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Creation of plastinated placentas as a novel teaching resource for medical education in obstetrics and gynaecology

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ABSTRACT

Introduction: Knowledge of the gross anatomy of the placenta is fundamental in order to help identify potential complications during pregnancy. The placenta is difficult to study without a three-dimensional appreciation of its structure. The aim of this study was to develop a collection of plastinated placenta specimens and accompanying clinical educational materials to provide learning resources for placental abnormalities and their associated pregnancy outcomes. These plastinates and educational modules were used as teaching resources for both undergraduate and post-graduate medical trainees in Obstetrics and Gynaecology.

Methods: Placentas were plastinated by S10 silicone plastination. Clinical education materials were created that included ultrasound images, photographs and information on the associated pregnancy outcomes. Utility of the plastinates was assessed using questionnaires completed by 70 medical students and 33 attendees at the 8th and 9th Annual International Human Placenta Workshop held at Queen's University, Kingston, ON. Attendees included graduate students, post-doctoral fellows, medical residents, research investigators and clinicians.

Results: Data collected demonstrated that 76.7% of medical student (n = 60) and 78.1% of Placenta Workshop attendees (n = 32) preferred plastinates as a supplemental learning resource compared to textbooks and images alone (36.7% and 37.5% respectively). All respondents also expressed the desire to have plastinated placentas available for future learning opportunities.

Discussion: Plastinated placentas are a valuable addition as teaching resources for many demographic groups with an interest in placental anatomy and pathology. Medical trainees and residents in Obstetrics and Gynaecology would benefit from the availability of plastinates as educational tools.

1. Introduction

The placenta is an essential organ during fetal development, one of critical importance for the exchange of gas and nutrients between the mother and the developing fetus. As such, a thorough knowledge of the anatomy of the placenta is critical to provide information regarding the health of both the mother and infant. At delivery, anatomical information is recorded regarding the weight, shape and size of the placenta, umbilical cord length, position, insertion and fetal membranes [1]. As this examination of the placenta is not routinely performed by a pathologist in an uncomplicated pregnancy, a general understanding of placental anatomy and pathology is important in the training of all medical students and residents in the area of obstetrics and gynaecology [1]. While we focus on understanding and researching the importance of the placenta from a developmental aspect, there is a significant gap in resources for teaching placental anatomy at any academic level.

Plastination is the general practice of removing water and lipids from biological tissues and replacing them with a curable polymer to produce specimens that are dry and odorless in nature, leading to resilient specimens that are ideal for teaching laboratories [2,3]. The general protocol of plastination involves fixation, dehydration, forced impregnation, and hardening [2,3]. Silicone polymers are the most widely used in the plastination process, as the specimens they generate are durable and are ideal for educational purposes [4].

Abbreviations: 3D, Three-dimensional; KGH, Kingston General Hospital; DiDi, Dichorionic diamniotic; MonoDi, Monochorionic diamniotic; IUCD, Intrauterine contraceptive device.

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The development of plastinates is a major improvement in the preservation of biological tissues and has revolutionized the way gross anatomy is taught across many disciplines [4–8]. The development of plastinates allows instructors to compliment and improve the quality of current teaching resources in the anatomical and pathological sciences. These plastinates allow students to more readily appreciate the difference between normal healthy tissues and diverse pathological specimens [9]. It is important to note that increasing the "hands-on" and self-directed learning opportunities is also important in learning 3D organization in structures that cannot be appreciated through the use of images or didactic teaching alone. Plastination has been widely used and is ever increasing in areas of anatomy [5], biology [6], chiropractic anatomy [7], pathology [9], human [4,5,8] and veterinary medicine [5].

Studies which have assessed the use of plastinates in medical laboratory sessions have evaluated these plastinates as additional teaching resources to be coupled with traditional teaching methods [8]. Studies established that both instructors and students alike found plastinates to be useful in a laboratory environment [10]. The utility of plastinates in many of these domains has not only been assessed in terms of structured courses and laboratories but also their integration into academic learning centers using self-directed learning modules [11–13]. There has been much discussion about the modernization of teaching methods used in undergraduate medical education, moving away from traditional didactic lectures and dissection laboratory to include a variety of resources [14–16]. From these studies there is consensus that no single method of teaching is more beneficial than the other, however learning opportunities are maximized when multiple learning modalities are used together to supplement didactic lectures [14,16,17]. Most medical anatomy curricula are now a unique amalgamation of lectures, dissection, use of prosections and plastinated specimens as well as the integration of other medical specialties such as radiology and surgery [15]. The addition of plastinates in the training of both undergraduate and post-graduate medical trainees can provide much needed resources in the field of reproduction and pregnancy, topics rarely covered in the context of a gross anatomy course.

The placenta, an organ critical in the study of pregnancy and embryology, has been described as a diary, which outlines pregnancy outcomes and complications, which are predetermined by the intrauterine life [18]. Other recent researchers have aimed to increase knowledge of placental anatomy and pregnancy complications by using a web-based initiative [19], however the development of plastinated specimens can benefit multiple groups aspiring to learn the anatomy of the placenta. Teaching of the macroscopic anatomy of the placenta in undergraduate and post-graduate medical education, as well as undergraduate medical education is limited. Although some concepts are being taught, literature on the development of teaching methods of placental anatomy and pathology is scarce.

Our aim was to determine if a collection of plastinated placenta specimens, and associated clinical outcomes, integrated, as educational modules are a useful resource for students' self-directed learning of placental anatomy at the level of undergraduate and post-graduate medical training in obstetrics and gynaecology.

2. Materials and methods

2.1. Pre-plastination specimen collection and preparation of placentas

Normal and pathological placenta specimens were collected at the Kingston General Hospital (KGH) either immediately or within 24 h following delivery. Placentas were stored at 4 °C until collection. Selection of specimens to be preserved was based on unique physical appearance of the placenta. The diagnosis of pathological features was completed by a physician upon inspection of the placenta following delivery. Fetal membranes were removed at the placental margin and discarded. The umbilical cord was cut in cross section to expose the umbilical vessels for cannulation. Blood was drained from the fetal vessels by means of intravascular cannulation where a 6″ straight arterial embalming tube (The Embalmers Supply Company, Connecticut, USA) was inserted into the umbilical vein. Size of the arterial embalming tube (3/32″ – 3/16″ O.D.) and attached plastic tubing (1/4″ – 5/16″ I.D. VWR, Pennsylvania, USA) were selected based upon the diameter of the umbilical vessels. Any residual or clotted blood on the surface of the placenta was removed by washing both the maternal and fetal surfaces with water. Following 60 min perfusion with laboratory water, placentas were placed into storage buckets (Uline Screw top pail with lid, S-156561 S-15636, Chattanooga, Tennessee, USA) and filled with water to allow residual blood to drain for 24 h at 4 °C prior to fixation.

2.2. Color vascular injection

The umbilical vessels of selected placentas were injected with a liquid latex polymer (B-1361 Red/Blue, Textile Rubber & Chemical Company, Saint-Jean-Sur- Richelieu, QC). Using a 10 mL syringe (BD Biosciences, New Jersey, USA) filled with red liquid latex, the polymer was introduced into the umbilical vein until the liquid polymer could be visualized in the smaller vessels on the fetal surface of the placenta. The same procedure was repeated with blue polymer in the umbilical artery. Only one umbilical artery was cannulated, as the flow of the polymer through the placenta filled most of the arterial network by collateral flow. Vinegar was injected into the colored vessels using a 10 mL syringe to harden the liquid latex polymer on contact.

2.3. Specimen fixation

Placentas were placed in plastic storage buckets filled with 10% formalin for fixation. Specimens remained in formalin for a minimum duration of seven days to allow fixation of the tissue and hardening of the liquid latex polymer. Placentas were fixed with the maternal surface face up to ensure that the umbilical cord was fixed in a natural position.

Silicone plastination of the placenta by S10 plastination was completed as previously described in detail [2]. In brief:

2.4. Dehydration

Tissue dehydration was performed by freeze substitution in acetone. The placentas were placed in a bath of 100% acetone (Fisher Scientific A18-20, Certified ACS, Fairlawn New Jersey). The temperature of the acetone dehydration baths were maintained at −20 °C in a plastination freezer (LabWorks International Inc, 10-09-13074, Vaughan, ON). Acetone concentration was monitored using an acetometer calibrated for 20 °C. 100% acetone was replaced for 5 subsequent baths, each 10–14 days in duration, or until the final measured concentration of acetone was maintained at greater than 99.5%.

2.5. Forced polymer impregnation

Forced impregnation of silicone was completed using the S10 Standard Technique as described by the International Society of Plastination and the current plastination processes in place at Queen's University. S10 liquid silicone (Biodur Products, Heidelberg, Germany) was mixed with 1% S3 hardener catalyst (Biodur