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Original Article

Teleproctoring in therapeutic neurointervention: Experience from Iraq-Saudi Arabia collaboration

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Received: 07 June 2024
Accepted: 20 July 2024
Published: 09 August 2024

DOI
10.25259/SNI_440_2024

Quick Response Code:

ABSTRACT

Background: Proctoring in neuroendovascular surgery is one of the potential solutions for the shortage of personnel and experience, particularly in unstable and limited-resource areas such as Iraq.

Methods: The study was conducted at the Baghdad Neurovascular Center (BNC), the first Hybrid neurovascular institution in Iraq, where sequential online zoom-based meetings between the BNC team and the expert from the Kingdom of Saudi Arabia were used for teleproctoring for neurointerventional procedures.

Results: A total of 28 sessions were conducted, four sessions for each case. Seven cases with various intracranial vascular lesions were operated for neuroendovascular procedures from July/2021 to March/2022. The teleproctoring for each case included four sequential sessions: (1) preoperative planning, (2) device selection and preparation, (3) intraoperative live-stream proctoring, and (4) postoperative reflection and follow-up planning. The procedures include coiling for dural arteriovenous fistula; preoperative tumor embolization; preoperative, partial, and staged embolization for arteriovenous malformation; coiling for intracranial aneurysm; and attempted Giant aneurysm flow-diversion. Major complications were avoided through teleproctoring, and all patients had good outcomes. In addition, the teleproctoring provided an effective training experience to the local neuroendovascular team that is otherwise not feasible.

Conclusion: Teleproctoring is an effective and feasible tool to improve patient outcomes and provide a training experience to the local neuroendovascular teams in resource-limited regions.

Keywords: Limited-resource area, Low- and middle-income countries, Medical Education, Neuroendovascular, Telemedicine, Teleproctoring

INTRODUCTION

Surgical proctoring, encompassing the practices of observation, supervision, and instruction provided by field experts, plays a pivotal role in various domains.[14] Within the neuroendovascular field, proctoring has established itself as a well-recognized tool. However, the rapid advancements in equipment, as well as imaging and operative technologies, necessitate

the availability of a readily accessible network of proctors.[7,13] Unfortunately, the emergence of the coronavirus disease 2019 pandemic has profoundly affected training opportunities, particularly due to travel restrictions, posing significant challenges to traditional in-person proctoring.[5] This issue is particularly pronounced in regions such as Iraq, where numerous factors contribute to an extensive shortage of neuroendovascular training. These factors include a scarcity of experts in the field, the high cost of materials and equipment for patients (as there is no medical insurance in Iraq), and the inherent difficulties associated with traveling to a war-torn territory. In response to these challenges, teleproctoring has emerged as a promising solution within the neuroendovascular field,[4] offering the potential to address the issues mentioned above, specifically in Iraq. This paper aims to provide a comprehensive account of the online proctoring experience involving the treatment of complex cases through neuroendovascular procedures in Iraq. The study leverages online video visual technology to establish a remote connection with an expert based in the Kingdom of Saudi Arabia (KSA) and aims to summarize the valuable lessons derived from this noteworthy experience.

MATERIALS AND METHODS

Participants

The proctor is an Assistant Professor, Hossam Al-Jehani, who is a highly qualified neurosurgeon with expertise in open vascular/neuroendovascular/neurocritical care. The field surgical team operating within the center comprises five vascular neurosurgeons with dual training. Notably, the head of the team possesses a 3-month fellowship experience in Japan, while the remaining team members have acquired their expertise through self-training within the team. In addition, the team includes two residents, one radiology assistant, three nurses, and three medical students who contribute to the collective effort.

Setting

The proctor is based in Dammam, Saudi Arabia, which is located at a distance of 944 km (587 miles) from Baghdad, where the surgical team is operating. All preoperative screening, operative procedures, and postoperative care were conducted in the Baghdad Neurovascular Center (BNC), which stands as the inaugural hybrid neurovascular institution in Iraq, having been established in 2021. Within the BNC, a wide range of neurovascular procedures are conducted, encompassing both open cerebrovascular surgeries and diagnostic/therapeutic interventions. The BNC itself comprises two fully equipped operative rooms. One room is specifically dedicated to open vascular neurosurgeries, while the other functions as a catheterization laboratory equipped with a GE Innova Cath Lab®, specifically designed for neurointerventional procedures. Over the past 18 months, the BNC has successfully performed over 200 diagnostic cerebral and spinal angiography procedures, in addition to 23 therapeutic neurointerventional procedures.

Technological preparations

A web conferencing platform (Zoom®) was used for communication between the proctor and the proctee's team. All hardware and software requirements were tested and ensured at the time of operation. Internet connection was tested before each procedure and meeting to be at a minimum of 10 Mbps. Both the proctor and field surgeon had 4G Wi-Fi hotspots. Two-way audio was provided through a speaker, and a portable smartphone stream in the operating room provided a video feed of the angiogram screen for the proctor. Within the angiography suite, a designated member of the BNC team was responsible for securely holding a phone attached to a stand. This arrangement enabled the proctor to remotely assess and monitor the pre-procedural preparations and provide guidance as needed, both before and during the procedure [Figure 1].

Preoperative preparations

The operating room was ensured to be extremely quiet, a situation which is not that usual with the involvement of multiple team members. Before commencing the

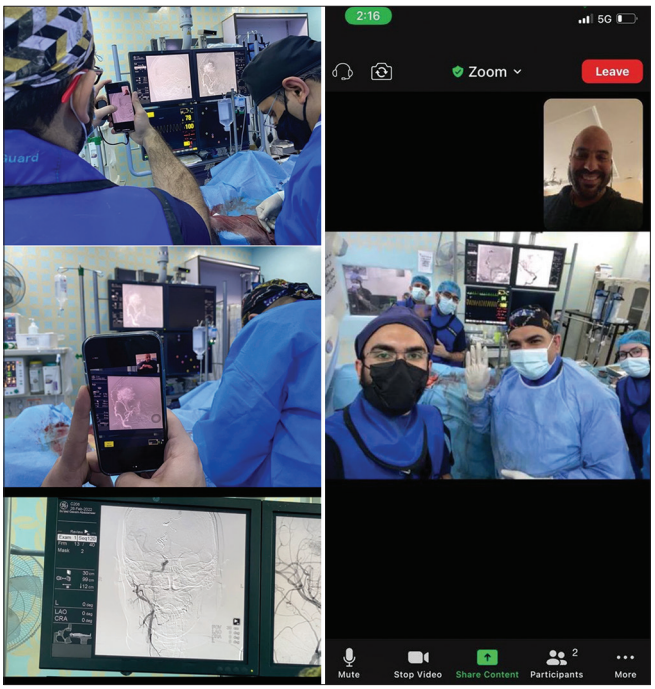

Figure 1: The setting, discussions, and view of the angio-screen during the teleproctoring procedure.

interventional procedures for the enrolled patients, the BNC team established a seamless online meeting with the proctor. These meetings served as a platform for comprehensive discussions regarding the treatment strategies and the specific type of intervention required for each patient. The discussions were based on a thorough analysis of the patient's diagnostic images, including computed tomography (CT) scans, CT angiography, magnetic resonance imaging, and catheter angiography. It is important to note that all selected patients were informed about the decision-making process and the implementation of teleproctoring as part of their treatment journey.

Teleproctoring procedure

During the operation, the teleprocotor followed the field surgeon through the procedure in a step-by-step fashion. The navigation was through one-to-one anatomy-based conversation. Occasionally, it was necessary to relocate to the angiography station during the procedure to engage in discussions with the proctor regarding decisions related to the initial contrast runs. Moreover, the proctor offered invaluable advice and direction throughout the procedure, fostering ongoing discussions with the surgical team. The frequency of these discussions escalated as the surgeon approached critical steps and neared the finalization of the intervention.

RESULTS

Throughout the pilot period, 28 teleproctoring sessions were conducted, spanning from July 2021 to March 2022. Seven cases with various intracranial vascular lesions were operated on for neuroendovascular procedures. The teleproctoring for each case includes four sequential sessions: (1) preoperative planning, (2) device selection and preparation, (3) intraoperative live-stream proctoring, and (4) postoperative reflection and follow-up planning. The seven cases included four males and three females with an age between 26 and 48 years old. Diverse intracranial vascular lesions were carefully selected for neuroendovascular procedures, including one case of dura arteriovenous fistula treated through coiling; one case involved pre-operative embolization of a meningioma; and two cases of intracranial aneurysms, including a giant aneurysm attempted through flow diversion. In addition, there were three cases of brain arteriovenous malformation (AVM), the first with preoperative embolization, the second needed partial embolization, and the last one required two stages of embolization for their AVMs. Further, details and indications for each of the seven cases are shown in [Table 1]. Major complications were avoided through teleproctoring, and all patients had good outcomes. None of the patients experienced any intra-procedural or post-procedural complications. In addition, the teleproctoring provided an effective training experience to the local neuroendovascular team that is otherwise not feasible.

Among the 28 teleproctoring sessions, all were successfully live-streamed in real time. There were no major technological issues, including any interruption in the stream, loss of video or audio, poor resolution, or significant lag time. Internet connection was stable throughout the procedures, and image quality was sufficient for the proctor to perceive and comment on pertinent anatomical structures, instrument handling, positioning, and technique. However, image distortion was encountered due to light overexposure and motion artifacts. Nevertheless, both the field surgeon and the proctor rated the overall video quality as good. They found the technology to be helpful for achieving better surgical results.

The teleproctoring sessions of our cases

The teleproctoring for each of our seven cases included four sequential online sessions. The first session was about the preoperative planning. This session involved case discussion and answering the question to treat or not, then selecting the appropriate treatment modality that can compensate for the patient's need and the potential affordable cost.

The second session involved the device selection and preparation. Due to the unavailability of direct outlets for endovascular companies in Baghdad, limited types and sizes were available for the team. Thus, the selected modality of treatment should be modified according to the available kits and settings. An example is the use of coils for embolization whenever possible as the cost is much more affordable as compared to embolization agents. Those coils were selected to the maximum length acceptable to the case to decrease the potential number of coils required for the procedure.

The third session was the actual intraoperative live-stream teleproctoring. Throughout this session, continuous discussion and step-by-step confirmation between the operating team and the proctor were maintained. This included the navigation through unforeseen technical challenges using the immediate clinical-radiological feedback and how to bail out in complex situations. In addition, the discussion with the proctor provided the answer to the most challenging questions for the operating team, like when to stop and whether there are additional steps that can be done to optimize the outcome.

The fourth and last session was the postoperative reflection and follow-up planning. This critical session was usually done within 24 hours of the procedure or before the patient's discharge from the hospital. The postoperative clinical status, long-term follow-up plan, medications, potential complications, and how to do better the next time were topics to be discussed in that session.

Table 1: The characteristic features of the seven teleproctoring cases.

ID	Age	Sex	Provisional diagnosis	Final findings
1	40	M	Orbital Dural AV fistula	Coiling of the ophthalmic artery resulting in total obliteration of the fistula
2	28	M	Pre. op. embolization of AVM	Embolized one of ACA feeders only/prepared for surgical resection
3	47	M	Rt. Ant. directing MCA Aneurysm for coiling	Successfully coiled MCA aneurysm
4	48	M	Rt. frontal atypical meningioma pre op. embolization	Successfully embolized feeders from IMA and STA
5	34	F	Giant ophthalmic a. aneurysm (flow diverter)	Failed flow diversion (difficult anatomy)
6	26	F	Rt. Thalamic AVM Partial embolization	Partial embolization of the feeders from posterior circulation
7	26	F	2nd stage of Rt. Thalamic AVM embolization	Totally embolization of the feeders from the anterior circulation

ACA: Anterior cerebral artery, AVM: Arteriovenous malformation, AV: Arteriovenous, IMA: Internal maxillary artery, F: Female, M: Male, MCA: Middle cerebral artery, OP: Operative, Rt: Right, STA: Superficial temporal artery

Illustrative cases

Case 5

A 34-year-old female presented with a giant ophthalmic aneurysm. Intraoperatively, the field surgical team encountered a difficult anatomical curve for the supraclinoid carotid while aiming to treat the aneurysm with flow diversion. The proctor navigates the operating team to troubleshoot the problem using variable catheters and wires and by reshaping the microwires. Due to the limited resources, several attempts were applied systematically, where all accessible options were fulfilled with no success. At that point, we decided to quit the procedure based on a discussion with the proctor and when all partners were convinced.

Case 6

A 26-year-old female with right thalamic AVM, the case was the first reported coil migration during the pressure cooker technique with coil-augmented Onyx injection technique in Iraq. The size and location of the AVM led to the decision to use onyx for multistage endovascular embolization. During the operation, the coil detached and migrated in the medial prefrontal branch through the anterior cerebral artery. The coil migrated distally before onyx insertion. After several attempts to retain the migrated coil, the decision with the proctor made as no intervention to retrieve the coil because the detachment piece is small and lodged distally [Figure 2]. The AVM is 90% obliterated in postprocedural digital subtraction angiography imaging. Otherwise, the surgery proceeded smoothly. The postprocedural evaluation showed a bilateral Glasgow coma scale of 15/15 and muscle power grade 5 bilaterally on the Medical Research Council of Canada.[10]

Figure 2: Digital subtraction angiography of AP view of the right internal carotid artery showing the coil migration in a distal branch of the anterior cerebral artery (Red arrow). It also shows the complete obliteration of the arteriovenous malformation nidus. Note: The callosomarginal artery, in this case, is a segmented artery with the two segments originating separately from the pericallosal artery.

DISCUSSION

Teleproctoring in surgery was first reported more than 20 years ago.[4] Subsequently, multiple instances of successful teleproctoring have been reported across various surgical specialties in the past three decades, with the majority of cases involving laparoscopic surgery.[4,9] Moreover, teleproctoring was a success as an educational tool in different countries.[3,11,12] Overall, both the proctor and field surgeon in our experience reported that the technology was very helpful for achieving better surgical results in both the preoperative and intraoperative contexts.

Advantages of teleproctoring

One of the benefits of teleproctoring is eliminating the need for the proctor's physical presence, which could reduce the scheduling delay for a procedure.[1,5,11] Teleproctoring could economize travel, meals, and lodging expenses. Moreover,

proctors would not be subjected to the risks associated with air travel and the radiation risks associated with being physically present in the angiography suite. Furthermore, teleproctoring has the potential to increase patient's access to novel neurointerventional procedures and technologies by allowing patients who would have had to travel abroad to receive optimal care at facilities closer to their counties.[6,8]

The advantage incorporated in the online experience of the proctoring is that the neuroendovascular suite in the hospital did not change the regular setting that the field surgical team operates within.[8] In contrast, within the setting of in-person proctoring, the proctor usually would arrange the equipment and materials in the suite according to his/her convenience. Such changes that are created in the regular environment of the operating team may increase the chance of error within the procedure. Therefore, teleproctoring usually takes place in surroundings familiar to the operating team, leading to better and easier performance procedures. In addition, this unchanged environment will increase the real-time experience and learning for the operating team.

Several intraoperative advantages are provided by the teleproctoring as perceived by the local BNC team through the following examples.[1,8] The proctor advised the team to select the type and length of coils, the amount, and the speed of Onex injection, where to put the tip of the microcatheter in relation to the lesion, and how to bail out if nuances and complications encountered. Even simple technical notes can make a difference in such complex procedures that are new to the operating team. For example, the proctor teaches the team how to apply a screening marker to denote the AVM nidus before injection. This helps in early anticipation of the reflux in the embolizing material and guides the progression and timing of injections [Figure 3]. In case 5, the field surgical team decided to quit the procedure based on a discussion with the proctor and when all partners were convinced. Without the involvement of the proctor, it is difficult for the local team to decide when to stop, and it is equally important for the patient to understand the whys and ifs in post-procedural counseling.

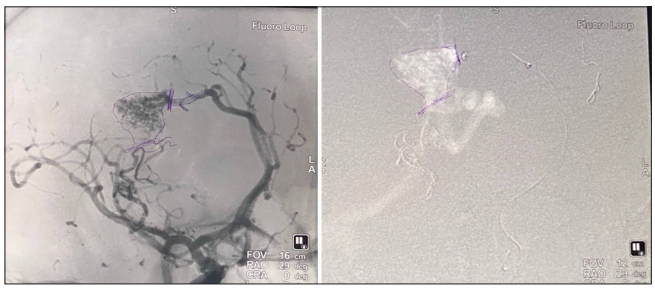

Figure 3: The use of markers on angio-screen before injecting the embolizing agent into the feeders of arteriovenous malformation. Those markers represent a technical note from the proctor that serves early detection of the reflux by the operating team.

Challenges of teleproctoring

In the context of online proctoring neurointerventional cases, high image quality for the remote proctor is crucial.[2,11] Image-guided interventions present a unique set of challenges in comparison to surgeries that focus primarily on the direct visualization of reasonably large structures through microscopes or fiber-optic cameras. On the other hand, in neurointervention, the ongoing interpretation of dynamic angiographic image data of structures with limited visibility necessitates a proctor to acquire a real-time, high-level visualization of the operator's field of view. Such a field consists mainly of image data visualization and procedural techniques. Consequently, transporting the field view to the proctor was explicit in using the proper technologies. However, utilizing the advanced technology of video-visual image processing is not necessary to accomplish the connection. The process of online proctoring does not require the latest advancements in devices or sophisticated internet networks to be functional. In our cases, a simple mobile smartphone, along with a monthly subscription to the Zoom application and a 4G internet connection, was all that was needed. Therefore, simple and regular devices may render such communication to be a success.

Time zone differences posed another logistical difficulty for live-streaming.[11] This problem was not felt in our experience due to the equivalent time zone between Iraq and KSA. Another potential consideration was the fitting of the headset onto surgical loupes.[11] Surgical loupes are used in the majority of reconstructive surgical procedures, which, depending on the style of the loupes, may interfere with the surgeon's ability to wear the headset. In our experience, we were able to conversate directly without using a headset, given the extremely quiet atmosphere that we ensured before the operation.

Apart from technical issues, situational awareness is regarded as a crucial non-technical element of decision-making and can be applied to intricate medical procedures as a precondition for preventing complications.[15,16] Hanning *et al*. reported 75% of the full level of situational awareness in their cases and 14% good level after a survey they performed in e-fellowship in neurointervention.[7] However, such numbers need validation with additional studies. In our cases, one of the targets of the proctoring was to increase awareness through visual video streaming and the use of simple technologies.

The ethical issue for preparing such proctoring in Iraq was another challenge and required peculiar communication with the patients before the procedures. The patients in Iraq may confront a societal issue as an external doctor participates in their case and advises the surgical team. Nonetheless, all the patients agreed on this point that an assistant professor

from Saudi Arabia would be present online with the team in the case. Such straightforward consent from the patients is interesting as such online proctoring is not widespread in healthcare delivery in Iraq. Furthermore, their consent reflects their trust in the doctors who manage their cases.

From the proctor's perspective, the continuous stress in every decision or advice the proctor gives during the procedure represents a major challenge. Furthermore, the pressure to understand all the possible details to make the best-informed decision is a highly demanding psychological state the proctor passes through. It is the inner fear of what if something goes wrong. Nevertheless, similar stress as a proctor will be present even if everything is in the right direction.

Finally, our study included a limited number of cases, rendering our experience to be less dependable. Expanding to include additional cases and surgeons will also be essential for proving the generalizability of our experience and findings.

In summary, lessons learned from Baghdad-KSA neuroendovascular teleproctoring included that teleproctoring accelerates the learning curve for the local neurosurgeon and simultaneity impacts the delivery of high-standard treatment in areas with limited resources. In BNC, seven patients were treated in the BNC center neuroendovascularly for various lesions using online proctoring with an assistant professor from Saudi Arabia. The post-procedural course of the seven patients was uneventful, and their follow-up period showed significant enhancement in their muscle power and level of consciousness. This experience consolidated the surgical team's learning experience regarding neurointervention and ensured an excellent outcome for the patients. This experience can be replicated in areas with similar circumstances as it opens opportunities for future collaborations.

CONCLUSION

Within limited-resource areas, such as Iraq, there exists a significant demand for proctoring services. Our teleproctoring experience, facilitated by regular technology and fostering a high level of communication between the surgical team and the proctor, has demonstrated its potential to enhance the learning experience for all involved parties and generate positive outcomes for patients residing in resource-limited areas. This underscores the valuable role that teleproctoring can play in addressing the educational needs and health-care challenges faced by such regions.

Ethical approval

In Iraq, the institutional review committee is not there so the ethical approval from the institution manager, is received, number 13, dated February 11, 2022.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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How to cite this article: Ismail M, Muthana A, Al-Ageely TA, Ahmed FO, Al-Taie RH, Al-Khafaji AO, *et al.* Teleproctoring in therapeutic neurointervention: Experience from Iraq-Saudi Arabia collaboration. Surg Neurol Int. 2024;15:280. doi: 10.25259/SNI_440_2024