Risk Factors for Infective Complications with Long-Term Subdural Electrode Implantation in Patients with Medically Intractable Partial Epilepsy

Sumiya Shibata[1], Takeharu Kunieda[1], Rika Inano[1], Masahiro Sawada[1], Yukihiro Yamao[1], Takayuki Kikuchi[1], Riki Matsumoto[2], Akio Ikeda[2], Ryosuke Takahashi[3], Nobuhiro Mikuni[4], Jun Takahashi[5], Susumu Miyamoto[1]

OBJECTIVE: **To evaluate infective complications with intracranial electroencephalography (EEG) recording so as to lessen them.**

METHODS: **A database of intracranial monitoring cases with subdural electrodes at Kyoto University Hospital between May 1992 and March 2012 was retrospectively reviewed.**

RESULTS: **This analysis included 46 EEG monitoring sessions. Infective complications related to intracranial electrodes occurred in 4 monitoring sessions (8.7%; 3 male patients). Causative agents were identified as *Staphylococcus aureus* in 3 monitoring sessions and *Staphylococcus epidermidis* in 1 session. In univariate analysis, the season of monitoring was identified as the sole significant risk factor. More infective complications occurred when monitoring occurred in autumn. More infective complications tended to occur in patients who had implantation in the right side or discontinuation of intravenously administered prophylactic antibiotics, although these factors were not statistically significant. Age, sex, duration of monitoring, number of electrodes, and pathologic diagnosis did not seem to be associated with an increased risk of infective complications. Infective complications had no significant influence on seizure outcome.**

CONCLUSIONS: **Invasive EEG monitoring during autumn might be a risk factor in terms of infective complications. *S aureus* was a common pathogen.**

INTRODUCTION

Although intracranial electroencephalography (EEG) monitoring has greater sensitivity and spatial specificity than scalp EEG, it also has some shortcomings (38). One shortcoming is that intracranial EEG monitoring is associated with neurosurgical procedures. Implantation of subdural grid electrodes inevitably accompanies a craniotomy. Insertion of depth electrodes requires not only trephination of the skull but also penetration of the cerebral parenchyma. As a result, intracranial EEG monitoring is associated with morbidity and mortality (11, 27, 34, 42). Minor complications such as headache, nausea, and transiently increased temperature and more serious complications such as infections, postoperative epidural or subdural hematoma, cerebrospinal fluid (CSF) collection, increased intracranial pressure, cortical contusion, CSF leakage, and brain herniation have been previously reported (7).

Among these complications, postoperative infection is one of the most severe (15, 18, 24). The development of central nervous system infection after a neurosurgical procedure represents a significant threat and requires immediate medical and possibly surgical intervention (20). Postoperative nosocomial infection was associated with increased postoperative length of stay, increased costs, and increased hospital readmission rate (14). Clarifying the risk factors directly associated with these infective complications is essential. We conducted a clinical study of infective complications with the goals to reduce further complications from long-term intracranial electrode implantation and to improve the safety of invasive evaluation of epilepsy surgery.

MATERIALS AND METHODS

This study was approved by the Ethics Committee at Kyoto University Graduate School and Faculty of Medicine (E2102). We

Key words
- Epilepsy
- Implanted electrode
- Infection
- Risk factors

Abbreviations and Acronyms
CSF: Cerebrospinal fluid
EEG: Electroencephalography

From the Departments of [1]Neurosurgery, [2]Epilepsy, Movement Disorders and Physiology, and [3]Neurology, Kyoto University Graduate School of Medicine, Kyoto; [4]Department of Neurosurgery, Sapporo Medical University Graduate School of Medicine, Hokkaido; and [5]Center for iPS Cell Research and Application, Kyoto University, Kyoto, Japan

To whom correspondence should be addressed: Takeharu Kunieda, M.D., Ph.D. [E-mail: kuny@kuhp.kyoto-u.ac.jp]

Citation: World Neurosurg. (2015) 84, 2:320-326.
http://dx.doi.org/10.1016/j.wneu.2015.03.048

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

performed a retrospective review of a database of patients who had undergone epilepsy surgery at Kyoto University Hospital between May 1992 and March 2012. We identified 49 patients who had undergone 53 invasive monitoring sessions. One patient died 2 days after the resection surgery of acute myocardial infarction. Because the death was unrelated to the neurosurgical procedure, this patient was excluded from the analysis.

All patients required intracranial monitoring because they were candidates for epilepsy surgery, and results of noninvasive monitoring did not reveal sufficient localizing information to delineate a resection procedure. The number and location of the intracranial electrodes to be implanted were carefully determined for each individual with reference to the noninvasive evaluation. For electrode implantation, 2 different types of platinum subdural strip and grid electrodes provided by 2 different manufacturers (Ad-Tech Medical Instrument Corporation, Racine, Wisconsin, USA, and Unique Medical Co., Ltd., Tokyo, Japan) were used.

In 5 of the monitoring sessions, depth electrodes were used in addition to either subdural electrodes or cavernous sinus electrodes (16, 23). In 1 other monitoring session, only epidural electrodes were used. These 6 sessions using other types of electrodes together with or instead of the subdural type were excluded from the analysis because of the small number of cases. The monitoring sessions with depth electrodes, epidural electrodes, or cavernous sinus electrodes had no infective complications at all. The analysis included 46 monitoring sessions (26 of which involved male patients).

All patients underwent general anesthesia for the subdural grid or strip electrode implantation surgery. In the first stage of surgery, a skin incision and wide craniotomy and cranioplasty were performed to create an operative field large enough to expose the appropriate cortical areas for electrode coverage. Most subdural electrodes were placed under direct visualization to avoid any damage to bridging veins or other cerebral cortex and vascular structures. In some cases, additional smaller grid or strip electrodes were slid over the brain without direct visualization. The cables of the electrodes were kept in a bundle. The dura mater was closed with an artificial dural patch in 25 sessions and primarily or with an autograft (without an artificial dura mater) in 19 sessions (data were unavailable in 2 sessions). When the electrode leads were exfiltrated through the dura mater to the outside, 2 techniques were used to fix the leads tightly to the dura mater and to prevent any damage (kinking, direct injury) to them. In some cases, small lateral slits were made off of the main incision (with suturing between the electrode leads and the main incision). In other cases, a small section of the dura mater along the main incision was raised slightly or pinched, creating a "tunnel" through which the electrode lead was fed and sutured in place. The bone flap was fixed back temporarily. The cables were tunneled >1 cm away from the initial skin incision line for each lead.

Data on the use of prophylactic antibiotics were available in 45 of 46 analyzed monitoring sessions. In 35 of the monitoring sessions, prophylactic antibiotics were administered intravenously not only during the operation but also throughout the monitoring period. In 10 of the monitoring sessions, prophylactic intravenous administration of antibiotics was interrupted, with prophylactic antibiotics discontinued completely in 5 of these monitoring sessions and administered orally for some period in the other 5 sessions.

After sufficient EEG monitoring, data were obtained along with determination of the regions of epileptogenesis and functional mapping of eloquent cortical areas, the subdural electrodes were removed, and the planned resection was performed as the second surgical treatment.

The following demographic data and monitoring variables were recorded (Table 1): age at surgery, sex, duration of invasive monitoring, season of monitoring, side of electrode implantation, number of electrode contacts, cumulative number of electrode contacts (number of electrode contacts multiplied by days of invasive monitoring), intravenous administration of antibiotics throughout the invasive monitoring period, pathologic diagnosis (hippocampal sclerosis was diagnosed with preoperative magnetic resonance imaging in some cases), state of associated infections, and seizure outcome. Because 1 patient had 40 contacts in the first 2 days and 60 contacts in the last 5 days, his number of electrode contacts was calculated as 54 $[(40 \times 2 + 60 \times 5)/7]$. Seizure outcome data were obtained from clinical visits. These data were obtained 13–243 months after surgery (mean 100 months). The outcomes of postoperative seizure control were categorized as either "good" (class I) or "not good" (classes

Table 1. Demographic Data and Monitoring Variables

Sex (monitoring sessions): male/female	26/20
Age at surgery (years) (mean ± SD)	26.5 ± 7.2
Side of electrode implantation (monitoring sessions): right/left/bilateral	20/25/1
Number of electrode contacts (mean ± SD)	50 ± 20
Duration of invasive monitoring (days) (mean ± SD)	11 ± 4
Cumulated number of electrode contacts (contacts · days) (mean ± SD)	567 ± 329
Season of monitoring (monitoring sessions)	
March–May (spring)	12
June–August (summer)	14
September–November (autumn)	9
December–February (winter)	11
Pathologic diagnosis (monitoring sessions)*	
BT	6
CD	24
HS	7
Others	14
Seizure outcome (patients)	
I	21
II	4
III	18
IV	0

BT, brain tumor; CD, cortical dysplasia; HS, hippocampal sclerosis.
*Some patients had >1 pathologic finding. The pathologic finding of 1 patient was unknown.