OPEN ACCESS

Case report

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

Matthias Bechstein ,[1] Samer Elsheikh,[2] Fritz Wodarg ,[3] Christian A Taschner,[2] Uta Hanning ,[1] Jan-Hendrik Buhk,[4] Rosalie McDonough,[1] Einar Goebell,[1] Jens Fiehler,[1] Maxim Bester [1]

► Additional material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/bcr-2020-016722).

[1]Department of Diagnostic and Interventional Neuroradiology, University Medical Center Hamburg-Eppendorf, Hamburg, Germany
[2]Department of Neuroradiology, University Medical Center Freiburg, Freiburg, Germany
[3]Department of Radiology and Neuroradiology, Universitätsklinikum Schleswig-Holstein Campus Kiel, Kiel, Germany
[4]Neuroradiology, Asklepios Hospitals St. Georg and Wandsbek, Hamburg, Germany

Correspondence to
Dr Matthias Bechstein, Department of Diagnostic and Interventional Neuroradiology, University Medical Center Hamburg-Eppendorf, Hamburg, Germany; m.bechstein@uke.de

Accepted 4 September 2020

Check for updates

© BMJ Publishing Group Limited 2020. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

To cite: Bechstein M, Elsheikh S, Wodarg F, *et al*. *BMJ Case Rep* 2020;**13**:e016722. doi:10.1136/bcr-2020-016722

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

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).

SL 8×3 under constant supervision by the remote specialist (figure 2A,D). Follow-up imaging showed complete occlusion of the aneurysm.

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.

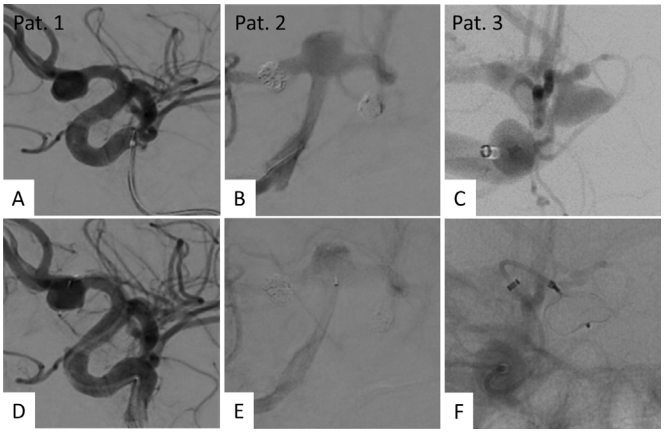
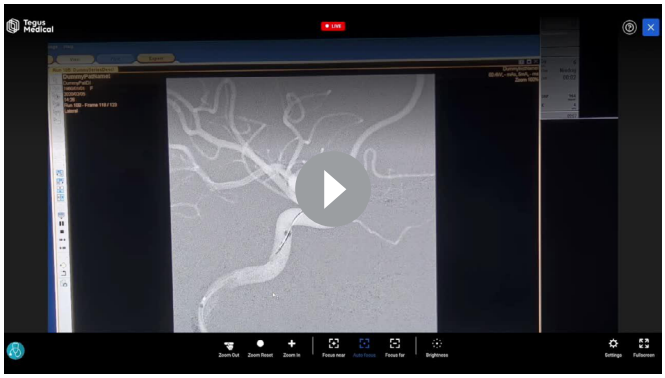


Figure 2 Digital subtraction angiography images of the treated aneurysms in each of the three patients: (A–C) before treatment and (D–F) after treatment.



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, MicroVention, 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, MicroVention). The footage does not originate from the cases presented in this report.

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. 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.

Learning points

- 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.

Contributors MBec, JF and MBes: conceptualisation, literature review, acquisition of data, draft and review of the manuscript; SE, FW, CAT and J-HB: major role in the acquisition of data and review of the manuscript; EG: conceptualisation and review of manuscript for intellectual content; UH and RMcD: review of manuscript for intellectual content.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests JF: research support: German Ministry of Science and Education, German Ministry of Economy and Innovation, German Research Foundation, European Union, Hamburgische Investitions- und Förderbank, Medtronic, Microvention, Route92, Stryker; consultant for Acandis, Bayer, Boehringer Ingelheim, Cerenovus, Evasc Neurovascular, MD Clinicals, Medtronic, Microvention, Penumbra, Phenox, Stryker and Transverse Medical; stock holder: Tegus Medical.

Patient consent for publication Obtained.

Provenance and peer review Not commissioned; externally peer reviewed.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/.

ORCID iDs
Matthias Bechstein http://orcid.org/0000-0002-5652-7499
Fritz Wodarg http://orcid.org/0000-0003-1413-2699
Uta Hanning http://orcid.org/0000-0002-7543-8555
Maxim Bester http://orcid.org/0000-0003-4007-5755

REFERENCES

1 Bechstein M, Buhk J-H, Frölich AM, *et al*. Training and supervision of thrombectomy by Remote Live Streaming Support (RESS) : randomized comparison using simulated stroke interventions. *Clin Neuroradiol* 2019:00870–5.
2 Hollander JE, Carr BG. Virtually perfect? Telemedicine for Covid-19. *N Engl J Med* 2020;382:1679–81.
3 Fiehler J, Brouwer P, Díaz C, *et al*. COVID-19 and Neurointerventional service worldwide: a survey of the European Society of Minimally Invasive Neurological Therapy (ESMINT), the Society of NeuroInterventional Surgery (SNIS), the Sociedad Iberolatinoamericana de Neuroradiologia Diagnostica Y Terapeutica (SILAN), the Society of Vascular and Interventional Neurology (SVIN), and the world Federation of Interventional and Therapeutic Neuroradiology (WFITN). *J NeuroInterv Surg* 2020.
4 Noorian AR, Bahr Hosseini M, Avila G, *et al*. Use of wearable technology in remote evaluation of acute stroke patients: feasibility and reliability of a Google Glass-based device. *J Stroke Cerebrovasc Dis* 2019;28:104258.
5 Mendes Pereira V, Cancelliere NM, Nicholson P, *et al*. First-In-Human, robotic-assisted neuroendovascular intervention. *J Neurointerv Surg* 2020;12:338–40.

Copyright 2020 BMJ Publishing Group. All rights reserved. For permission to reuse any of this content visit
https://www.bmj.com/company/products-services/rights-and-licensing/permissions/
BMJ Case Report Fellows may re-use this article for personal use and teaching without any further permission.

Become a Fellow of BMJ Case Reports today and you can:
- Submit as many cases as you like
- Enjoy fast sympathetic peer review and rapid publication of accepted articles
- Access all the published articles
- Re-use any of the published material for personal use and teaching without further permission

Customer Service
If you have any further queries about your subscription, please contact our customer services team on +44 (0) 207111 1105 or via email at support@bmj.com.

Visit casereports.bmj.com for more articles like this and to become a Fellow