Robotics In Interventional Neuroendovascular Therapies: A Systematic Review

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Background & Purpose: As advances in technology continue to shape the field of medicine, robotics is playing an increasingly important role in interventional neuroendovascular therapies. These therapies, which involve the use of specialized devices to treat conditions within the blood vessels of the brain, can be complex and technically demanding procedures. A recent systematic review of the literature has shown that the use of robotics in interventional neuroendovascular therapies can offer a number of potential benefits, including improved accuracy and precision, reduced radiation exposure for both the patient and the operator, and increased efficiency. There are several potential reasons why a robot might be used in neurointerventional surgery: 1) Improved accuracy and precision: Robotics can provide a high degree of control and stability, allowing for more precise movements and manipulations within the blood vessels of the brain. This can be particularly useful in complex procedures, where small errors can have significant consequences; 2) Reduced radiation exposure: Some robotics systems allow for procedures to be performed with reduced or no fluoroscopy, which can help to minimize radiation exposure for both the patient and the operator; 3) Increased efficiency: The use of robotics in neurointerventional surgery can increase efficiency by allowing for the performance of multiple tasks concurrently and by reducing the time required to complete certain procedures; 4) Enhanced visualization: Some robotics systems come equipped with advanced visualization tools that can provide a clearer and more detailed view of the surgical site, which can help to improve the accuracy and precision of the procedure; 5) Reduced fatigue: Performing complex and technically demanding procedures can be physically and mentally taxing for surgeons. Robotics can help to reduce the physical demands of surgery, which can help to reduce fatigue and improve overall performance.The purpose is - To discuss the feasibility and current problems in Interventional Neuroendovascular Therapies where robots can help along with their challenges and benefits.

Material and Methods: A comprehensive literature search of PubMed, Ovid MEDLINE, and Ovid Embase was performed for studies published from 2000 to October 2022. The search used the following keywords: “Humans,” “Nervous System Diseases / diagnostic imaging*,” “Nervous System Diseases / surgery,” “Radiography, Interventional / methods*,” “Robotics / methods*,” “Stroke / diagnostic imaging,” “Stroke / surgery; Telemedicine,” and “Thrombectomy” in both “AND” and “OR” combinations. The inclusion criteria are the studies that reported the use of Food and Drug Administration (FDA) approved robotic navigation platforms in interventional radiology. The search strategy was confined to English language.

Results: Commercially available systems such as the Sensei and Magellan robotic catheter systems (Auris Surgical Robotics), Amigo remote catheter system (Catheter Precision Inc), and CorPath vascular robotic system (Corindus Vascular Robotics) are electromechanically operated, and the Niobe magnetic navigation system (Stereotaxis USA) is magnetically controlled. Robotics are being developed to assist with endovascular interventional neuroradiology procedures, which involve using imaging guidance to access and treat blood vessels or nerves in the head and neck. These systems typically involve a responder unit that is manually loaded with a wire and catheter, and a controller that may be operated using a combination of joystick, handheld remote, foot pedal, and/or touch screen. A literature review[1] identified 81 published neurointerventions that have been performed using robots, which were mostly diagnostic cerebral angiograms or extracranial carotid artery stenting procedures. One therapeutic intracranial intervention involving stent-assisted coiling of a large basilar aneurysm was also identified. In most cases (97%), the procedures were completed without the need for manual conversion. In addition to the cases described in the literature, there have also been reports of live conference cases involving the use of robotics for stent-assisted coiling and woven endobridge device treatment. A review of the literature identified a review article[1] which reported eight articles that described the use of robotic systems for interventional neuroradiology procedures involving 81 patients; seven studies focused on the use of these systems for diagnostic cerebral angiography or cerebrovascular angioplasty and stenting (CAS), while one case report described the use of a robotic system for an intracranial intervention. The studies involved the use of experimental robotic systems, the Magellan system, or the Corpath GRX system. In most cases (78/81, or 96%), manual conversion was not required during the procedure, and there were no reported safety issues or complications. However, only one study compared the use of robotically-assisted and manual procedures and found that the procedure time was significantly longer for the robotic approach. Currently, there is no high-level evidence to demonstrate that robotically-performed neurointerventions are at least as effective as manual procedures. This is due to the fact that all of the identified evidence is classified as level 4 evidence, which is considered to be of low quality. The QUADAS-2 methodology, which is used to assess the quality of studies, found that all of the studies had a high or unclear risk of bias and concerns regarding applicability in all domains. Additionally, none of the studies had clearly defined patient selection criteria, reference standards, or index tests. Despite these limitations, the studies are still considered to be valuable as they provide a snapshot of the current state of the art and can serve as a baseline for future research. Two studies have evaluated the use of experimental robotic systems for cerebral angiography, with 15 and 5 patients undergoing successful procedures without complications, respectively. However, the specific mechanics of these systems are not described in detail.

Conclusions: Despite these potential benefits, the use of robotics in this setting is still in the early stages of development, and further research is needed to fully understand the potential risks and benefits of this technology. As the field of robotics in medicine continues to evolve, it is important for healthcare providers and researchers to stay up-to-date on the latest developments and to carefully consider the role of robotics in interventional neuroendovascular therapies. The preliminary data from these studies are promising for the future of robots in Interventional Neuroendovascular Therapies. However, multicenter prospective studies are required to improve patient outcomes.

References: 1. Crinnion, W. *et al.* Robotics in neurointerventional surgery: a systematic review of the literature. *J. NeuroInterventional Surg.* 14, 539–545 (2022).
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