E.J. Wylie Traveling Fellowship Report

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Sight Unseen: Advanced Imaging and the Future Vascular Specialist

Think of the last time you walked into an emergency department to evaluate a patient with a pulseless extremity or worried if their abdominal discomfort was related to an acute aortic syndrome; you already appreciate the importance of medical imaging. “What imaging has the patient had” is likely the first thought in your head. Those imaging studies likely provided you with evidence that helped shape your next set of decisions and saved your patients extremity or life. But what about what you couldn’t see? What if your patient’s acute limb ischemia was related to plaque rupture and not thromboembolism? Would that change your approach? What if the stranding seen around the aortic aneurysm was not related to aortic rupture but rather IgG4-related aortitis?

A mentor of mine once told me, “we will never be better surgeons if we can’t see what we are doing.” That single statement unlike any other, has shaped my curiosity towards advanced imaging and diagnostics as it pertains to vascular disease. We simply can’t fix what we can’t see or understand. I realized that most of our efforts are spent on treating the end result of disease rather than understanding the effects of the disease process. With data scientists, basic scientists, clinicians and Artificial Intelligence (AI) at a crossroads, the foreseeable future stands to gain from our deeper understanding of disease and its anatomic/physiologic constraints rather than devices and therapies engineered to control a dynamic and often unpredictable arrangement. It is my opinion that in the next few decades will see a renaissance of diagnostics and advanced imaging so that we may look back at this time and realize our limited ability to understand disease.

For centuries, the only way to evaluate and understand maladies was through surgery and autopsy. Then, in 1895, Wilhelm Roentgen discovered X-rays, giving us a tool that allowed us to “see” the human condition without an incision. Fast forward 120 years and one cannot escape a medical encounter without some form of medical imaging. Since the early 80’s, magnetic resonance imaging (MRI) has become an important tool for the clinical evaluation of patients with cardiovascular disease.

For our cardiology and cardiac surgery colleagues, 2-dimensional phase contrast MRI (2D PC-MRI) is a routine part of the assessment of blood flow in the heart and great vessels. More recently, time-resolved PC-MRI with velocity

encoding along all three flow directions and three-dimensional (3D) anatomic coverage (also termed ‘4D flow MRI’) has been developed and applied for the evaluation of cardiovascular hemodynamics as well as the comprehensive evaluation of blood flow patterns.

Given that pulsatile flow in blood vessels is “multidimensional and multidirectional”, this unique technique enables a wide variety of options for visualization and physiologic/pathophysiologic quantification of blood flow. In addition, visualization of aortic blood flow can be helpful to identify regions close to the vessel wall that translates altered fluid mechanical effects on the intima into atherosclerosis. Bottom line, MR and 4D-flow are promising non-invasive tools that provide functional information in addition to the morphological visualization of vessels and vessel wall architecture.

Since 2012, key opinion leaders in MR throughout the world (medical physicists, physicians, computer scientists and biomedical engineers) have met on a regular basis in an interdisciplinary fashion to find a platform for clinical application as well as the various technical aspects regarding data acquisition, processing, visualization, and quantification. While there have been early adopters and forerunners of this technology within the Society for Vascular Surgery, the field of magnetic resonance, outside of a handful of leading research centers, has largely escaped vascular surgeons. That is not to say that vascular surgeons as a whole have not been interested or participated in advanced imaging.

Quite the contrary, today's vascular surgeons are more than ever uniquely poised to take advantage of the innovative biomedical imaging technologies that is transforming our understanding of biological and disease processes within blood vessels. Still, for the majority of vascular surgeons today, MR technology remains an awkward and challenging modality to absorb and implement for routine practice. Further, research into medical imaging technology receives less attention than one would hope, even though patients can benefit greatly from this research. The most cutting-edge MRI machines are only found in research facilities and not found at your local hospital. Replacing an MRI machine is pricey, so it’s easy to understand why hospitals are using older models and older software. Some US hospitals still use film!

As healthcare systems are pressured to cut costs without compromising quality of care, entire imaging initiatives linger. While advanced computing, AI, automation, and deep/machine learning will improve technologies involved in all aspects of medical imaging, we as vascular surgeons need to secure our place at the table and collaborate with other vascular specialists at the forefront of these advancements.

Throughout this year long fellowship, I had the privilege of learning how advanced vascular MRI techniques and vascular imaging centers in North America have evolved over the last decade. This evolution is quite separate to that of more traditional vascular research. Most notable is the collaboration required to combine the fields of computer science, statistics, medical imaging, medical physics, radiology, cardiology, cardiac surgery and most recently vascular surgery. Sometimes the progress seems congruent but there are also quite often subtle and important differences, revealing an alternative view or insight into vascular disease. This experience underscores the potential benefit, opportunity and importance of the free and open exchange of novel ideas and practices. How amazing would it be to have an open repository of redacted 4D MRI images for all SVS members to access for education and research purposes.

In 1970, EJ Wylie’s presidential address to the International Cardiovascular Society was entitled: “Vascular Surgery--A Quest for Excellence.” I can’t think of another slogan that so aptly characterizes the past and the future of vascular surgery and surgeons. My own quest for excellence comes from the humility provided daily by my patients and their disease processes. I have learned to appreciate the limits of my own abilities and our existing technologies and understand the importance of those limitations in their healing process. I am further humbled by what treatment is clinically indicated and what choices patients consider appropriate. However, being humble does not concede embracing mediocrity and being hesitant does not equate to incompetence. In fact, it is this humility that is the key driver that has committed me to the continuous pursuit of my own quest for excellence.

In conclusion, MRI already plays a major role in modern medicine. This role will continue to grow with expanded clinical and research applications and advancing MR technologies. Artificial intelligence and machine learning will only accelerate this while human oversight will try to make clinical sense of it all. My experience with the EJ Wylie Travelling fellowship was truly remarkable in helping me understand the infrastructure and progress existing behind 4D MRI as it stands in vascular research in North America. My new understanding of the variety of successes will help my own

mission to better understand aortopathies as it pertains to structure, stress and physiology of blood flow.

Thinking back, it is difficult to pay justice to the care, thoughtfulness, and generosity of my hosts, who prided themselves on a warm culture of open hospitality. I have made many new colleagues, which I will continue to work with and be in contact. Finally, none of this would have been possible without the SVS and its members who have so kindly supported the EJ Wylie Travelling fellowship for years. Thank you!

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