernization of everything, digitalization of teaching aids, transferring to Society 5.0 . . . it all renders 50-year-old textbooks obsolete [14,23–26]. Although the current textbook was last updated before the COVID-19 crisis, and we are all aware that it was a whirlwind for the educational system [27]. The significances are addressed both nationally as a suggestion for curriculum updating and globally as an idea of a CSE as a means of vertical integration, specifically grouping curricular content and delivery mechanisms.

However, students' fingers have been put on electives as a valuable, highly regarded experience, complementary to the core curriculum [28]. They provide an opportunity for students to customize their curriculum and to amend the basic body of knowledge expected to be learned by all students.

3. Current Adjustments to Traditional Education

In the broadest sense, teaching forensic medicine to undergraduate students with the aim of producing a physician who is well-informed in the medico-legal field is an inevitable responsibility [29]. A recently graduated physician should be instantly capable of making observations and extrapolating conclusions by logical deductions. As a guideline to the minimum teaching that should be provided to undergraduate medical students in legal medicine for such students to be able to meet their daily professional duties, the European Council of Legal Medicine produced (though long ago) the "Perugia Document" [30,31]. Naturally, according to that document, grossing and meticulously studying histological slides has been an integral part of the medical curriculum.

However, if we glimpse the vertical integration of medical education, any student–future practicing physician needs to be proficient in the core body of knowledge (essential to all students). Considering harsh restrictions in the curriculum and academic-workload guidelines, traversing the traditional boundaries of medical education depends on the ingenuity of the specific teacher. Learning anatomy is one example, as anatomy is essential for any medical student. The problem of medical students' decreasing anatomical knowledge is coupled with the increasing number of people commenting on it. Though empirical evidence in that regard does not exist [32], according to popular belief, the diminished use of cadaver dissection is responsible for this. The result is the neglect of vertical integration [33,34]. The proper vertical integration of education in courses on anatomy and forensic medicine is well described by Pakanen et al. [35], but (at least today) greatly relies on fresh or preserved bodies.

Early exposure to clinical practice could facilitate integrating clinical-reasoning skills in a pre-professional undergraduate human-anatomy course. At the end of a clinical course, the student should be offered an opportunity to analyze what has been seen from a forensic viewpoint [22,36]. This should stimulate problem-based, student-centered educational approaches with the primary learning strategies that were adopted [3,37].

Although anatomical education and forensic-medicine training with cadavers seem irreplaceable as a method of teaching in the core curriculum [38], budget cuts in many academic anatomy departments have caused dissection to be replaced by alternative, less-hands-on learning with the use of prosections and, in some cases, new technologies. In that context, comprehensive software with deep-learning and artificial-intelligence technologies may have a rising role in medical education, being an integrative tool to combine with human-cadaver dissection [39,40].

Since forensic histopathology is an inevitable utility of any university department, as a part of a core curriculum, students should be introduced to forensic histopathology and routine microscopy [41]. As forensic pathologists prefer straightforward and rapid tools

such as digital pathology, it is reasonable to believe that in the present variety of commercial systems, a tool feasible even for the forensic pathologist exists. Students should be introduced to the capacity of these tools to enable the pathologist to perform most of their work remotely [3,34,42–44]. Following that, they should be given to understand that the option of digital imaging is widely used by pathologists for the creation of static images, and its use in forensic pathology should be preferred, at least for educational purposes [45]. Conversely, the diagnoses made by digital pathology were shown to be statistical non-inferior to diagnoses from glass slides; therefore, it appears to be the most propitious modality in the forensic-pathology laboratory, and this whole review concentrates on applications involving it. With this aim, even smartphones have been used recently. Although this idea might be a bit farfetched, it does unveil a new approach to quickly obtaining and sharing information from a slide and using it for documentation and publication [46,47].

4. Electives to Expand Core Subject Areas in the Core Curriculum

The range of forensic topics that are relevant to undergraduate medical students is very broad, so when designing a program of electives, the educator must carefully consider what to include [10,28]. The present author used the University of Rijeka Faculty of Medicine's curriculum [48] to list a range of topics that could be included in an undergraduate forensic-medicine CSE (Table 1).

Therefore, the present author suggests a list that may be extensive, but it is important to be aware that this list can be used as a kickoff to select content for a CSE. Any involved educator's guiding principle should be that the CSE should not unnecessarily duplicate learning that students will be involved in elsewhere. These electives should be considered an opportunity to study a subject beyond the scope of the core curriculum. Thus, the list provided in Table 1 should be taken with a grain of salt [49].

4.1. Year lV Electives

Based on the curriculum, it is the present author's suggestion to offer the following topics: 1. Death and dying in the cardiology unit, 2. Ethical and medico-legal issues in clinical practices, 3. Alcoholism, 4. Drug abuse, and 5. HIV/AIDS and COVID-19 [48]. These topics do follow the core subject areas in the core curriculum, but equally important is that this list is merely a starting point for selecting content for a CSE. A particular institution should analyze this list and bring it in line with the core curriculum. Students themselves should also be encouraged to study in greater depth a topic that was included in the core curriculum [50].

4.2. Year V Electives

The present author suggests the following topics to expand core subject areas in the core curriculum for year five of medical study: 1. Death and dying in the intensive care unit (ICU); 2. Organ transplantation; 3. Traveling and migrations; 4. Abortion, contraception, pregnancy, and birth; and 5. Child abuse [48].

As in the instance of year four, the institutional curriculum and students' preferences have to be acknowledged as a primary objective if every elective is to allow students to develop specialist knowledge and skills in a particular area of interest [50].

5. Core Subject Areas in the Core Curriculum

The toughest challenge is probably reforming the things expected to be learned by all students—in other words, how to specify the body of knowledge and skills important to all subjects and learning areas. This challenge deals with topics common to all students and delivering those topics in a setting where, in the undergraduate medical curriculum, this course has constantly deteriorated over the past few decades. The recent COVID-19 pandemic, social-distancing rules, and lockdowns brought this almost to a close. To keep students engaged as required by the academic-workload guidelines and to maintain their

ability to see the relevance of forensic medicine to their future clinical practice, I suggest covering six topics as a part of the core curriculum [9,10,17,32].

In the broadest sense, everyone involved in medical education in the legal context ultimately aims to provide students with an understanding of the medical and legal framework of certain deaths and to educate them on the nature and circumstances of certain injuries.

5.1. Introduction to the Subject—Education on Death and Dying

Taking a look and introducing a course using clear, concise, and easy-to-understand language helps set the tone for everything that follows. Students will summarize the principles of medicine adopted during human-anatomy and physiology classes. Students will learn about the main aims of this course—identification, cause, and manner of death. Then, they will be instructed on the natural (non-violent) and violent deaths, and the coroner system and medical-examiner systems [51].

Formal education on death and dying—thanatology in medical schools is an overlooked and ill-defined topic. The topic is assumed to be taught when it happens, and may be the medical student's first encounter with the death of a patient. This was first identified a few decades back in a survey of nursing students by Doyle et al. Ever since, surveys have been showing on average a significantly low number of hours of death education that medical students receive.

A future practicing physician's education on death and dying should nevertheless be limited to a few occasional lectures and seminars. Limited educational material available cannot be an excuse, so much more has to be formally or informally included in the curriculum.

5.2. Thanatology and Traumatology

After presenting death as a reality and part of our culture, students will learn about estimating postmortem intervals. Theoretical knowledge of mechanical injury and consideration of specific and non-specific injuries will take place. Thermal injuries and electrical injuries will be discussed. Students will learn about high-altitude illness and the effects of ionizing-radiation injury and illness. This is also a place to emphasize the main objective of this course—to familiarize students with the examination and documentation of wounds. The examination of a dead body will be demonstrated and performed by students.

Students will become accustomed with trauma biomechanics—in other words, the application of the principles of mechanics in the injury of the biological system, specifically the human body. Students shall also become informed on background information and the tools used in everyday life, including an overview of anatomy and locomotor apparatus.

Medical examination of a dead body/certification will be demonstrated so that students are informed on types of autopsies and familiar with the documentation required for an autopsy as well as autopsy reporting. The process of performing an autopsy should be demonstrated elsewhere, building upon the core idea of the vertical integration of medical education—a grouping of curricular content and delivery mechanisms [14].

As a part of this subject area, students shall learn about the forensic investigation of traffic accidents. This is an opportunity for students to familiarize themselves with high-speed instrumentation necessary for impact experiments, public databases for use in determining injury rates in the population and these data's application to impact-biomechanics research, anthropomorphic test devices (crash-test dummies), the use of radiological (X-ray, CT, MRI) data sources for injury analysis, and multi-body dynamic and cadaver/animal models used for injury-biomechanics research. This is also an occasion to pick up devices and approaches that are focused on the prevention of injury—safety equipment.

This is the place to discuss the medico-legal perspective on suicides. Knowledge about the different methods (of suicide and expertise in differentiating suicide from accident and homicide). In addition, suffocation, mechanical asphyxia, drowning, and diving accidents (barotrauma, decompression sickness) shall be discussed here [52,53].

5.3. Anthropology and Osteology

This part of the forensic-medicine course focuses on the identification and interpretation of human skeletal remains from legal contexts [54].

In that vein, topics to be covered in this class consist of human skeletal and dental anatomy/morphology, skeletal growth and development, sexual dimorphism, and applications of this knowledge to judicial use. Identifying age, sex, stature, and ancestry by assessing skeletonized individuals with the term" biological profile" will be put in use.

During this subject area, students will learn about the application of osteological skills to identify the cause and manner of death, and trauma patterns as they relate to a certain event.

5.4. Forensic Toxicology

Students should pick up on the development of forensic toxicology; its definition; branches of forensic toxicology; the significance, scope, duties, and responsibilities of forensic toxicologists; and analysis reports. In the same vein, students will become familiar with the terms "absorption", "distribution", "metabolism", and "excretion" [55,56].

In this part of the course, students will be introduced to the forensic diagnosis of poisoning, types of poisons, and general aspects of poisoning. Students will pick up on methods in forensic toxicology, as well. They will discuss the extraction and isolation of poison from viscera and other biological specimens.

This is the part of the curriculum in which features of introduction, absorption, distribution, metabolism, excretion, sampling, and analysis of ethanol and estimation of liquor in breath, blood, and urine are explained and discussed in the legal context. Pathways, nature, type, mode of action, extraction, isolation, and identification of various drugs of abuse will be discussed,

Some other frequent poisonings, such as carbon monoxide, carbon dioxide, and environmental poisonings, are also discussed.

5.5. Forensic Genomics and Molecular Techniques, Paternity Testing

Students shall be given to understand basic DNA and RNA techniques and their applications for prenatal diagnosis and paternity testing in forensic medicine.

This part of the course will provide students with an understanding of the science of DNA analysis in a criminal investigation. Students will attain an understanding of the history of forensic DNA analysis, sample collection and storage, and DNA extraction, quantitation, amplification, and separation. Students will pick up on STR-marker analysis; analysis of non-autosomal DNA, including mitochondrial DNA, Y-chromosome DNA, and X-chromosome DNA; and interpretation of data [57].

After this subject area, students will be able to identify the role and importance of molecular methods in genetic research. They will be able to identify limitations in molecular-diagnostics strategy and ethical issues. Irrefutably, the application of molecular techniques for proving parentage and detecting child relevance will be clarified.

5.6. Expert Witness, Medical Error, and Liability

This part of the course acknowledges medical students as potential expert witnesses. For this reason, a medical student is made aware of the increased legal scrutiny applied to an expert's testimony, particularly in medical-malpractice litigation [58,59]. The latter is probably the most lucrative and controversial area of law and medicine. Students should attain knowledge of all ethical, legal, and professional issues required for later independent work [58,60]. Students will be informed of the practicalities related to expert witnessing—it shall be explained that an expert witness can be anyone with knowledge or experience of a particular field or discipline beyond that to be expected of a layman [61].

6. Today's Student-Clinician of the Future

Although an important and integral part of medical education, forensic medicine has seen many ups and downs in the recent past [20,62].

Gross anatomy and forensic-medicine courses are constantly reduced [32]. To make things even worse, forensic medicine is usually placed at the end of learning. Forensic pathologists being responsive and agile while teaching procedural skills needs to fit into the concept of caring for a technically simple but convenient tool. It is reasonable to believe that even in the existing variety of commercial systems, a tool feasible even for the forensic pathologist exists. For instance, adding smartphones to traditional slide handling and updating the body-donation system, integrating learning with clinical needs, and including some specialistic topics in CSE, should all relieve the core curriculum. When it comes to updating the existing collections of educational material, that area will need to be organized better and more effectively, with improved logistics.

Teaching, laboratory quality control, and research are all reliant on human tissue [63]. However, we should always bear in mind that human tissue must be treated, used, stored, and disposed of with respect [64,65]. In addition, it is not too difficult to understand families' fear that some organs have been retained without permission [66]. Infamous activities known as "organ retention" started long before the Alder Hey organ scandal; moreover, there is evidence of this in virtually every cathedral and many churches in Europe. Likewise, only a few undergraduate medical schools have no pathology museum. However, the rest of the world cannot easily put Europe to shame, either. New Zealand's top cardiologic hospital had its own organ scandal. They were retaining and using (yes, even for education) hearts, brains, and other organs [67,68].

Traditionally (and for the time being), autopsy has been used as a tool in undergraduate medical education. However, recent decades have seen a sharp decline in its use for teaching [69]. Learning anatomy with an increasing amount of contextual learning should provide students with a reason to learn and understand [70–72]. Therefore, there is no rationale to worry that eventually forensic medicine will be detrimental to anatomy, as surgery was. Namely, in the traditional curriculum, dissections gradually became the responsibility of the surgeon specialist, and that marked the beginning of a decline in the role of anatomic dissection [33].

Since many studies have shown that revisiting information enhances retention, student learning and retention of anatomical knowledge will be enhanced if some type of unique educational activity in anatomy is added [71,73].

Today's European guidelines from the European Parliament and Council [44,45], building upon the longest tradition of legal medicine in the world, impose Europe as the most likely solution to all curriculum and vertical-integration problems [13,33,74].

Many graduates without a specialty/young trainees are unaware of the legal principles that govern their liability. In that phase, they should be able to balance different specialty services to support optimal patient care. Irrespective of the country's legal system, the principles of medical liability in case of malpractice claims are based on the opinion of a panel of average professionals of the same specialty. Therefore, specialty-specific legal principles of the patient–physician relationship should be explained during clinical years, as in CSEs. Building upon lessons learned from the COVID-19 crisis should help produce a more pleasant learning environment. Or rather, it may be time to transfer learning (at least in part) to some other environment, possibly a virtual one [26]. For example, the use of simulation, which was transferred from the aviation industry a few decades ago [38,75–77], has become a part of healthcare education worldwide. A significant amount of research demonstrates its value in surgical training, and there are health authorities that have identified it as a medium to improve patient safety [78,79].

Procedural medicine learning is gradually moving away from the bedside as the sole, primary learning venue [38,79]. This gains even more importance with an increased number of complaints about medical malpractice over time [80,81]. For that reason, today's student-clinician of the future should have qualities of someone agile enough to dynamically work across public health and public safety, in the synergy of both fields—someone who should not have difficulty at all adopting the rigid coronial system and meeting academic-workload requirements.

Even though residents felt their anatomy education prepared them well for residency, in a self-assessment survey among medical students, they evaluated their forensic-medicine course with an average score of "medium" [82]—which surely requires improvements. No exception should be made whatsoever regarding any practicing physicians who attend victims of physical or sexual assault, abuse, or trauma when bearing in mind the legal needs of their attendees [1].

7. Conclusions

Usually, the conclusion section is a short, bottom-line paragraph or two intended to help the reader understand why the author's research matters Therefore, it would not be out of bounds to repeat the main message of this review—to deepen the core subject areas in the curriculum through using CSEs.

Naturally, this approach has several limitations, primarily related to the current curriculum and its flexibility and ability to integrate (especially to integrate with clinicians). The core curriculum should be better balanced and any organizational ineffectiveness mitigated. Academic-workload pressure and students' interest in a specific field are specific elements that need to be considered. Surely, there is always a danger of creating an elective that is too specific for the audience (Table 2).

It is an exquisite solution for the vertical integration of the medical curriculum. This was truly a motive that ignited this review, and should be achieved by creating CSEs—electives covering clinical courses from years four and five. We shall provide an integrated approach towards allied disciplines to teach training regarding the medico-legal responsibilities of physicians at all levels of health care (primary and up). Integration with relevant disciplines will provide a scientific basis for clinical forensic medicine.

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