Case report

Complete robotic intervention for acute epistaxis in a patient with COVID-19 pneumonia: technical considerations and device selection tips

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SUMMARY

The use of robot-assisted technology is expanding in interventional laboratories with an increasing number of reports of effective treatment delivery in neurointerventional procedures. Here we report the feasibility of complete robot-assisted neurointervention including the guide catheter and microcatheter manipulations with subsequent embolization of the arterial source of hemorrhage in a patient hospitalized with severe COVID-19 complicated by acute epistaxis.

CASE PRESENTATION

A man in his late 30s with a history of severe COVID-19 with respiratory failure on mechanical ventilation, renal failure and coagulopathy developed acute refractory bilateral epistaxis. Diagnostic angiography and embolization of the arterial source of the hemorrhage were planned using the CorPath GRX Robotic System (Corindus, a Siemens Healthineers Company, Waltham, Massachusetts, USA).[1] Proximal carotid artery selection is included in the current CorPath indications, and the primary operator had completed the phase I training on the robotic system, which includes performing five diagnostic angiograms with a Corindus specialist. The robotic console is positioned outside the angiography suite. It is equipped with a 26-inch monitor to view live biplane fluoroscopic views and controls consisting of three joysticks and a touchscreen. The robotic system is capable of advancing, retracting, and rotating the catheter and guidewire separately. It also includes a side port capable of deploying an additional device such as a coil.

Robotic cerebral angiography was performed under general anesthesia using a femoral artery approach. In an initial manual phase of the procedure, a 5-Fr Pinnacle groin sheath was inserted into the groin and a 90 cm 5-Fr Envoy catheter (Cerenovus) was advanced to the descending aorta prior to loading the catheter into the robot. The catheter was then connected to a co-pilot hemostatic valve and a micro guidewire (V-18 ControlWire, Boston Scientific, Marlborough, Massachusetts, USA) was inserted for subsequent robotic manipulation. The catheter was continuously flushed with heparinized saline and another side port was connected to an extended connection tubing that allowed for contrast injections manually or using a contrast media injector. The robotic arm was then brought into position and the catheter/guidewire combination was loaded into the single-use cassette and secured to the groin sheath (figure 1A,B).

The primary operator navigated the catheter to the proximal external carotid artery over the wire robotically while sitting at the console outside the angiography room. At the bedside, the supporting operator monitored flush lines and connection tubing as well as manual contrast injections from the side port as needed. Once the Envoy guiding catheter was placed in an optimal position, the wire was removed. The Envoy was then manually unloaded from the robotic cassette (while maintaining the position in the external carotid artery) and the robot was loaded with a 135 cm Rapidtransit (Cerenovus) microcatheter and a Synchro-14 microwire (Stryker Neurovascular), so that the microcatheter/microguidewire combination was loaded into the robotic cassette and secured to the Envoy guide sheath (figure 2). Using the robotic console, the microcatheter was navigated over the microwire into the distal internal maxillary artery in an ideal position for embolization, and then polyvinyl alcohol particles (Boston Scientific 250–355 μm) embolization was performed. A coil was delivered through the device port and deployed at the tip of the microcatheter using the robot. The same steps were then repeated for the contralateral side. The patient experienced no complications and was medically stable on the day following the procedure.

OUTCOME AND FOLLOW-UP

The embolization was successful with good control of the epistaxis and no future episode of epistaxis occurred.

DISCUSSION

The Corindus robot was originally designed for coronary and peripheral vascular procedures, in which implants are deployed directly from the guiding catheter.[2–4] For neurointerventional procedures the use of the Corindus robot is limited to the hybrid approach, where the extracranial placement of a guiding catheter and also the navigation of an intermediate catheter is performed manually and the intracranial manipulation of a microcatheter and implants is conducted robotically. To our knowledge, this is the first report on the feasibility of complete robotic neurointervention where both guiding catheter and microcatheter are manipulated by an endovascular robot. The ability to control devices from the console offers multiple advantages

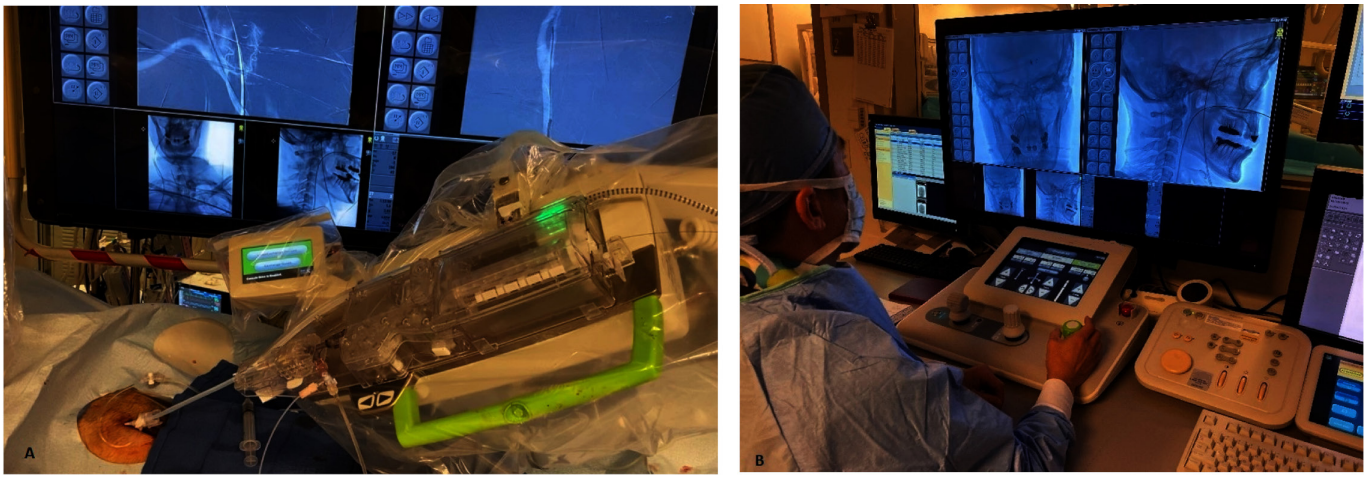

Figure 1 (A,B) Catheter/guidewire combination loaded into the single-use cassette and secured to the groin sheath (A) and navigated robotically into an optimal position for the guiding catheter (B).

in addition to the reduction of the occupational radiation exposure. Lowering the risk of transmission of communicable conditions such as COVID-19 is a tremendous advantage during a pandemic. The surgeon can also operate in a convenient seated position with easy visualization and interaction with the monitor. Although neurointerventionalists will benefit from significantly reduced radiation exposure, there may be increased procedure time and radiation exposure during the learning process. As experience grows, it is expected that increased precision of robotic catheter and device manipulation will ultimately decrease radiation exposure. Prior to performing complete robotic procedures, it is highly recommended that hybrid robotic procedures or extensive in vitro modeling sessions are conducted to reduce procedural time and patient radiation exposure and to maximize the likelihood of a successful robotic procedure. Although the procedure can be completed with only one operating staff member, at this point it is recommended that there should be an operating assistant at the bedside to monitor the lines, adjust the fluoroscopic table and connections, and perform hand injections. Future integration of robotic system controls with fluoroscopic machine functionalities would reduce this need.

The complete robotic procedure poses unique challenges such as the selection of devices, calculating the working length, and maximizing visual information. The guiding catheter, microcatheter, and coiling procedure were primarily manipulated using a push/pull and rotation joystick control solely based on the visual information (figure 3). Particular attention has to be given to the working length of the catheters with respect to the movement range of the robotic arm. Prior to switching the robotic control from the guiding catheter to the microcatheter, the robot was maximally pulled backward to obtain the full 20 cm of forward working length. With regard to device selection, we recommend using a long guiding catheter that can accept any excessive microcatheter length that is retained outside of the robotic cassette tube. Future robotic designs may be improved by lengthening the robotic cassette tubing to enhance microcatheter compatibility. Obtaining proximal support by the use of a microwire such as Synchro Support helped reduce excessive slack of the microcatheter in the robotic cassette tube.

Coil embolization was feasible with careful attention to the deflection of the coil loops and the microcatheter tip without the need for haptic feedback. Precise and controllable delivery and advancement of the coiling wire and the microcatheter showed promising potential for precise delivery of coil loops in the desired fashion. In our experience, visual attention to coil morphology and friction force by observing subtle changes in the motion of devices was sufficient to perform successful coil embolization.

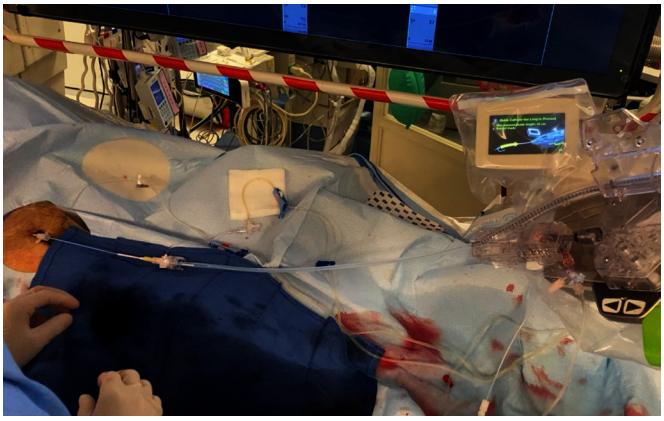

Figure 2 Demonstration of loading the microcatheter/microguidewire combination into the robotic cassette secured to the Envoy guide sheath.

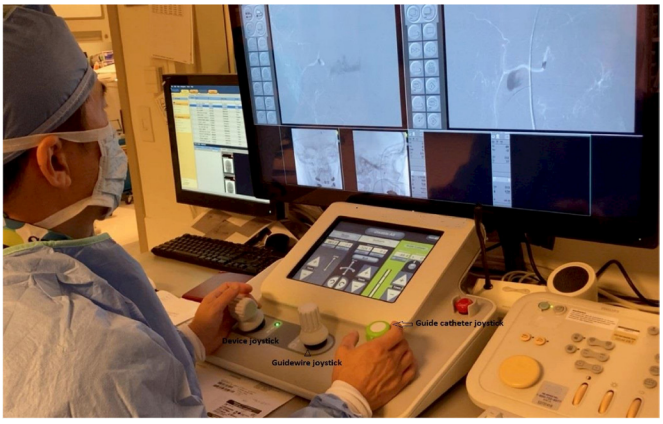

Figure 3 Manipulation of the microcatheter and coiling procedure performed using a push/pull and rotation joystick control solely based on the visual information.

Learning points

- Complete robotic intervention is feasible by carefully choosing the devices.
- Complete robotic intervention reduces the risk of the operator being exposed to biohazardous materials.
- Particular attention must be paid to the working length of the robot, the length of the guiding catheter, and the length of a portion of the microcatheter that protrudes from the distal and proximal ends of the guiding catheter.
- It is highly recommended that hybrid robotic procedures or extensive in vitro modeling sessions be conducted prior to performing complete robotic procedures.

Recent studies have reported the feasibility of the robotic system for performing hybrid neurointerventional procedures including carotid artery stenting and cerebral coil embolization.[5–7] In the future, robotic endovascular systems should be able to function remotely on secured networks and be capable of handling triaxial systems. This will hopefully allow for the possibility of telerobotic acute stroke treatment, thus reducing the geographic access gap to these interventions.[8 9] Our experience of coil embolization of the distal internal maxillary artery feeder in a patient with epistaxis and a history of COVID-19 further highlights the potential and benefit of neurointerventional procedures using robotic systems.

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