The Concept of a Hybrid Operating Room: Applications in Cerebrovascular Surgery

Javier Fandino, Philipp Taussky, Serge Marbacher, Carl Muroi, Michael Diepers, Ali-Reza Fathi, and Luca Remonda

Abstract The use of intraoperative digital subtraction angiography (iDSA) is a tool in cerebrovascular surgery. According to recent studies, iDSA has been shown to alter surgical treatment in approximately 12% of cases. Moreover, it has been demonstrated that even experienced cerebrovascular surgeons might not accurately predict the need for iDSA. Intraoperative DSA prevents unnecessary surgical manipulations after occlusion of aneurysms and accurately demonstrates occlusion rates. We present our preliminary experience using routine iDSA within the concept of a hybrid operating room for cerebrovascular surgery. A total of 99 patients underwent iDSA in our hybrid operating room. Indications included intraoperative evaluation of occlusion rate of clipped aneurysms and patency of vicinity vessels (n=82), chemical angioplasty with papaverin (n=4), and balloon angioplasty (n=1). In four (5%) patients, a reposition of the clip was needed due to neck remnant and perfusion of the aneurysm sack after clipping. A total of five cases underwent combined microsurgical and endovascular treatment of ruptured aneurysms and arteriovenous malformations (AVMs). The concept of a hybrid operating room has been considered in the planning and design of operation rooms dedicated to cerebrovascular surgery. Hybrid procedures combining endovascular with microsurgical strategies within the same surgical session are feasible and safe. These procedures are associated with cost-benefit advantages.

Keywords Intraoperative angiography • Cerebrovascular surgery • Hybrid operation room

Introduction

Intraoperative digital subtraction angiography (iDSA) is still a rarely applied tool in cerebrovascular surgery. In recent studies, iDSA has been shown to alter surgical treatment in approximately 12% of cases [1–4]. It prevents unnecessary surgical manipulations after occlusion of aneurysms and accurately demonstrates occlusion rates. The introduction of iDSA within a hybrid operation room enables the combinations of endovascular and microsurgical techniques in cerebrovascular surgery. We present our experience and concept of a hybrid operating room for interdisciplinary treatment of cerebral aneurysms and arteriovenous malformations (AVMs).

Materials and Methods

The hybrid operating room is defined as a surgical theater that enables the combination of endovascular and surgical treatment of cerebrovascular pathologies and the use of interventional tools such as temporary occlusion during clipping in a single procedure. In our experience, the combination of mono- or biplanar angiography apparatus with standard surgical tables is crucial to allow standard positioning of the patient during surgery. The surgical table (Alphamaquet 1150, Maquet AG, Switzerland) and C-arm (Xper FD20, Philips, Netherlands) are coupled, and a collision alarm system prevents independent or uncontrolled movements of the table or C-arm. The carbon fiber top of the table is 360 radio translucent. Radiolucent head pins and head holders are required for optimal acquisition of angiograms and intraoperative CT scans. Surgical personnel have been trained to assist endovascular procedures. Neurosurgeons are responsible for all technical issues during the procedures. This setting allows the utilization of the operating room by vascular surgeons and other surgical specialties with or without performance of angiograms (Fig. 1).
Results

A total of 99 patients underwent operations in our hybrid operating room. Indications included intraoperative evaluation of occlusion rate of clipped aneurysms and patency of vicinity vessels \((n=82)\), chemical angioplasty with papaverin \((n=4)\), balloon angioplasty \((n=2)\), and primarily endovascular coiling with option of neurosurgical intervention \((n=4)\).

In four \((5\%)\) patients, a reposition of the clip was needed due to neck remnant and perfusion of the aneurysm sack after clipping. In one case, the clip was repositioned due to occlusion of a vessel near the aneurysm. In one case, a suboptimal occlusion of an aneurysm (anterior communicating aneurysm) could be documented. In this case, reposition of the clip was unsuccessful in reaching a total occlusion of the aneurysm, and the postoperative follow-up conventional angiogram and coiling of the remnant aneurysm were uneventfully performed. All endovascular aneurysm embolizations were successful; in two cases, coiling of ruptured aneurysms was performed after emergency craniotomy for evacuation of an intracerebral hematoma. A total of five cases underwent combined microsurgical and endovascular treatment of ruptured aneurysms and AVMs. Three illustrative cases are presented (Figs. 2, 3, and 4).
Fig. 2 Illustrative case 1. Acute subdural hematoma after aneurysm rupture of a left posterior communicating artery aneurysm (arrow). The patient underwent emergency craniotomy for evacuation of the hematoma followed by coiling of the aneurysm. The duration between hospital admission and final angiogram was 4 h.

Fig. 3 Illustrative case 2. Combined endovascular and microsurgical treatment of a right temporal arteriovenous malformation (AVM). After embolization of two main feeders, complete resection of the AVM could be achieved. Postinterventional angiogram and computed tomography (CT) showed no remnant of the AVM.
Intraoperative imaging in neurosurgery allows the early identification of complications and optimizes the treatment objectives. Intraoperative DSA [1–4] and near-infrared indocyanine green video angiography for the assessment of vascular flow during cerebrovascular surgery have contributed to safety and the prevention of severe complications during cerebrovascular procedures [5]. The concept of a hybrid operating room not only allows the performance of routine iDSA in all cerebrovascular procedures but also opens the possibility for combined approaches in a sterile environment. Both microsurgical and endovascular techniques can be applied to achieve excellent results and prevent complications, whose possible causes might be detected during surgery. From our point of view, the following important issues have to be included in planning for a hybrid operation room for cerebrovascular procedures: location, table, multidisciplinary application, operating room technicians, and surgeon’s capability for operating the equipment. The hybrid operating room should be planned within the concept of a conventional surgical environment that allows sterile procedures and personnel flexibility. According to our experience, a surgical table that allows all standard positions is crucial not only for neurosurgeons but also for other surgical specialties; this can contribute to optimal utilization of the operation room during the slots when neurosurgical procedures are not planned. In our concept, operating room technicians have to be trained for endovascular techniques to integrate them in combined procedures and facilitate the surgical processes. Finally, we consider it crucial that the neurosurgeon be trained for operating all the equipment installed in the hybrid operating room, including the angiogram apparatus and software for the acquisition and evaluation of three-dimensional rotational angiography.

Conclusion

The concept of a hybrid operating room should be considered in the planning and design of operating rooms dedicated to cerebrovascular surgery. Hybrid procedures combining endovascular with microsurgical strategies in the same surgical session are feasible and safe and have cost-benefit advantages.

Conflicts of Interest Statement  The authors do not have financial interests with the manufacturing companies of the equipment mentioned in this manuscript.

References


