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Differential Diagnosis of Abnormal Muscle Gross Anatomy of a Male Cadaver

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Abstract

The ability of healthcare providers to carefully consider all presentations of illness and injury, draw upon research and knowledge to develop a list of potential diagnoses, and further investigate systems expected to be impacted by these diagnoses, is crucial for accurate identification of a condition and subsequent treatment plans to improve the welfare of patients. In order to determine a possible cause for unusual anatomic changes in multiple regions of the male cadaver used in the University of Montana's Anatomy and Physiology lab, we performed a differential diagnosis.This research is exempt from IRB approval because the individual is no longer living. Permission was obtained from the Montana Body donation program. To generate preliminary diagnoses, we identified possible conditions associated with our initial observations of the abnormalities in the lower extremities. Further dissections of the colon, the femoral artery, and the heart were completed to evaluate the involvement of the cardiovascular and digestive systems after detecting distension of the lower intestine and a suture in the artery. We noted evidence of renal and vascular disease, prompting additional dissection of the kidneys and brain. Comprehensive assessment of the observed indications, in conjunction with subsequent research into the demographic information related to each preliminary diagnosis, supported the conclusion that stroke as a result of chronic kidney disease and atherosclerosis was the cause of death of the cadaver. This project is highly relevant in the healthcare industry as chronic kidney disease is a global health threat affecting approximately 10% of the adult population, and comorbidities are seldom investigated (Lee et al.) Additionally, the use of cadaver research, as demonstrated in this project, is an invaluable opportunity to those in and entering the medical field to enhance the comprehension of anatomy, physiology, and pathology during the educational process by allowing for the practical application of learned concepts and skills.

Introduction

The opportunity to apply the scientific method and the cumulative knowledge of anatomy, human biology, and pathology gained during the undergraduate or graduate years of a prospective healthcare professionals' education in practice is pivotal in enhancing the ability to think critically and holistically upon beginning patient care. We were presented with this opportunity during our dissections of the male cadaver in the Human Anatomy and Physiology lab on the University of Montana campus, which was an extension of our roles as teaching assistants in the lab. As our dissections progressed, we observed abnormalities in the lower extremity muscles, particularly on the posterior aspect. The affected muscles were the semitendinosus, semimembranosus, biceps femoris long and short heads, and adductor magnus

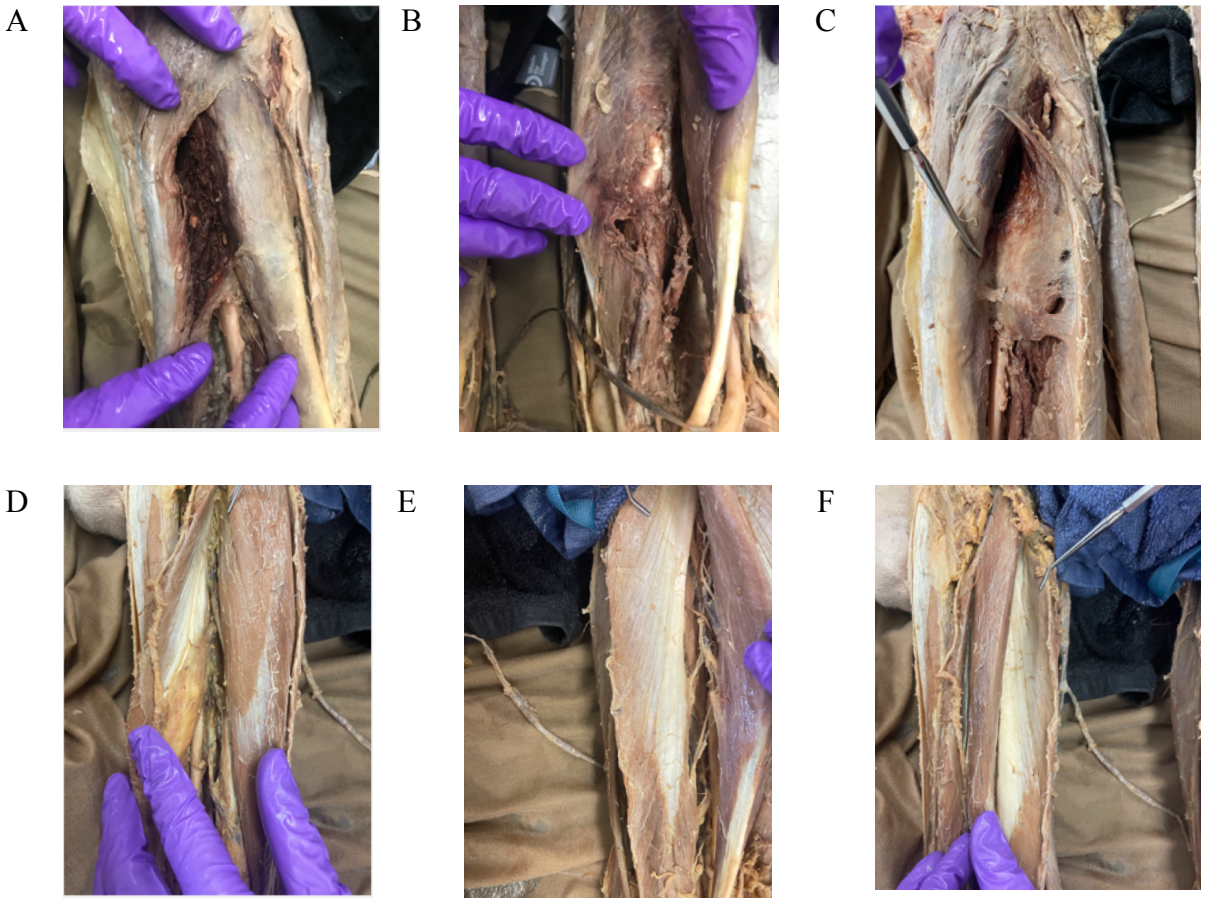

Figure 1. Affected left semitendinosus and biceps femoris long head (A), right semimembranosus (B), and left semitendinosus (C) on the male cadaver. Healthy left semitendinosus and biceps femoris long head (D), right semimembranosus (E), and left semimembranosus (F) on the female cadaver are included for comparison of the differences in the tissue. Other affected muscles are not depicted as the muscles shown in this figure adequately represent the abnormalities present in the additional impacted muscles.

on both legs, as well as the left gluteus maximus, medius, and minimus. These muscles appeared to be deep red or black in color, and the muscle fibers were damaged, lacking the organized and striated pattern that is characteristic of healthy skeletal muscle. In addition, the fascia at the interface of the damaged areas of these muscles was exceptionally fragile, and disintegrated at the touch. The extent of the differences in the appearances of healthy muscle, which we observed on the female cadaver in the lab, and the affected muscles on the male cadaver were extreme (Figure 1). We began our research with the objective of identifying a potential diagnosis to elucidate the cause of the abnormalities observed on the male cadaver. The only information about the cadaver that was available to us upon beginning our research was his age at the time of

Diagnosis	Characteristics	Causes	Typical Age of Onset
Rhabdomyolysis	Muscle weakness, swelling, pain; myofiber contents in bloodstream[1]	Substance abuse, medication, trauma[1]	All ages[7]
Acute Compartment Syndrome	Numbness, tingling, paralysis, pain[2]	Trauma, surgery, minor injuries[2]	Under 30 years[8]
Type II Diabetes	Muscle fat infiltration, sarcopenia, peripheral neuropathy[3]	Insulin resistance from excessive body fat, genetic influences[3]	45+ years[9]
Proximal Myopathy	Symmetrical weakness, malaise, fever, fatigue[4]	Drugs, alcohol, thyroid disease, infections[4]	All ages[4]
Large Histiocyte-Related Immune Myopathy	Anemia, acute muscle pain and weakness, high serum creatine kinase[5]	Injuries; immune system attacks injured muscle tissue[5]	Unknown (all ages)[5]
Disseminated Intravascular Coagulation	Acute bleeding, organ damage[6]	Inflammation, overactive clotting factors, tissue damage[6]	All ages[10]

Table 1. Preliminary diagnoses along with characteristics, causes, and common ages of onset for these diseases.

death, which was 88 years. Additionally, we noted that no evidence of trauma was apparent on the skin prior to its removal at the start of our dissections. This paper first describes the procedure that we followed to generate differential diagnoses, and ultimately a final diagnosis, and then evaluates this project as an educational resource.

Methods

This project required the dissection of several bodily systems, including the integumentary, muscular, cardiovascular, digestive and renal systems. Routine dissections were conducted by the undergraduate dissection over the period of the academic year, and additional dissections outside the scope of customary dissections were performed as we saw fit. To remove skin and dissect the kidneys and arteries, we used sharp dissection, a method in which a scalpel is used to incise, remove and reveal tissue. In the case of separating tissue and surrounding fascia, we used forceps and probes to perform blunt dissection. Additionally, we used probes to move and manipulate

A

B

Figure 2. Male's descending colon (A) with strictures and blockage compared to the female's healthy descending colon (B).

tissue, as well as highlight structures for identification in photos.We obtained photos during the time of dissection which were then arranged into figures for comparison of healthy and abnormal tissue. As a control to demonstrate a comparison of healthy tissue, used the female cadaver that is also studied in the anatomy lab on UM campus.

Ethical Considerations. This research is exempt from Institutional Review Board (IRB) approval. We obtained permission from the Montana Body Donation Program to conduct this research and display photos obtained as it pertains to the scope of the research.

Results

Based on initial findings which, due to the nature of dissections, were limited to the muscles of the lower extremity, we compiled a table of preliminary diagnoses seen in Table 1. Our initial hypotheses included rhabdomyolysis, a disease characterized by the release of muscle fiber contents into the bloodstream which results in damaged muscles[1], acute compartment syndrome, characterized by inflammation of muscles, intramuscular bleeding, and damage to surrounding fascia due to increase intramuscular pressure[2], and type II diabetes, which can lead to gangrene and necrotic tissue[3]. Other potential diagnoses include proximal myopathy, large histiocyte-related immune myopathy, and disseminated intravascular coagulation, all of which are consistent with hemorrhage, muscle weakness, or muscle degradation[4,5,6].

Abdominal Cavity. After generating preliminary diagnoses, we began to investigate other anatomical regions, starting with the abdominal cavity. During this examination, we found that

A  B  C 

Figure 3. The stitch in the femoral artery indicating potential atherosclerosis (A). Stents (C) were observed in the right coronary artery (B) and the anterior interventricular artery, not shown here.

the descending colon had constricted segments, called strictures, alternating with areas of blockage (Figure 2). While these findings were initially concerning as potential indications of intestinal or autoimmune disease, we ultimately determined these irregularities to be of small significance in the final diagnosis.

Cardiovascular Implications. During the continued exploration of the cadaver, we found a stitch in the right femoral artery, seen circled in yellow in Figure 3. The femoral artery is commonly used in an angioplasty procedure, in which a catheter is threaded from the artery to to heart, and a meshed metal stent is inserted into the artery to expand the arterial walls and restore blood flow to compromised arties. This procedure is common in individuals with atherosclerosis, a disease characterized by the build up of fats, cholesterols and other substances, called plaque, on the walls of arteries[11]. Patients with high blood pressure are more likely to develop artery disease such as atherosclerosis because the added pressure on the artery walls causes damage and makes the arteries more susceptible to the buildup of plaque. After finding evidence of angioplasty, we performed further dissections of the vessels on the heart, and found stents in both the right coronary artery and the anterior interventricular artery, shown in Figure 3. This confirmed our hypothesis that the patient did have an angioplasty for atherosclerosis and probable hypertension.

Kidney Involvement. The most significant findings of this study were those involving the kidneys. As the dissection of the abdominal cavity progressed, we were able to further examine

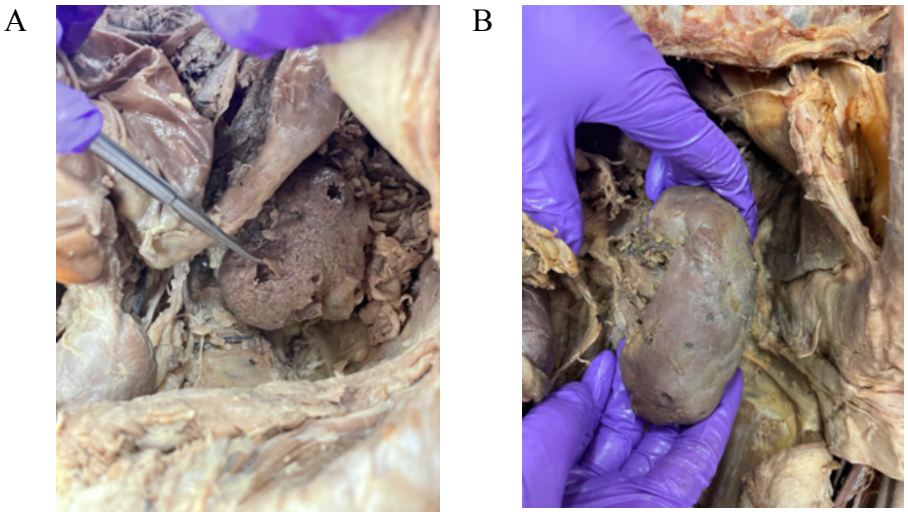

Figure 4. Cavities left by cysts can be seen on the surface of the male cadaver's left kidney (A). The female cadaver's healthy left kidney is depicted for comparison (B).

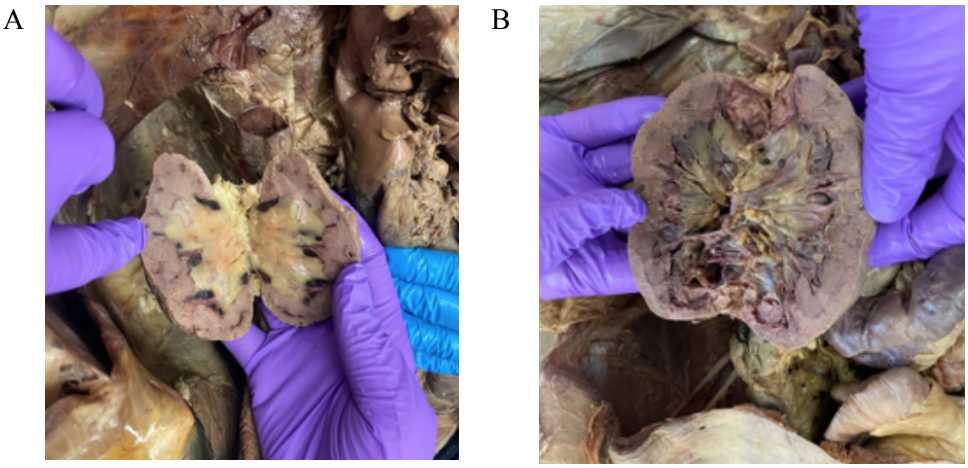

Figure 5. The key functional structures within the male cadaver's kidneys were obstructed by a fat-like substance, as seen in his right kidney (A). The female cadaver's right kidney is depicted for comparison (B).

this region and access the kidneys, which were previously obscured. The left and right kidneys had a bumpy and rough surface, and the left kidney had cavities that were left by cysts, some of which remained embedded (Figure 4). The dissection of the kidneys revealed that the internal structures were enveloped in a fat-like substance that had obscured the renal cortex, pyramids, and major and minor calyces (Figure 5). The kidneys act as the filtration unit for the body, ridding waste and toxins while allowing glucose, hormones, amino acids, and other vital substances to remain in systemic circulation. When the kidneys fail, the body accumulates

Organ/ Location	Description	Consistent with...
Heart	Stents in anterior interventricular and right coronary artery	Atherosclerosis/ cardiovascular disease
Right Femoral Artery	One stitch in proximal right femoral artery Indicative of angioplasty	Atherosclerosis/ cardiovascular disease Chronic kidney disease
Kidneys	Cystic, yellow in color Obstruction of major and minor calyces	Chronic kidney disease Cardiovascular disease
Posterior and medial muscles of the thigh	Areas of degradation with a dark red or black appearance Weak and thin fascia Areas of muscle lack organized striated appearance, disintegrate to the touch	Cardiovascular disease Type II diabetes Acute compartment syndrome
Colon	Highly distended areas alternating with constricted, shorter lengths of colon	Crohn's disease[15] Chronic kidney disease Cardiovascular disease

Table 2. A comprehensive description of the abnormalities observed within each affected system, as well as the diagnoses with which they are each consistent, is included here.

wastes and toxins which leads to a series of serious complications and will eventually prove fatal. Based on the state of the kidneys at the time of dissection, it is reasonable to conclude that the kidneys were either minimally effective, or completely ineffective.

Discussion

Upon completing our dissections, we compiled an adjusted diagnosis table with diseases consistent with our data that could have been the cause of the stroke (Table 2). These hypothesized diagnoses include type II diabetes, disseminated intravascular coagulation, atherosclerosis, and chronic kidney disease. After further investigation and review of existing literature on these illnesses, we concluded that chronic kidney disease (CKD) along with atherosclerosis were the primary conditions that resulted in the cadaver's death. It was disclosed to us by our mentor that the Montana Body Donation confirmed the cause of death to be a cerebrovascular event, also known as a stroke, and this is consistent with our conclusions.

CKD is characterized by the gradual loss of kidney function and eventual kidney failure[16]. Poor kidney function leads to dysregulation of hormones that control blood pressure, and this, along with associated inflammation resulting in arterial cholesterol buildup, increases the risk for high blood pressure and atherosclerosis. Presence of atherosclerosis in the renal

arteries also increases the risk for CKD, as plaque buildup in this area compromises the blood flow to the kidneys, which decreases function and diminishes filtration[20]. We were unable to detect which was the primary disease, as CKD and atherosclerosis can either cause or be caused by the other. Additionally, our hypothesis is supported by the average age of CKD onset, which is 65 years. This aligns with the cadaver's age of 88, and even suggests that CKD had been present and worsening for several years before death. Furthermore, kidney presentation in CKD is consistent with the irregular, bumpy, atrophied kidneys of the cadaver. Finally, because of the positive feedback loop between CKD and atherosclerosis, which we know was present due to the discovery of stents in the cardiac arteries, the risk of stroke for patients with CKD to be 5-30 times higher than that of a healthy patient. All of these factors, along with evidence found on the cadaver, provide overwhelming evidence that the stroke was ultimately caused by chronic kidney disease and atherosclerosis.

Conclusion

Besides generating a diagnosis for the cadaver, this research granted us the opportunity to greatly enhance our understanding of human anatomy and the diagnostic process. It reinforced the principle that medical diagnostics, and the scientific method as a whole, is a cyclical process of forming and testing a hypothesis, analyzing results, reviewing and considering existing and gained information, and starting the process over again. While we initially hoped to quickly discover the cause of death, this research required patience and reflection while we generated and ruled out multiple different hypotheses.

A key component of this project was the utilization of the active learning process. Through the process of this research, our objective shifted from rapidly deciding upon a diagnosis, to appreciating the learning process and considering our observations holistically to determine an accurate diagnosis. This project enhanced our understanding of the process of creating and testing theories in a way that is otherwise limited by purely consuming the literature surrounding the conditions that we considered. We had the opportunity to not only see how CKD and atherosclerosis affects the body, but to also further understand the intricate ways by which various systems within the human body interact and impact the functions of one another. Additionally, we demonstrated a similar method within our research approach as is used in the process of diagnosing patients in vivo, which is a practice widely implicated in the various medical professions and specialties.

Not only did this research project expose us to a variety of medically relevant conditions, but it also provided us with the opportunity to apply the skills and knowledge that we have obtained over the course of our undergraduate education. Due to the limitations of the lecture-based instructional method, learning opportunities presented during undergraduate courses predominately teach only about symptoms, physiology, and treatment, but this research provides the opportunity to dynamically and practically apply this information in a way that is relevant to a student's career goals. In addition, it reinforced the reality that significant variability

exists in the symptoms of any particular illness on an individual bases, despite finite descriptions of these variances in textbooks, which is a factor that we had to take into consideration while attempting to elucidate the conditions impacting the cadaver and that healthcare providers must consider while treating patients as well. For these reasons, we can conclude that this is a relevant research opportunity to supplement the education of both future and current healthcare professionals, as it allows for hands-on experience, application of knowledge and research skills, and visualization of human tissue and its response to various pathologies.

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