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Case report

Republished: Interhospital teleproctoring of endovascular intracranial aneurysm treatment using a dedicated live-streaming technology: first experiences during the COVID-19 pandemic

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SUMMARY

This is a report of the first three cases of endovascular aneurysm treatment that were proctored by a remote interventionalist using a novel high-resolution low-latency streaming technology. The proctor was located in a neurovascular centre and supported the treating interventional teams in two distant cities (up to 800 km/500 miles apart). All aneurysms were treated using the Woven EndoBridge (WEB) embolisation system, either electively or following subarachnoid haemorrhage. On-site proctoring was not possible due to travel restrictions during the COVID-19 pandemic. WEB placement was feasible in all cases. Good rapport between proctors and treating physicians was reported, enabled by the high-resolution image transmission and uninterrupted feedback/discussion via audiostream. No clinical complications were encountered. Short-term follow-up revealed adequate occlusion of all treated aneurysms. The employed streaming technology provided effective remote proctoring during complex aneurysm cases, including the management of technical complications.

BACKGROUND

With rapidly evolving neurointerventional techniques and an ever-increasing selection of devices on the market, neurointerventionalists are faced with multiple learning challenges, even in high-volume centres. Continuous local proctoring by specialists highly trained in the use of specific devices, for example, the Woven EndoBridge (WEB), is expensive and often not logistically feasible. The COVID-19 pandemic has further complicated the ‘learning from an expert’ process, otherwise possible by on-site training at another centre or by the assistance of a visiting specialist at the treating institution. Remote streaming support in lieu of local proctoring has been tested in simulated thrombectomies.¹ Live audiovisual on-demand streaming from the angiography was feasible for thrombectomies with comparable recanalisation times and no increase in procedural complications. We report the first clinical proctoring cases of WEB device placements for incidental and ruptured intracranial aneurysms using live telestream technology through

a dedicated web-based platform, accessible on-demand on a personal computer. This technology has been specifically developed for low-latency high-resolution streaming with particular emphasis on stable image transmission quality and minimal resource requirements (Tegus Medical, Hamburg, Germany). The system includes a 360° rotatable and 180° tiltable high-definition network camera, which is placed on a tripod ([figure 1A](#)). The field of view and zoom function is controlled remotely using a simple user interface ([figure 1B,C](#) and online supplemental file). Access to the platform is password secured. Any data transfer is encrypted. In contrast to audiovisual streaming with a handheld device (eg, Apple FaceTime), view angle and zoom are controlled by the remote proctor to guarantee the best possible visualisation and to avoid unnecessary distractions for the trainee. Both the treating interventionalist and the proctor used headsets to communicate with each other.

CASE PRESENTATION

Patient 1 presented with an incidental wide-necked aneurysm of the anterior cerebral artery (A1 segment). Neurovascular treatment options were discussed, and elective interventional embolisation using the WEB system was recommended. The option of on-site proctoring by a visiting specialist was impossible due to the COVID-19-associated travel restrictions. Therefore, a remote proctoring session with the use of live audiovisual on-demand streaming technology was scheduled, with a neurointerventional specialist as the proctor located at another hospital using a high-speed internet connection. The audio connection to the proctor was initially unstable, but eventually improved early during the diagnostic part of the procedure and remained stable for the remainder of the time. The camera could be aimed at any location within the angiography suite, for example, the monitors, the femoral access site or the device set-up next to the patient table ([figure 1](#)). The aneurysm was treated with a WEB SL 8×3 under constant supervision by the remote specialist ([figure 2A,D](#)). Follow-up imaging showed complete occlusion of the aneurysm.



Figure 1 Live telestream set-up for remote proctoring. (A) Stand-alone rig with the installed high-definition web camera (red box). (B) Screenshot of the device set-up as seen by the proctor from his computer. The proctor can change the field of view, focus and zoom with dedicated buttons on the streaming platform. (C) Screenshot of the proctor's selected field of view with visibility of the angiography monitors (sample image taken during a thrombectomy).



Video 1 Demonstration of the user interface and image quality of the Tegus system (reduced image quality for practicability purposes). Exemplary transmission of an angiography screen with prerecorded roadmap loops, displaying an aneurysm with a WEB device and the probing of an aneurysm with a guide wire (Traxcess 14, MicroVent, Aliso Viejo, California, USA; Excelsior SL10, Stryker, Kalamazoo, Michigan, USA). In the final section of the video, the preparation of a WEB device is shown (SLS6, 6.0×4.6 mm, MicroVent). The footage does not originate from the cases presented in this report.

Patient 2 presented with subarachnoid haemorrhage Hunt and Hess III. In addition to two aneurysms of the anterior circulation, a wide-necked aneurysm of the basilar tip was diagnosed with digital subtraction angiography. Following interdisciplinary discussion, the anteriorly located aneurysms were treated with coil embolisation, while WEB device embolisation was judged to be the safest treatment option of the basilar aneurysm. For the latter procedure, an interventional specialist from another facility was contacted and was immediately available for remote proctoring. He was able to access the session ad hoc from his computer; the browser-based technology required a broadband internet connection but was otherwise minimally designed with no specific software requirements. The WEB SL 8×3 device showed minimal dislocation after detachment with consequent narrowing of the parent vessel (P1 segment) (figure 2B,E). Following discussion with the remote proctor, it was agreed that insertion of a permanent stent was unnecessary due to a lack of haemodynamic effect. No haemodynamic or thromboembolic complications were observed during clinical follow-up. Follow-up imaging revealed complete occlusion of the aneurysm.

Patient 3 suffered a subarachnoid haemorrhage due to a ruptured aneurysm of the anterior communicating artery. A WEB SL 8×4 was placed without procedural or clinical complications (figure 2C,F). As in case 2, the proctor used his personal laptop computer via a secure connection to monitor the procedure.

DISCUSSION

We report the first clinical application of remote proctoring in the neurointerventional setting. Participating hospitals employed a live-stream system specifically developed for this purpose.

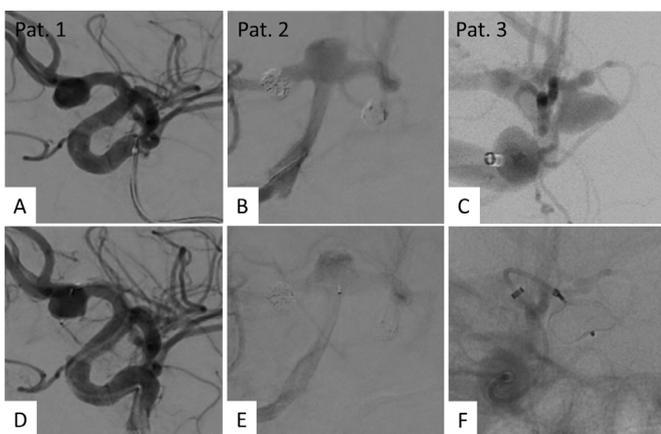


Figure 2 Digital subtraction angiography images of the treated aneurysms in each of the three patients: (A–C) before treatment and (D–F) after treatment.

Although the local interventionalists involved at the two distant cities had moderate to solid experience levels in WEB-based aneurysm treatment, procedural proctoring by a highly specialised neurointerventionalist was deemed helpful. On-site presence of a proctoring specialist was not possible because of the COVID-19 pandemic.

In the case of patient 1, the procedure was routinely scheduled and the remote proctor was previously informed. Patients 2 and 3 were treated in an emergency setting so that the proctoring had to be requested at short notice. Without the possibility for remote proctoring, cases 2 and 3 would have been treated with alternative techniques to the WEB system (most likely with stenting and coiling). Because stent placement requires subsequent antiplatelet therapy, the clinical management of the subarachnoid haemorrhage would have been critically complicated.

The implemented technology provides the remote proctor with a high level of situational awareness. A high image quality for the remote proctor is critical in the context of teleproctoring neuroendovascular cases. The dedicated technology used in these cases allows live video visualisation of deployment and detachment of devices such as the WEB, in sufficiently high resolution (see video 1 and online supplemental figures). This translates to full perception of each procedural step, including high-quality visualisation of the angiographic images and the real-life images, and oversight of the handling of the devices on the patient table. The situational awareness was challenged in case 1 with an initially unstable audio connection but did not compromise the safety of the procedure. The proctors reported that, compared with on-site proctoring, the possibility to zoom in on the screen or the hands of the operator enhanced their awareness of the procedure, without the need to disturb the operating team.

The delivery of healthcare using communication technology, including web-camera solutions, has gained much attention during the ongoing COVID-19 pandemic.^{2,3} The majority of the present telehealth technologies aim to assist in the triage of patients before transfer to a specialised hospital or to connect the physician with patients at home.

Although technology specifically designed to provide real-time remote support from one physician to another was tested during neurointerventional cases, it has not been established in

the clinical practice.⁴ Such solutions would facilitate the introduction of complex neurointerventional techniques and new devices in neurovascular centres.

Another approach for fostering remote neurointerventional procedures is the use of robotics.⁵ However, such options are under development and require more time before clinical implementation can be realised. The current need for remote proctoring and/or training demands immediate solutions.

Clinical studies are needed to examine the impact of telestream solutions on the learning experience of interventionalists challenged with highly specific procedures and, in turn, on patient safety.

Key messages

- ▶ High-resolution low-latency live streaming between an angiography suite and computer of an interventional specialist is feasible, both in emergency and routine clinical situations.
- ▶ Complex interventional cases, that is, WEB placements, can be safely monitored and proctored by a specialist at a distant hospital, where a conventional computer with internet access is the only technological requirement.
- ▶ Studies are needed to test whether the technology facilitates the learning process of neurointerventional surgeons.

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