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TRENDS IN WHOLE BODY DONATION IN A SOUTH AFRICAN INSTITUTION OVER A THREE-DECADE PERIOD (1988-2017): IMPLICATIONS FOR MEDICAL EDUCATION

ADANA MY[1, 2], NAIDU ECS[1], AZU OO[1, 3]

[1]Discipline of Clinical Anatomy, School of Laboratory Medicine and Medical Sciences, University of KwaZulu-Natal, Durban, South Africa
[2]Department of Anatomy, Faculty of Basic Medical Sciences, College of Health Sciences, University of Ilorin, Ilorin, Nigeria.
[3]Department of Anatomy, School of Medicine, Windhoek, Namibia

Introduction: Dissection and prosection remain the gold standard for the teaching of anatomy to pre-clinical medical students across the world. This has made the practice of whole body donation the cornerstone of medical programs.

Objective: This study aimed at determining the trends in body donation among South Africans, and at predicting the best possible, and most realistic, approach for the teaching of anatomy in the near future.

Materials and Methods: Data from 696 cadavers donated during a three-decade period (1988-2017) were obtained from the files of the Discipline of Clinical Anatomy, University of KwaZulu-Natal South Africa. Data were analysed as percentages, mean ± standard deviation, using Statistical package for social sciences version 24.

Results: Most bodies were donated in the first decade of this study (1988-1997). Funeral services accounted for the major source of donations. Bodies were predominantly in the seventh decade of life (18.8%) and a larger proportion were males (61.6%). The practice of body donation were found to be more among the whites (57.5%) than all the other races. Most deaths according to this study were related to cardiovascular and cardiopulmonary issues (21.6%) and malignancies (11.1%), while a larger percentage were due to “unknown” causes (37.3%).

Conclusions: The study was able to show that the trend in the practice of body donation in South Africa has been erratic, which makes it difficult to predict the number of bodies available for medical education. Alternative approaches to anatomy education such as plastination techniques and computational models need to be sought to ensure sound and uninterrupted medical programs in South African medical schools.

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CORROSION CAST OF THE MALE CANINE URETHRA

ARREDONDO-RAMOS J[1], DEL-ANGEL-CARAZA J[2], DOMÍNGUEZ-CALDERÓN G[3], CASTELÁN-ORTEGA O[1], RODRÍGUEZ-CASTILLO E[3], HERNÁNDEZ-CABRERA W[3]

[1]Cuerpo Académico en Ciencia e Inovación Tecnológica Pecuaria
[2]Cuerpo Académico en Medicina y Cirugía Animal y
[3]Departamento de Anatomía FMVZ-UAEMex, Facultad de Medicina Veterinaria y Zootecnia. Universidad Autónoma del Estado de México, Toluca, México

Introduction: The male urethra carries urine, semen and seminal secretions to the distal end of the penis. Retrograde ejaculation has been shown to occur in the dog, however, in the author´s knowledge, studies regarding the retrograde flux of the urethral contents to the ductus deferens have not been made. Despite the clinical interest involving the urethra, due to its common pathological conditions, and conventional and minimally invasive surgical protocols, the urethra has been given little attention, in contrast to the abundance of studies on the urinary bladder, ureter and kidney.

Objectives: The purpose of the present study was to create a three-dimensional model of the urethra by means of a corrosion cast, to describe the structure of the pelvic and penile urethra and their relationship to the ducts of the prostate, and to identify if retrograde flux to the ductus deferens can occur.

Materials and Methods: Ten male mixed-breed dog cadavers were used in this study. Dogs were between 1-5 years of age with mean weight of 24 kg (range 18–28 kg). The cadavers were obtained from the Veterinary Hospital of the Autonomous University of the State of México, and were subjected to euthanasia with an overdose of sodium pentobarbital for reasons not related to reproductive or urinary disorders. All animals received humane care in compliance with the Animal Care and Bioethics Committee of the Autonomous University of the State of México. The caudal abdomen was dissected in order to clamp the vesical trigone with Kelly forceps. A 16- gauge vascular catheter was introduced into the external urinary meatus, and 20 ml of yellow epoxy Biodur® E20 was injected, followed by refrigeration at 4° C for 48 hours. The reproductive system was isolated from the body and then corroded using sodium hydroxide (NaOH).

Results: The three-dimensional model obtained was useful to observe the pelvic and penile portions of the urethra. This model can be used to observe the narrowing of the urethra at the level of its ischial curvature, and before the access of the os penis. A large dilation was present at the level of the prostate. Morphological characteristics of the inner surface of the urethra remain imprinted in the cast. These details may be helpful to describe the prostatic ducts draining to the urethra. In three cases, the polymer was able to fill the ductus deferens, which may explain the possibility of retrograde flux of urinary secretions.

Conclusions: The three-dimensional model of the male canine urethra by means of epoxy E20 is a useful tool to perform research on the reproductive tract in the dog, due to its capability to preserve the spaces and contours of it.

SETTING-UP A PLASTINATION LABORATORY IN RESOURCE-LIMITED SETTINGS

AZU OO

University of KwaZulu Natal, Durban, South Africa

A low-resource setting, or resource-limited setting (RLS), is typically characterized by lack of funds to cover costs for implementation of essential and critical components of projects leading to one or all of the following consequences: limited access to equipment, supplies, devices, capacity, and training, as well as overall retardation in outcomes/outputs. Whether an industry or medical/educational establishment, many institutions in sub-Saharan Africa are poorly funded and thus may fit into this model.

Medical institutions are established to train health professionals for the needs of the country, and therefore this involves infrastructural, technical, and human capacity developments that are tied to adequate funding. The academic activities of an anatomy department thrive with a sustainable repertoire of cadaveric and other materials for training. With dwindling resources, coupled with poor uptake of body donation programs, it becomes difficult to fulfil this mandate. Setting up a plastination laboratory (PL) to generate sufficient and augmented training/research materials becomes imperative. However, it is an expensive venture especially, in RLS.

The design of a plastination laboratory frequently involves technical issues, structural problems of the facility, & especially economic problems that may delay or mar its use, and the possibility of obtaining plastinated anatomical specimens in a brief period of time. We shall be sharing our thoughts and experiences from various African settings with a view towards encouraging other smaller units or labs to start a PL irrespective of the teething challenges in RLS.

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THE EVOLUTION IN THE TEACHING OF ANATOMY: PLASTINATION TO THE RESCUE

AZU OO[1,2] and IHUNWO AO[3]

[1]*University of KwaZulu Natal, Durban, South Africa*
[2]*University of Namibia, Windhoek, Namibia*
[3]*University of the Witwatersrand, Johannesburg, South Africa*

Anatomical science and education has progressed so rapidly in the last century, owing to the positive revolution in technological innovations. From the use of paintings, sketches and models, the imparting of anatomical knowledge evolved across institutions, utilizing fresh (unfixed) and then later, formalin-preserved specimens, corrosion casts, plastinated materials, to 3-D computer aids.

These radical transformations have all come with their attendant consequences on the manner of knowledge acquisition, and perhaps the overall goals thereof. Questions are generated, have we reached the crescendo in anatomical innovations with regards to the various modalities adopted in the delivery of anatomical knowledge?

We shall be examining the relative contributions made towards the development of various modalities for the teaching of the subject of anatomy, and perhaps x-ray the role of the plastique technique as an added repertoire.

PLASTINATION APPLIED TO THE CONSERVATION OF CULTURAL HERITAGE: THE ELEPHANT TUSKS OF BAJO DE LA CAMPANA'S PHOENICIAN SHIPWRECK, NATIONAL MUSEUM OF UNDERWATER ARCHEOLOGY, CARTAGENA.

BUENDÍA M [1], LATORRE R [2], LOPEZ-ALBORS O [2]

[1] *National Museum of Underwater Archaeology, Cartagena, Spain*
[2] *Department of Anatomy and Compared Pathological Anatomy; Regional Campus of International Excellence "Campus Mare Nostrum", University of Murcia, Spain*

Introduction: The archaeological excavation of a Phoenician shipwreck at Bajo de la Campana, San Javier, Murcia, Spain, was developed between the years 2007 to 2011 under a collaboration agreement signed between the Institute of Nautical Archeology of Texas A & M University and the Ministry of Culture Of Spain, through the National Museum of Underwater Archeology of Cartagena. Throughout successive campaigns of systematic excavation, the archaeologists documented and raised an extraordinary cargo from the wreck, dated between the 7th-6th centuries B.C. Among the raw materials it carried, there is a magnificent set of 53 elephant tusks and fragments of elephant tusks, some of them with inscriptions. The uniqueness of this archaeological find is that it is one of the few signs of Phoenician navigation in Spain and in the Mediterranean sea, and also it is one of the few examples of ships carrying ivory as a raw material, which is why conservation procedures are not well developed.

Objective: Our main goal was to study the Biodur® S15 technique, at room temperature, on archaeological waterlogged ivory as an alternative to traditional conservation procedures that have been found to be ineffective.

Materials and Methods: Tusk section (SJBC_11_2471_5a), tusk fragment (SJBC_11_2980) and tusk (SJBC_10_1926) were dehydrated in successive acetone baths in a refrigerated chamber at 5° C, to avoid contraction and tension forces. Impregnation of dehydrated tusk specimens was carried out in a vacuum chamber with a mixture of silicone polymer and catalyst: Biodur® S15 and S3, 1%. The pressure in the chamber during impregnation was gradually decreased from 760 mm Hg to 3 mm Hg. This stage was carried out at room temperature, between 18° C and 20° C. After impregnation, specimens were placed in a curing chamber where Biodur® S6 crosslinker was vaporized.

Results: The results obtained have been satisfactory, both in dimensional stability and visual aspect. After treatment, no discernable changes were observed in the physical dimensions and they have acquired the necessary mechanical strength to make study or display possible.

Conclusions: The plastination procedure meets the main objective of water removal and dimensional stability. It is also retractable, a preferred quality in conservation of cultural heritage, but not exclusive, which could be considered as a study option to see the results on ivory. The results after two years after processing enable the authors to validate the Biodur® S15 technique as a conservation procedure in archeology.

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GENERAL PRINCIPLES OF DEHYDRATION IN PLASTINATION

DE JONG KH

Medical School of Zhejiang University Hangzhou, PR China

As plastination is defined as the replacement tissue water, both intra- and extracellular, with a curable polymer (i.e. silicone, polyester or epoxy), there is a major problem as water is not miscible with each of these polymers.

In order to make the replacement of water with one of these polymers possible, the water must be replaced with a fluid that is both miscible with water and the specific polymer, and can later be replaced with this polymer. In everyday practice in plastination 2 fluids can be used: ethanol and acetone. They are called intermediate solvents.

During the impregnation stage, this intermediate solvent is replaced by the polymer of choice by means of an increasing vacuum (or a decreasing pressure), making the intermediate solvent evaporate, and being replaced by the polymer. It is preferred that this process, impregnation, proceeds very gradually. As acetone starts to evaporate much earlier than ethanol, acetone is by far the intermediate solvent of choice during plastination. During the presentation we will discuss all the practical pitfalls that can occur during the process of plastination.

PRINCIPLES OF THE POLYESTER TECHNIQUE

DE JONG KH

Medical School of Zhejiang University Hangzhou, PR China

In plastination 2 different kind of specimen are distinguished, 3 dimensional specimens, like normal anatomical specimen, that are normally impregnated with silicone, and thin (<4 mm.) slices, that can be impregnated with either polyester or epoxy. Both polymers have their own characteristics, and field of use. Originally, polyester was developed for its famous distinction between white and gray matter in the CNS, whereas epoxy was used for sections of other organs. Later, many people tried to use epoxy also for brain slices, and polyester for body slices, and with success.

However, there are big differences between these 2 techniques, and because of these differences there are some limitations to both techniques.

Polyester can be used for impregnation right from the factory, no additives need to be used, and hardening or curing takes place by UV-A light. This means that very dark and thick sections will not be penetrated enough by the UV-A light, and consequently will fail to harden. In the end the slices will become very deformed. On the other hand, once impregnated, polyester slices can be kept in the polyester for months (or years), as long as they are kept in the cold. Also, impregnation is not time-dependent, you can start impregnation, stop halfway, and go on after a few days, or even after your holiday. Curing will only succeed well in absence of oxygen, so the specimen can only cure in a completely closed chamber, when in contact with air the curing will fail.

Epoxy has to be mixed to a reactive mixture before impregnation. As soon as the mixing of the mixture is completed, the mixture will start to harden. Therefore there is a limited time window in which the impregnation can be finished, once you start, you must go on. On the other hand, as the curing will go on independent of other circumstances, there is no need to pack the slices in an airtight chamber, just packing them between two foils of polyester will give the slice a nice and smooth surface. In this presentation we will discuss the principles of polyester sheet plastination.

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PRELIMINARY ASSAY OF STANDARD S10 PLASTINATION METHOD TO PRESERVE MACROPARASITES SPECIES

GONZÁLVEZ M[1], ORTIZ J[1], LATORRE R[2]

[1]*Department of Animal Health (Parasitology and Parasitic Diseases)*
[2]*Department of Anatomy and Comparative Pathological Anatomy; Regional Campus of International Excellence "Campus Mare Nostrum", University of Murcia, Murcia, Spain*

Introduction: Plastination is a well-known process usually employed in human/veterinary anatomy and surgery teaching, but this method has been rarely used for parasites to date. Indeed, only three works have been found in this line, one focused on the human nematode *Ascaris lumbricoides*, other on eleven species of animal cestoda, nematoda and arthropoda and a previous study by the authors on mature and inmature larvae of diptera (*Oestrus ovis)* using adaptions in the standard methodology.

Objective: The aim of this study was to assay and validate the use of S10 plastination to preserve different macroparasites species.

Materials and Methods: Several specimens of nematodes (*Ascaris suum* n: 9 and *Parascaris equorum* n: 5*),* acanthocephalans *(Macracanthorynchus hirudinaceus* n: 5*)* and trematodes *(Fasciola hepatica* n: 5*)* were used during the assays with the standard S10 silicone plastination technique. Half of the specimens of nematodes and acanthocephalans were cut along their cuticle to check if a better exchange during impregnation occured.

Results: Nematodes presented several morphological alterations related to collapse of their structures: all *P. equorum* individuals suffered collapse; three of *A.* suum specimens were successfully plastinated, while the others showed body collapse; three *M. hirudinaceus* were correctly plastinated, but one parasite presented collapse of their structures, and the other one was broken as a consequence of its fragility. *F. hepatica* was successfully plastinated (100%), showing similar characteristics to parasites in formaldehyde, alcohol or other traditional preservation method. No relationship was found between results and the use of cuts or not. Further studies are needed to validate damage areas, comparing the abnormal structures of the plastinated and non-plastinated parasites.

Conclusions: Although the plastinated parasites might be quite useful for teaching, it is essential to apply modifications to the standard procedure for each parasitic species, because is not possible to use the same protocol for organisms so different from each other.

PRENATAL DEVELOPMENT OF THE MODERATOR BAND WITH SPECIAL REFERENCE TO PURKINJE FIBERS IN THE GOAT (*CAPRA HIRCUS*)

GUPTA SK, ARCHANA P, FAROOQUI MM, AJAY P

Department of Anatomy, College of Veterinary Science and Animal Husbandry, Mathura, India

Introduction: Prenatal development of the moderator band was studied in 36 morphologically normal fetuses of the non-descript goat (*Capra hircus*), divided in 3 groups with equal number (12) in each; Group I (early prenatal< 50 days), Group II (mid prenatal 51-100 days), and Group III (late prenatal 101 days to full term).

Materials and Methods: The heart was were fixed in standard fixatives, then washed and processed for paraffin microtomy. Thin (5µ) sections were stained with routine standard fibrocellular stains.

Results: The first histological evidence of juvenile cardiac myocytes and Purkinje cells were noticed in the 4 chambered heart stage at 34 days of gestation. But the moderator band was first observed in the right ventricle of a 42-day embryo. Bundlization and initial differentiation of cardiac muscle fibers and Purkinje cells were observed in 46-49-days embryos. Conduction tissues were ensheathed by the fibro-reticular connective tissue on the 49th day. Grossly identifiable moderator band occurred in the right ventricle on day 51, but in the left ventricle it happened only after 60 days. On day 71 a strong, thick, muscular moderator band grew in the right ventricle. Between 94-99 days the moderator bands of both ventricles assumed typical postnatal-type morphology and disposition. They grew thicker and stronger at a much faster rate in the late prenatal subjects. Cardiac muscle fibers were striated branched and showed intercalated discs. The Purkinje cells located peripherally spread myofibrils and single or multiple nuclei, these mostly occurred in groups surrounded by fibro-reticulo-elastic connective tissue sheath.

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AUGMENTED REALITY PRESENTATION OF ANATOMICAL VARIATIONS: EXAMPLE WITH ABERRANT RIGHT SUBCLAVIAN ARTERIES

HONG T, TAMURA K, THOMPSON J, LOZANOFF BK, LABRASH S, MATSUI T, LOZANOFF S

Department of Anatomy, Biochemistry, and Physiology, University of Hawaii John A. Burns School of Medicine, Hawaii, USA

Introduction: Clinical recognition of anatomical variations is critical for proper diagnosis and treatment. However, spatial arrangements and underlying mechanisms are difficult to conceptualize. Augmented reality (AR) can provide a novel method to enable rapid and effective understanding of variations.

Objective: The purpose of this study was to develop a computer model of an aberrant right subclavian artery (ARSA) and assess its usefulness within the context of anatomy education.

Materials and Methods: Two ARSA variants were identified during routine anatomy dissections, and quantitative characterization was performed. A plastinated heart was generated and subjected to photogrammetry. Utilizing quantitative features of dissected anatomical specimens, the heart was modeled, polished and viewed within AR space. A video was created utilizing AR projection and a clip of the proposed embryological mechanism of ARSA. Audio descriptions in English and Japanese languages were synced with the video and presented to students (n=161) who subsequently completed a survey.

Results: Students found the clip with AR to be helpful for understanding ARSA (scored as 4.2 ± 0.9; 1, not helpful; 5, very helpful). While four students (2.5%) responded that a textbook/journal article is more useful, 64 (39.8%) believed the clip alone and 93 (57.8%) felt the clip with text was helpful for understanding ARSA. Most (n=154, 95.7%) would use AR tools in the video for learning anatomy, stating benefits that included the ability to visualize and manipulate structures, and good clarity and emphasis on specific structures.

Conclusions: The AR tool and clip, together with traditional anatomy resources are valuable, since important spatial information is provided facilitating a rapid understanding of variations. In the classroom, AR may also be helpful for learning complex normal anatomy concepts. Work is being directed at developing quantitative tools to assess the educational usefulness of AR.

PERSISTENCE OF UMBILICAL ARTERY IN THE MEDIAL UMBILICAL LIGAMENT: CLINICAL ASPECT

KAUSHAL P, RANI N

Department of Anatomy, All India Institute of Medical Sciences, New Delhi, India

Introduction: Knowledge of anatomic variants on the anterior abdominal wall has often been underestimated. Minimal access surgery (MAS) involves the creation of pneumoperitoneum for improving visualization of the viscera which is established by blind insertion of either a Veress needle or trocar. Since the initial placement of the trocar is the most dangerous aspect of MAS, understanding of the anatomy of this region becomes imperative.

Objectives: To observe the variations in the medial umbilical ligament (MUL) with respect to persistence of the umbilical artery (UA).

Materials and Methods: of 24 cadavers were observed during routine dissection (carried out according to the Cunningham's Manual of Dissection volume II) of the undergraduate students.

Results: The medial umbilical ligaments is the fold of peritoneum raised bilaterally by the obliterated UA, which arise from the anterior division of the internal iliac artery (AIIA). The distal part obliterates to form the MUL, while the proximal part remains patent as the superior vesical artery (SVA). In the present study, 23 cadavers presented with an obliterated UA with normal MUL anatomy, however, in one elderly male cadaver, we observed a small mesentery associated with the right MUL along with a persistent underlying UA. Both the UA and SVA were seen as separate branches of the AIIA. The length of the UA from the origin was 37cm, and it ran inferior to the ureter near its origin, and the vas deferens after it emerged from the deep inguinal ring. A preliminary grading scale for the MUL was proposed by Tokar and Yucel, based on the anatomical appearance of the MUL in 126 patients (aged 28 days - 17 years). These investigators reported 11% of cases with no visible ligament (grade 0), 50% of cases with MUL as a fibrous cord without web formation (grade 1) while 39% of cases presented a fibrous cord with a web in the MUL (grade 2). Here, we propose a new category in the existing classification, with the MUL associated with a mesentery and containing a persistent UA.

Conclusions: A few clinical reports have associated the presence of persistent UA with hydronephros and lower flank pain, highlighting the need for examining the presence of aberrant vessels in the differential diagnosis of distal ureteric obstruction. Furthermore, the possibility of an anomalous UA compressing the vas deferens cannot be ruled out. Besides, awareness of such anatomical variants of the MUL is of relevance as they may expedite a surgeon determining the site of safe trocar insertion in the lower abdomen, preventing technical difficulties during MAS, and also assist in planning appropriate excisions of such structures to provide space for exploration.

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THE VALUE OF USING PLASTINATED SPECIMENS FOR TEACHING ANATOMY AT THE UNIVERSITY OF CAPE TOWN

KEET K

Division of Clinical Anatomy and Biological Anthropology, Department of Human Biology, Faculty of Health Sciences, University of Cape Town, Observatory, Western Cape, South Africa

Introduction: The Department of Human Biology at the University of Cape Town has a fully-equipped plastination laboratory that produces dry, odourless specimens as an alternative to traditional wet specimens for teaching Anatomy. The use of wet specimens is being supplemented with plastinates in consultation with the lecturing staff to ensure that the practical teaching needs are met in courses where whole body dissection does not take place. Plastinated specimens provide several advantages over wet specimens, such as ease of storage, as buckets of harmful formalin are not required. Plastinates are also more pleasant to handle by staff and students as they are dry and gloves are not required.

Objective: The aim was to survey students who are studying Anatomy to find out whether plastinates aid in their learning more efficiently than wet specimens and whether the students support the increased use of plastinates for teaching Anatomy in the practicals.

Materials and Methods: Students studying Anatomy in the first and second year Health and Rehabilitation Sciences courses were selected for the sample. A cross-sectional study was undertaken by means of a five-point Likert scale survey consisting of questions about background information, such as degree registered for, and previous exposure to anatomical specimens. Specific questions regarding the physical appearance of plastinated and wet specimens were included, as well as the students' opinions about the use of both types of specimens. The survey was anonymous, and ethics approval was obtained from the Human Research Ethics Committee. The scale ranged from 1 (strongly disagree) to 4 (strongly agree) with 0 being "unable to say". Descriptive statistics were used and the data were represented as percentages, and displayed on bar graphs. The non-parametric Wilcoxon signed-rank test was used to determine whether there were any significant differences in the responses between the first and second year classes.

Results: The response rate was 17%, with a total number of 47 students completing the survey. Previous anatomy exposure was reported in 60% of the sample, namely from high school biology or first year Anatomy courses. There were no statistically significant differences between the responses of the first and second year students for all the questions. Just over half of the students had heard of plastination (51%), with 32% reporting attendance at the Body World's exhibitions. Most of the students found the odour of plastinates to be less strong than that of wet specimens (83%) and supported the use of them in Anatomy practicals (80%). There was support for the continued use of wet specimens as 51% of students stated that they would not prefer the exclusive use of plastinates for exam revision.

Conclusions: The opinions of the students studying Health and Rehabilitation Sciences support the continued use of both plastinated and wet specimens in the Anatomy practicals in the Department of Human Biology at the University of Cape Town.

TOWARDS A GEOMETRICALLY ACCURATE HUMAN UPPER AIRWAY MODEL: CONTINUOUS POSITIVE PRESSURE DILATION IN CADAVERS

KUTSUKUTSA J[1], SAMAN Y[1], NAIDU ECS[2], AZU OO[2,3]

[1] *Department of ENT-Head and Neck Surgery, University of KwaZulu-Natal, South Africa*
[2.] *Disciplie of Clinical Anatomy, Nelson R Mandela School of Medicine, University of KwaZulu-Natal, South Africa*
[3.] *Department of Anatomy, Faculty of Health Sciences, University of Namibia, Namibia*

Introduction: Obstructive sleep apnoea is a high morbidity condition characterised by repetitive upper airway closure causing intermittent hypoxia. There is currently no intervention that is both acceptable and effective. The full role of different anatomical structures and patterns of deformability is not yet understood.

Objective: Geometrically correct human upper airway models are vital for any flow and deformability studies yet there is no single best method of recreating the human upper airway.

Materials and Method: Appropriate specimen preparation is important in anatomical model recreation. Hollow organs require dilation to increase flexibility and overcome rigor. Continuous positive pressure ventilation (CPPV) has been used in forensics to overcome rigor in the airway prior to forensic imaging, with success. We envisage a role for CPPV in dilation of the human upper airway for a geometrically correct reconstruction. Our project is set within the Department of Anatomy at UKZN. It was granted full ethics BE037/17 from our UKZN Biomedical Research Ethics Committee.

Results: The project is experimental with a control and experimental group involving a total of 10 cadavers purposively sampled. All 10 initially underwent computed tomographic 3D reconstruction of the upper airway, followed by silicone casting for the control group, and CPPV for the experimental group, for 5 days. CT 3D reconstruction for the experimental group was repeated on day 3 and day 5 whilst being ventilated. The experimental group then underwent silicone casting on day 5. Silicone cast and 3D cast analysis was undertaken to measure geometrical correctness, effect of CPPV dilation, and compare silicone casts to 3D casts of same cadaver.

Conclusions: The results set the stage for creation of a geometrically correct HUA model, creating a model suitable for use in further OSA flow and deformability studies, and augment the body of data on HUA reconstruction. The project is on-going.

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EPOXY TECHNIQUE OVERVIEW

LATORRE R

University of Murcia, Murcia, Spain

Epoxy plastination techniques were designed to preserve transparent body sections. Although several techniques have been described, the E12 (Biodur®) is the best known and widespread technique. Some aspects about E12 protocol:

Preparation of specimens and slicing:

Usually we work with fixed specimens to obtain the sections. However, fresh material is also an option. To obtain transparent sections the specimen should be frozen at the lowest possible temperature, at least -70 or -80° C. Thus, 1.5-3 mm thick sections are obtained. The use of -40° C acetone during the cleaning of the sawdust prevents sections from thawing.

Dehydration by freeze substitution and defatting:

The main difference with regular dehydration in plastination techniques is the need to remove the fatty tissue to get the highest transparency, especially in areas of connective tissue. This is done with several baths of acetone or methylene chloride at room temperature.

Forced impregnation:

The impregnation solution employed consists in epoxy E12 plus the hardener E1. The dehydrated sections are immersed in the impregnation mixture, and forced vacuum is performed at room temperature for 6-12 h. Impregnation is completed when pressures reached are below 5 mmHg.

Polymerization:

Polymerization must be done immediately after finishing the impregnation, which prevents the slices from polymerizing in the impregnation chamber. The temperature, combined with the hardener E1 acts as the polymerization agent.

Although this technique has become established as the best choice for learning sectional anatomy as the basis for diagnostic imaging, its main application is in anatomical research. The low refractive index of the epoxy resin E12 with its minimal shrinkage during polymerization makes it the method of choice to study different tissues, in different planes of cutting, from macroscopic to microscopic levels. The absence of manipulation and decalcification means that the topography of anatomical structures are not disturbed. The removal of fat tissue allows the connective tissue, blood vessels and nerves to be identified quite clearly, without any manipulation.

GENERAL PRINCIPLES OF IMPREGNATION (SILICONE TECHNIQUE)

LATORRE R

University of Murcia, Murcia, Spain

Concept: This is the most critical step in plastination. The impregnation of a biological specimen with a curable polymer is based on the difference in boiling points of the volatile intermediary solvent and the polymer-mixture. The replacement of the intermediary solvent (acetone) by silicone is done under forced impregnation. Forced impregnation: The physicochemical characteristics of acetone allow, besides acting as a desiccant for dehydration, its progressive substitution by the impregnation solution under vacuum conditions. This solution contains silicone S10 plus a catalyst (S3) that acts as silicone chain extender.

Equipment: The impregnation unit has the follow components: (i) vacuum chamber for plastination, (ii) vacuum pumps, (iii) valves and vacuum tubing, (iv) vacuum measuring devices: Bennert-type manometer vacuum gauge.

Protocol: The acetone within the tissues of the dehydrated pieces is replaced in a controlled way by the impregnation solution. This replacement is done at cold temperature (-15 / -20° C) and under vacuum conditions, therefore it is known as forced impregnation. Adjusting the pressure in the impregnation chamber through the valves makes it possible to control the impregnation speed, by adjusting the manometers to monitor the pressure. The impregnation rate is reflected by the number of acetone bubbles that appear on the surface of the impregnating solution. Fast impregnation results in an imbalance between the amount of acetone removed from the specimens and the volume of impregnation solution that reaches the tissues, and consequently, a higher degree of shrinkage. In general, the impregnation phase is considered complete when the pressure reached is below 5 mmHg, which occurs after several weeks. Small pieces and hollow organs can be impregnated in a week, while solid organs or large items such as whole cadavers may take several months.

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A GRAPHIC PIPELINE FOR COMMUNICATING ANATOMICAL VARIATIONS THROUGH ANIMATED ILLUSTRATIONS

LOZANOFF BK[1], HONG TM[1], BEZARD G[1], LABRASH S[1], TUNALI S[1 2], LOZANOFF S[1]

[1]Department of Anatomy, Biochemistry & Physiology, John A. Burns School of Medicine, University of Hawaii at Manoa, Honolulu, HI 96813, USA
[2]Department of Anatomy, TOBB University, Ankara, Turkey

Knowledge of anatomical variations is critical to avoid complications during clinical interventions, as well as to provide a basis for understanding basic morphogenetic mechanisms. Although useful presentations exist in the literature, many comprise photographs or illustrations, often ignoring the complex, spatial three-dimensional relationships. The use of electronic media to present scientific communications represents a major technological advantage for presenting anatomical variations. The purpose of this study is to present a graphics pipeline for generating animations of anatomical variations. The pipeline consists of four steps, including: data collection, 3D-modeling, model polishing, and presentation. Base structures are generated using a hand-held scanner or medical images. The second step, 3D modeling, is achieved using Scan Soft (scanner) or ER3D (medical images) software to render initial models. Polishing is achieved utilizing Maya software (Mudbox) to adjust surfaces, and then converted to Quicktime animations for presentation. Two anatomical variants are presented, including an aberrant right subclavian artery, and a third head of the biceps brachii muscle. Quicktime Movies present the structures with clarity, and can be individually manipulated by the user to examine three-dimensional relationships. For additional realistic presentation, the obj foundation models were ported to a Z-space platform and projected into 3-D space. Individual model elements could be individually manipulated to provide even greater spatial resolution. It is concluded that animations provide a useful approach for visualizing and presenting anatomical variations.

UTILIZING PLASTINATED SPECIMENS TO GENERATE AND ARCHIVE COMPUTERIZED MODELS OF ANATOMICAL VARIATIONS WITH AUGMENTED AND VIRTUAL REALITY TECHNOLOGIES

LOZANOFF[1] S, HONG[1] TM, THOMPSON[1] J, LOZANOFF[1] BK, LABRASH[1] S

[1]Department of Anatomy, Biochemistry & Physiology, John A. Burns School of Medicine, University of Hawaii at Manoa, Honolulu, USA

Introduction: Anatomical variations are frequently encountered in the gross anatomy dissection laboratory. Unfortunately, it is unlikely that a program can retain the novel finding for future students to observe. It would be beneficial to retain a model of the anatomical variation for future students to experience. The purpose of this presentation is to present a strategy for retaining novel variations uncovered in a medical gross anatomy course.

Resources: Multiple variations were identified during gross anatomy dissection; these were then plastinated and subjected to digital photogrammetry (agisoft.com). Three-dimensional meshes were generated and then polished, based on quantitative measurements recorded from the original dissections using Maya® software (autodesk.com). The model was then ported to Unity-based platforms including Aurasma, Augment, Sketchfab, Hololens (Microsoft.com), Z-Space (zspace.com), and viewed.

Description: The anatomical models were viewed from all perspectives and an understanding of embryological development could be more fully understood. Models could be viewed and manipulated in a collaborative fashion, further promoting small-group learning consistent with the approach commonly pursued by dissection.

Significance: This anatomical variation pipeline represents a novel process for recording and archiving observations from year-to-year within a program. Models could be potentially shared between sites depending on the commonality of Unity platforms.

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ETHICAL ISSUES AROUND PLASTINATION OF HUMAN MATERIALS

IHUNWO AO

School of Anatomical Sciences, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

Human anatomy dissection is a core activity in the Anatomy curriculum offered in our School of Anatomical Sciences, with the majority of the cadavers obtained through the body donation program. The same can be said for most anatomy courses in medical schools on the African continent, with the exception of most cadavers obtained from unclaimed bodies. However, some medical schools do have challenges in securing cadavers for dissection, and in these places there is a need for plastination of the few cadavers received. While the International Federation of Associations of Anatomists (IFAA), through the Federative International Committee for Ethics and Medical Humanities (FICEM), has presented guidelines on acquiring cadavers through the body donor program, this remains a challenge in Africa, due to cultural and religious practices. Most cadaver dissections are premised on Human Tissue Acts of Health Departments in different countries, which are explicit on the acquisition and use of cadavers, but without making reference to plastination. Ethical issues therefore become critical for plastination of human specimens, as it rightly provides an extended period of usage of the cadaveric materials, which is to the advantage of the Anatomy departments. This paper will highlight and discuss questions such as 'How well informed are the body donors of what their remains will be used for, and how? Are there areas to draw a line? It is envisioned that other ethical questions will be generated for discussion.

RESIN-REPLICA BOVINE AND EQUINE CARPAL AND TARSAL BONES

OLIVIER, W

Department of Anatomy and Physiology, Faculty of Veterinary Science, University of Pretoria, Pretoria, Gauteng, South Africa

Introduction: Osteology is an essential component of the veterinary anatomy curriculum. At the beginning of the 2nd year at the Faculty of Veterinary Science, University of Pretoria, groups of 4 students are supplied with a set of bone boxes which they have to share. The boxes contain all the relevant bones of the equine, bovine, canine and ovine species. For convenience, the carpal and tarsal bones of the equine and bovine species are arranged in their normal anatomical position, and attached to each other by means of string. These bones are of specific importance for the veterinary surgeon. The current teaching situation creates a problem, as 4 students have to share these bones during the year and then return them at the end of the course. This problem is exacerbated by a dramatic increase in student numbers from 140 to 220. The ideal solution would be to provide each student with a set of carpal and tarsal bones which they could keep permanently. Since it was not a viable option to obtain large quantities of animal bones, it was decided to make replicas using the resin-replica technique.

Materials and Methods: An adult horse and ox were donated to the department, and the carpal and tarsal joints removed. The soft tissue was manually cleaned from the bones, after which they were boiled in water for 3 days. The bones were then cleaned thoroughly and placed in a peroxide solution for 3 days, after which they were taken out and left to dry. They were then defatted by boiling in trichloroethylene for 3 days. Each individual bone was then placed in a container into which silicone was poured. The silicone was allowed to cure, after which the bone was removed leaving an exact negative mould of the bone. Resin was then poured into the mould and allowed to cure. The dry resin-replica was removed and refined using a sharp blade until it resembled the original bone. The resin bones were arranged in their normal anatomical position and attached loosely to each other by means of string threaded through holes drilled in the bones.

Conclusions: The silicone moulds, if made correctly, can be used to produce large numbers of resin replica bones of high quality without sacrificing animals.

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DIFFERENT DEPLASTINING METHODOLOGIES FOR MAKING HISTOLOGICAL SECTIONS OF SPECIMENS PRE-PLASTINATED WITH BIODUR® S10 / S3

RAMOS ML, DE PAULA TAR, ZERLOTINI MF, SILVA VHD, CARAZZO LB, DE PAULA MF, SILVA FFR, SANTANA ML, SILVA LC, FERREIRA LBC

Department of Veterinary Medicine, Federal University of Viçosa, Viçosa, MG, 36570-000, Brazil.

Introduction: Plastinated specimens have advantages over organs preserved in formalin including: low toxicity, odorless, dry, clean and durable specimens. One of the most interesting and potentially useful qualities of silicone-plastinated tissues is the preservation of structures at the histological level. This implies that the specimen can be preserved in a form that is easily stored, while maintaining the full potential for future histological and histopathological studies.

Objective: The objective of this study was the development of protocols for the preparation of histological slides from plastinated specimens with BIODUR® S10 / S3 technique.

Materials and Methods: For this study, samples of aorta, heart, and kidney of pigs were used. Four treatments were made to investigate protocols for light microscopy (LM). For comparative use, non-plastinated tissue was used (treatment 1), as follows: immersion in 10% formalin for 48 hours at room temperature. After fixation, tissue samples were processed for LM histology. For treatments 2, 3 and 4, samples from specimens plastinated with Biodur® S10/S3 were used. Treatment 2: plastinated fragments were directly embedded in paraffin without previous deplastination and blocks were made. Treatment 3: plastinated tissue samples were deplastinated by immersion in 99% ethyl alcohol for 24 hours, and then in methylbenzene for 48 hours. After deplastination, the fragments were processed for LM histology. Treatment 4: plastinated samples were deplastinated in xylene for 36 hours and processed for LM histology. Serial sections of 5 µm thickness were obtained in the microtome for each specimen, and stained with hematoxylin and eosin or Verhoeff techniques.

Results: Histological results from the different treatments were compared. Plastinated (treatment 2) and deplastinated with methylbenzene, and desplastinated with xylene (treatments 3 and 4) sections revealed a similar preservation of the histological characteristics of the tissues as fixed tissue (treatment 1), but with low affinity to hematoxylin. In the kidney, the integrity of the renal capsule was preserved in all treatments. The renal cortex showed damage, and the epithelium of the renal tubule showed some retraction in treatments 3 and 4. In the heart, changes in the structure of the myocardium were visible in treatments 2, 3 and 4. With the aorta, it was not possible to visualize the *vasa vasorum* in the adventitial tunica following treatments 2, 3 and 4, and there were areas of refraction in the connective tissue. All treatments showed elastic lamellae relatively organized with Verhoeff stain.

Conclusions: We observed that deplastination with xylene and methylbenzene both produced a material similar in quality, and similar to plastinated tissue.

EXPRESSION OF cKIT PROTEIN AS A PROGNOSTIC MARKER IN GASTRONEUROENDOCRINE TUMORS

RANI N, KASAPURAM D, DHINGRA R, SINGH S, PAL S, KUMAR R

All India Institute of Medical Sciences, New Delhi, India

Introduction: Gastroneuroendocrine tumors (GNET) are rare, with an incidence of 10-30% of all carcinoid tumors. The molecular mechanism and progression of the disease remains unclear. These tumors are malignant endocrine neoplasms that present diverse clinical behaviors. Therefore, identification of biomarkers of GNETs is important for stratification of the prognosis of patients. Recently it was reported that cKIT (a transmembrane receptor tyrosine kinase) has an important prognostic role in various solid cancers and pancreatic NETs. So, we aimed to evaluate the expression of cKIT in GNETs.

Objective: To study the prognostic significance of cKIT in gastroneuroendocrine tumors, and its correlation with histopathological findings.

Materials and Methods: Five surgically resected NETs were obtained after taking ethical clearance from the GI surgery department, AIIMS, New Delhi. Clinical history and pathological findings were recorded. Tissues were fixed in 4% paraformaldehyde, and paraffin blocks were processed for immunohistochemistry. Rabbit monoclonal antibody (1:200) was used to assess the expression of cKIT using the streptavidin biotin complex method. Images were captured using Nikon Ti-S microscope, and intensity was analysed.

Results: Each NET was graded according to WHO guidelines, and the Ki67 index was calculated. Expression of cKIT was observed in the cytoplasm. The intensity of cKIT expression was low in grade1 tumors whereas it was high in grade 3 tumors indicating the variable expression of cKIT.

Conclusions: Expression of cKIT correlates very well with WHO grading and Ki67 index. Therefore, cKIT may be used as prognostic marker, and possible molecular target, for therapy in patients with NETs.

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THE MORPHOLOGY OF THE MAXILLARY AIR SINUS UTILISING 3D RECONSTRUCTED MODELS

RENNIE CO, HAFFAJEE MR, SATYAPAL KS

University of KwaZulu-Natal, School of Laboratory Medicine and Medical Sciences, Discipline of Clinical Anatomy, South Africa

Introduction: The maxillary air sinus varies according to age, however, there are limited studies that have illustrated its 3D form over time.

Purpose: This study aimed to classify the maxillary air sinus by the shape, number of septa and scallops in a 1 to 25 year age group, utilising computerized tomography (CT) scans and 3D reconstruction.

Materials and Methods: CT scans (n=480) were reviewed from the picture archiving and communication system (PACS) of the state and private hospitals in Pietermaritzburg and Durban KwaZulu-Natal (KZN), South Africa. The sample consisted of 276 males and 204 females, 1-25 years of age, and of two population groups, black African and white. Morphological traits such as the presence of the air sinus, scalloping, and septa within the air sinuses were categorised. In addition, the shape of the 3D model of the air sinus was analysed anteriorly (coronal) and laterally (sagittal) adapting the classifications by Kim (1962) and Kim *et al.* (2002).

Results: The maxillary air sinus was present bilaterally in n=477 individuals (99.4%). Five different anterior shapes *viz*. Type 1 (triangular), Type 2 (inverted triangle), Type 3 (square), Type 4 (irregular) and Type 5 (rectangular) were identified in the anterior view. The shape was associated with age and population groups ($p<0.05$). In the lateral view, the maxillary air sinus appeared to be quadrilateral with differences noted along the inferior wall. Intrasinus maxillary septa were more evident in the anterior region of the maxillary air sinus (27.9% right; 28.5% left). The maxillary septa were more common in females (37.9% right; 39.4% left) than in males (28.5% right; 30.3% left). They were also more commonly observed in the white cohort (63.8% right; 68.1% left) than in the black African cohort (29.1% right; 30.5% left). Scalloping in the axial plane from above along its anterior border was also observed.

Conclusions: An in-depth classification of the morphology of the 3D form of the maxillary air sinus according to age (1 to 25 years) was established. The shape of the air sinus changed in the form according to age. Laterally, the shape was related to the development of the teeth, as the inferior wall of the air sinus was classified. Surgically, the air sinus morphology is essential for dental procedures such as sinus augmentation or dental implants, and anthropologically, in forensic identification.

VITAMIN K-DEFICIENCY AFFECTS SPERMATOGENESIS IN SPRAGUE-DAWLEY RATS

SANYAOLU AO[1], OREMOSU AA[1], OSINUBI AA[1], VERMEER C[2], DARAMOLA A[3]

[1] Department of Anatomy, College of Medicine, University of Lagos, Lagos, Nigeria
[2]R&D Group VitaK, Maastricht University, Maastricht, The Netherlands
[3]Department of Anatomic & Molecular Pathology, College of Medicine, University of Lagos, Lagos, Nigeria

Introduction: Vitamin K deficiency in extrahepatic tissues such as the bone and the heart contribute to conditions such as osteoporosis and cardiovascular disease respectively. However, its impact on some other extrahepatic tissues, like the reproductive system remains largely unknown.

Objective: This study investigated the impact of dietary vitamin K deficiency on the testes of Sprague-Dawley rats.

Materials and Methods: Histological examination was carried out on testes fixed in modified Davidson fluid. Semen samples obtained from the cauda epididymis were used to analyse the semen of the Sprague-Dawley rat. The experiment was in three phases (two, four and eight weeks). In each phase, there were two groups (control group and warfarin-induced vitamin K-deficient group (VK def)) of five rats each. All the rats were allowed to acclimatize for two weeks before the commencement of the study. Quantitative data were analysed using one-way ANOVA to compare variables, and results presented in tables and figures.

Results: The results show histopathological changes in the VK def group ranging from delayed spermiation, the presence of multinucleated giant germ cells in the tubules, exfoliation/degeneration of germ cells, poor spermatogenic activities, low sperm count, poor motility, and increased abnormal sperm morphology, when compared to the control groups.

Conclusions: The findings of this study clearly demonstrated that dietary conditions (e.g. vitamin K deficiency) in the body negatively impact on the male reproductive capacity.

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GENERAL ISSUES OF SAFETY IN PLASTINATION

SCHILL V

BIODUR® Products GmbH, Im Bosseldorn 17, Heidelberg, Germany

When people intend to start plastination in their institution they are sometimes not aware of the scope of equipment, auxiliaries and chemicals they need. And, to an even lesser extent, are they aware of the potential hazards which arise from the plastination activity. Special chemicals may possess acute or chronic health hazards. Acetone, which is used for dehydration and defatting, is a flammable liquid and therefore brings about fire and explosion hazards.

In this presentation, information is given about the characteristics of the most commonly-used chemicals in plastination. Technical room ventilation or workplace ventilation is required to keep the concentration of hazardous vapours below their respective concentration limits. Personal protective equipment must be used to allow for safe work when handling these substances.

Avoiding the risk of fire and explosion caused by handling of acetone or other flammable solvents is achieved by a bundle of measures: proper laboratory furnishings (ventilation system, electrical installations, etc.) are of importance as well as the equipment used for plastination. Furthermore, the scale of your work determines the safety measures: running a large-scale plastination lab, where you may store and handle several cubic metres of acetone, understandably requires other devices and utilities than working at a smaller scale, with a small equipment package where you dehydrate your specimens in barrels of just 20 or 30 litres of acetone.

SILICONE TECHNIQUE AT ROOM TEMPERATURE

STARCHIK D

International Morphological Centre, Saint-Petersburg, Russian Federation

Purpose: There are two silicone plastination techniques all over the world. The classical one (S10) was introduced by Gunter von Hagens in 1977. It uses a reactive silicone impregnation mixture, and needs a freezer to keep it cold for slowing down polymerization. The second technique was proposed by Daniel Corcoran & Dow Corning Corporation in 1998, and it uses an unreactive silicone mixture, and carries out impregnation at room temperature (RT). Cold and RT silicone plastination techniques have differences in polymer components in the impregnation mixture, and also in the sequence of their combination in the curing stage. Because the RT technique is less popular than the cold method, it is advisable to know how to realize RT plastination stages, and what features those plastinated specimens have.

Materials and Methods: We plastinated a variety of organs, regions and whole body specimens with the RT technique using standard procedures (dissection, dehydration, defatting, impregnation, curing), and evaluated the advantages and shortcomings of this method. Criteria used for evaluation included shrinkage, duration of impregnation and curing, quality of plastinated specimens, the need for extra equipment and its maintenance, as well as other cost considerations. Cylindrical core samples of parenchymatous organs were used to efficiently evaluate shrinkage and plastination duration. Core cylinder volume was evaluated at the end of each stage of the process by fluid displacement.

Results: The first three steps for the RT procedure are identical to the cold technique, and the difference is in the impregnation and curing steps only. Room temperature impregnation composition consists of 93% silicone and 5% cross-linker. That is not a reaction mixture, and there is no need to keep it in a freezer. The molecular weight is about 500, and 12-second dynamic viscosity. The average shrinkage calculated for tissue cores plastinated by the RT technique (16.2 ± 1.49 %) was 1.5 times less than by the cold method ($p < 0.05$). The total duration of impregnation and curing stages of samples for the RT plastination was proved to be 1.54 times shorter than that of S10 technique. The silicone impregnation-mix for the RT technique, because of its low viscosity, drains very easily from impregnated hair, fur, and feather specimens, which is a large time saver. Hollow organs and body part specimens plastinated by the RT procedure were less flexible, more fragile, and harder after curing than those made with the cold technique. There is no need for an additional freezer for the impregnation vacuum chamber, or a special chamber equipped with a fan, an aquarium pump and desiccant for RT technique.

Conclusion: The specimens plastinated with the RT technique are less flexible and elastic, but this process allows production of good quality specimens with minimal shrinkage, and in a shorter period of time. This method is preferable for whole brain, parenchymatous organs, body parts, fetus, fur/hair/feather-covered specimens, reptiles & fish, as well as for long-time formalin-fixed specimens, for archaeological and fossil objects. The room temperature plastination laboratory is more economical to set up.

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CLINICAL PLASTINATION

STARCHIK D

International Morphological Centre, Saint-Petersburg, Russian Federation

Purpose: Plastination was invented and developed as a technique for preserving biological tissue, and producing anatomical specimens for studying human and animal anatomy. The added potential of plastination for clinical research was discovered later. Clinical plastination is a special area of scientific exploration and clinical education, with particular interest in the field of applied medicine.

Materials and Methods: Different organs (hearts, lungs, brains etc.) and body parts were taken by autopsy from cadavers, and fixed in formalin. We used the room temperature silicone plastination, and epoxy technique standard protocols for producing demonstration specimens for particular clinical requirement, and for anatomico-clinical research. Injection of colored silicone reactive mixtures was used to contrast arteries and veins. Prosthetic heart valves, rings, electrodes, and stents were implanted during dissection or after curing. We used cutting of hard epoxy-impregnated anatomical blocks to get thin sheet plastinated slices of organs with metal and plastic implants and devices.

Results: Silicone plastination has some innovative approaches to enhance the quality of educational process of clinical disciplines. Three modifications of silicone plastinated specimens were developed: 1) pathological organs to demonstrate diseases, congenital and acquired defects; 2) modified types of surgical dissections for studing clinical anatomy; 3) organs and body parts with implanted metal or plastic construction, valves, prosthetic devices and electrodes. Silicone plastinated specimens are useful for diaphanoscopy, endoscopy of joints, gastrointestinal tract and branches, radiography, CT and MRI tomography. Sheet plastination techniques with epoxy resin have more advantages for clinical research than silicone plastination. It may be used for studing topographical anatomy and tomography. Despite it being more complicated than the silicone plastination technique, the modificated epoxy method is the method of choice to research stents in coronary arteries and metal elements in bones.

Conclusion: Clinical plastination brings new facts in clinical research, and provides new opportunities for using plastinated specimens to expand the clinical manner of thinking. It could be made available in clinical centers to allow improved effectiveness of teaching of ultrasound, and radiographic and surgical anatomy and techniques. It is advantageous to combine routinely-used diagnostic and surgical procedures with plastinated specimens, as it gives a better understanding even to the specialists in terms of clinical necessities. Sectioning hard anatomical blocks plastinated with the epoxy technique offers great new opportunities for anatomical and clinical research.

MULTI-DISCIPLINARY USE OF A HUMAN PLASTINATION MODEL FOR GROSS ANATOMY REVIEW

SULLIVAN K, ILIFF S, HERMEY D

Lincoln Memorial University – DeBusk College of Osteopathic Medicine, Harrogate, TN, USA

Introduction: Plastination is a unique process that provides a direct representation of the human body. Human models are advantageous for improving comprehension of gross anatomy concepts because real time interpretation and familiarization of structures can easily be obtained, compared to the use of traditional models. Traditional models are limited because they only provide a 2D view. The ability to use the same human model in various levels of education, such as high school, undergraduate, and more specifically, graduate, physician assistant, and medical school curriculum, is what makes them distinctive and convenient.

Objective: To create a human plastinate that displays anatomical relationships and high-yield learning concepts related to human gross anatomy as an effective instructional tool, specifically focused towards medical students.

Materials and Methods: Wet dissection was performed using a donor obtained through the Lincoln Memorial University – DeBusk College of Osteopathic Medicine's Anatomical Donation program. The view of the specimen extended from the first cervical vertebra to the mid-humeri and mid-femora, including focal dissections of the thorax, abdomen, and pelvis. The posterior aspect of the donor integrated superficial and deep muscular dissections of the back and gluteal region. The dissection was thoughtfully rendered to reveal anatomical relationships that are spatially and visually relevant for learning medical gross anatomy. The dissection also integrated concepts that can be difficult for students to assess in standardized wet dissections, as well as concepts thought to be high-yield in patient care.

Results: The following items can be appreciated with our model (and are not limited to): the structure and relationship of the first and second cervical vertebrae, the path of the vertebral artery through the cervical vertebrae, the exit of the brachial plexus between the scalene muscles, the muscles of the anterior neck, the spatial arrangement of the heart and lungs *in situ*, the intercostal nerves and arteries of the anterior chest, the structures of the anterior chest wall, the chambers of the heart, the pleural spaces and their relationship to the diaphragm in the thoracic cavity, the major branches of the abdominal aorta, the kidneys, the paracolic gutters in the posterior abdominal wall, the superficial and deep muscles of the back, the superficial and deep muscles of the gluteal region, the structures of the femoral triangle, and various muscles of the proximal upper and lower limbs.

Conclusions: This human plastinate can easily be presented to coincide with variable curriculum objectives. While this model can be utilized to build the foundational groundwork of human gross anatomy in high school and undergraduate studies, the major aim is to provide professional students (graduate, physician assistant, and medical) with a model that will advance their more intricate understanding of the human body. Students of medicine will be able to apply clinical scenarios to various anatomical structures and reinforce highly important material related to direct patient care.

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ANATOMICAL AND DIAGNOSTIC IMAGING STUDY OF THE MEDIAL ASPECT OF THE CANINE ELBOW JOINT

VILLAMONTE-CHEVALIER A[2], LATORRE R[2], SOLER M[1], GIL F[2], SARRIA R[2], AGUT A[1]

[1] *Department of Medicine and Surgery, University of Murcia, Spain*
[2] *Department of Anatomy and Comparative Pathological Anatomy, University of Murcia, Spain*

Introduction: Anatomic, ultrasonographic (US) computed tomographic (CT) and magnetic resonance imaging (MRI) studies of the canine elbow joint have been reported separately.

Objective: The purpose of this study was to correlate the images resulting from the evaluation of the canine elbow joint by means of high frequency ultrasonography, CT, MRI, and plastinated anatomical sections, obtained on the same planes used in the imaging protocols.

Materials and Methods: Anatomical study: 10 forelimbs obtained from 5 adult German Shepherd-crossed breed dog (GSD) cadavers were frozen at -70ºC to obtain transparent sections (2mm thick) on the same planes as the imaging studies; anatomical sections were preserved using the E12 plastination technique. Ultrasonographic study: 10 elbow joints from 5 adult GSD dogs were evaluated using an 18 MHz linear array transducer. For the CT study: 6 elbow joints from 3 adult GSD dogs were evaluated, and reformatted images were obtained on the same planes as the ultrasonographic study. Magnetic resonance study: 6 elbows joints from 3 adult GSD dogs were scanned. Correlations between imaging techniques results and anatomical sections were assessed.

Results: The correlation of anatomical sections and imaging techniques allowed an accurate identification of multiple soft tissue and bone structures. High frequency US accurately identified the insertion tendons of brachialis and biceps brachii muscles, the medial collateral ligament and the medial coronoid process, whilst CT recognized the cortical and subchondral bone of the MCP, the trochlear notch of the ulna, the radial incisures, the anconeal process and the humeral condyles. The MRI assessed soft tissue structures such as cartilage, the flexor muscles and their tendons of origin, the course of the medial collateral ligament (MCL), and the insertion tendons of brachialis and biceps brachii muscles. There was an excellent correlation between the images from diagnostic imaging techniques and the transparent anatomical sections.

Conclusions: Our results support those of previous publications. This work, however, combines anatomical plastination and three diagnostic imaging techniques at once. The use of a high frequency transducer provided a greater ultrasonographic resolution of soft tissue structures allowing a better assessment and identification of tendinous structures. By means of MRI the course of the MCL extending to the fibrous sheath of the biceps complex was described for the first time. Correlation beyween plastinated anatomical sections and images from three different diagnostic imaging techniques leads to a more comprehensive understanding of the canine elbow joint. Moreover, it demonstrates the high value of the plastination techniques as a tool, not only for education, but for a better understanding of the clinical anatomy of the canine elbow joint.