ROUNDTABLE DISCUSSION

Robotics in Neurointervention: Where Are We and What Is the Future?

Moderator Dr. James Milburn asks Dr. Vitor Mendes Pereira, Prof. Tufail Patankar, and Dr. Stavropoula Tjoumakaris about their respective robotics programs, the types of cases they perform, ethical considerations for robotic-assisted procedures, and what the future holds in robotics in neurointervention.

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Dr. Milburn: Each of you was a speaker during the "Robotics Applications in Neuroendovascular Surgery" session of the Society of NeuroInterventional Surgery 2021 annual meeting, and this was one of the meeting's highlights. Please give an overview of your robotics program and share what types of cases you are doing.

Dr. Pereira: Our program at the University of Toronto began in early 2019. I lead a research group called RADIS lab that specializes in tackling the most critical problems with advancing imaging and innovative therapeutic technologies. Our program manager is Nicole Cancelliere, who is also our bedside robotics specialist and operator. Our program started by conducting experimental studies to evaluate the CorPath GRx (Corindus, a Siemens Healthineers Company) in patient-specific vascular models of brain aneurysms. We performed numerous surgical simulations and tested different access products, defined optimal catheter lengths, and identified potential issues with different systems. We have also tested coils, stents, intrasaccular devices, and flow-diverting devices. This testing experience allowed us to perform the world's first robotic-assisted brain aneurysm treatment in November 2019. We are proud to have one of the largest robotic neuroendovascular programs globally, with multiple operators including my partners Drs. Julian Spears and Tom Marotta, and an active research group in robotics. Our center is currently enrolling patients into the CorPath GRX Neuro study and has performed more than 30 robotic-assisted brain aneurysm treatments.

Prof. Patankar: I was lucky to be involved with another robotic system that is still undergoing early clinical trials. In Leeds, we are at the beginning of developing a Corindus robotic program and negotiating with Siemens and Leeds NHS Trust to set up the robotic service. The aim would be to do wide variety of cases, starting with coiling of aneurysms and then develop experience over time. We hope to eventually perform complex aneurysm cases, including those with flow diverters and mechanical thrombectomies.

Dr. Tjoumakaris: Our robotics program at Thomas Jefferson University Hospital in Philadelphia Pennsylvania, includes robotic-assisted catheter cerebral angiography and stenting of extracranial cervical carotid atherosclerotic disease. We utilized the CorPath GRx second-generation robotic operating system. So far, we have successfully completed approximately 30 robotic-assisted carotid artery balloon angioplasty and stenting procedures. We have published our experience thoroughly and compared robotic versus manual carotid balloon angioplasty and stenting. In our study comparing the two different modalities, there was no difference overall in total fluoroscopy time, patient radiation exposure, technical success, and morbidity between the two approaches.[1] Most importantly, the radiation exposure to the console operating physician was minimal to zero. Like any new technology, there is a steep learning curve for the first few cases, and the efficiency of the interventionalist and team increases with every subsequent procedure. In our series, five procedures seem to be the threshold for a notable increase in team efficacy. Current robotic systems require software and hardware updates to increase the devices' haptic feedback to the interventionalist, which would allow for safer access to intracranial lesions such as aneurysms, arteriovenous malformations, and acute ischemic stroke.

Dr. Milburn: What do you feel are the ethical considerations with endovascular robotic surgery, and how are these addressed?

Prof. Patankar: The robotic system still is in early stages of development. There are ethical concerns regarding ownership of the case and who takes the responsibility, particularly if remote use of the robot is undertaken. The safety data still need to be collected, and we need to show noninferiority to existing methods of treatment. This needs to be collected systematically across users from centers around the world, if possible. If complications occur during a robotic procedure, robust steps need to be put in place to maintain the safety of the patient and determine who discusses with the patient and family afterwards.

Dr. Tjoumakaris: Due to the recent advancements of robotic-assisted endovascular procedures, several ethical challenges need to be acknowledged and addressed. Robotic-assisted device and guidewire manipulation may dilute the experience, technical knowledge, and skill set of the endovascular interventionalist over time. With future software and hardware robotic updates, there is a growing concern that the interventionalist as the primary surgeon may be reduced to a first assistant to the robot. In addition, a conflict of interest for utilization of robotics in endovascular procedures may exist as hospitals and health systems heavily advertise this new technology. At this juncture, there are no data to suggest that robotic-assisted procedures are more accurate or safer than conventional manual approaches. Furthermore, the cost of robotic surgery is prohibitive in community hospitals, restricting access to this new

technology to only large university hospitals. Lastly, the ethical concerns of robotic-assisted remote neurointerventions (eg, endovascular management of acute ischemic stroke) include inability of the primary remote operator to communicate and consent the patient and family, limitations of the procedure to local training of the interventional team at the remote hospital, and the complexity of professional liability in the case of an adverse event. Some of these concerns are addressed via FDA approval processes and other professional medical associations. Institutional review boards also play a primary role in the oversight and regulation of such new technology at a local level.

Although robotics may supplement endovascular procedures, critical decision-making, and surgical experience and skill set, the interventionalist will remain paramount in the leading role for these procedures. Patient informed consent and full disclosure of the risks and benefits of such new technology need to be thoroughly reviewed prior to every approach. Training of physicians, technologists, and nurses in these technologies and maintenance of recertification are extremely important in ensuring the safety and efficacy of robotic-assisted procedures not only at the main university setting but also at the local community hospital. Tracking outcomes of new technology both at a local and national levels is required to balance robotic technical precision with long-term patient safety.

Dr. Pereira: I don't believe there are ethical concerns with endovascular robotic surgery. As with any new technique, its feasibility and safety must be assessed in clinical studies as well as how it may influence long-term treatment results. We performed our first cases in a feasibility study, and the results of the first case, safety, and long-term results are published in peer-reviewed journals. All subsequent cases have been enrolled in a multicenter study to assess brain aneurysm treatment using coils or regular stents. We are submitting an investigator-initiated study to expand the indication to intrasaccular and flow diverters in the near future.

I think that there is an unconscious fear of the unknown in everyone's mind, but it sometimes blocks people from realizing the potential that these innovations could have. Robotic surgery has been used in medicine since the 1980s, and it has grown considerably in other fields in the last few years. We have to inspire ourselves by looking at aviation—a field that has demonstrated that with innovation comes safety!

Dr. Milburn: What do you believe is the future of endovascular robotic surgery in the neurointerventional field?

Dr. Tjoumakaris: The future of endovascular robotic surgery is certainly very bright. With the FDA approval of robotic-assisted endovascular cranial interventions, new opportunities are opening for implementation of this technology in the treatment of cerebral aneurysms, arteriovenous malformations/fistulas, and acute ischemic stroke. It will also allow access to these life-saving procedures in remote areas, where the interventionalist may log in through a robotic console. This will complement or perhaps be part of the same telemedicine evaluation of remote patients in critical neurologic conditions.

Dr. Pereira: I believe that endovascular robotic surgery will be the future. It already comes with precision, controllability, reliability, and radiation protection to the operator and bedside teams. Future advances such as automation, imaging guidance, and remote capabilities will expand even more robotic endovascular surgery. Remote stroke treatment will improve access to care for thousands of patients worldwide, which will be transformational.

I envision that we will be doing surgeries from a "cockpit" with lots of automated functions and intelligent tools that will facilitate procedures and improve performance and results. I also think that simulation will be a big part of our surgical specialty, including therapeutic planning. I hope we will be able to "take flight" and choose our paths using simulation, expand our minds, and adapt to each situation—leading to performing a "perfect flight" in every real-world procedure. Robotics can help us get there!

Prof. Patankar: Robotic systems will become an extension of our arm, and we will be controlling it. New generations with automation will improve, and eventually, robots will offer the possibility of multi-microcatheter controls or dual access or using balloons and stents and flow diverters. The precision of robotics will enhance our skills and make procedures shorter and safer. In the future, it's possible that the interventionalists will sit in the cockpit, with remote operators doing thrombectomy in smaller centers. ■

1. Sajja KC, Sweid A, Al Saiegh F, et al. Endovascular robotic: feasibility and proof of principle for diagnostic cerebral angiography and carotid artery stenting. J Neurointerv Surg. 2020;12:345-349. doi: 10.1136/neurintsurg-2019-015763.