Strategic hospital partnerships: improved access to care and increased epilepsy surgical volume

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OBJECTIVE Surgical treatment of patients with medically refractory focal epilepsy is underutilized. Patients may lack access to surgically proficient centers. The University of California, Irvine (UCI) entered strategic partnerships with 2 epilepsy centers with limited surgical capabilities. A formal memorandum of understanding (MOU) was created to provide epilepsy surgery to patients from these centers.

METHODS The authors analyzed UCI surgical and financial data associated with patients undergoing epilepsy surgery between September 2012 and June 2016, before and after institution of the MOU. Variables collected included the length of stay, patient age, seizure semiology, use of invasive monitoring, and site of surgery as well as the monthly number of single-surgery cases, complex cases (i.e., staged surgeries), and overall number of surgery cases.

RESULTS Over the 46 months of the study, a total of 104 patients underwent a total of 200 operations; 71 operations were performed in 39 patients during the pre-MOU period (28 months) and 129 operations were performed in 200 patients during the post-MOU period (18 months). There was a significant difference in the use of invasive monitoring, the site of surgery, the final therapy, and the type of insurance. The number of single-surgery cases, complex-surgery cases, and the overall number of cases increased significantly.

CONCLUSIONS Partnerships with outside epilepsy centers are a means to increase access to surgical care. These partnerships are likely reproducible, can be mutually beneficial to all centers involved, and ultimately improve patient access to care.

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KEYWORDS NAEC; epilepsy center; patient care strategies

THE literature suggests that surgery improves outcomes for patients with medically refractory epilepsy, and that surgical treatment can be potentially curative.^{11,12,18} The American Academy of Neurology recommends that appropriate patients should be referred to an epilepsy surgery center for evaluation following failure of an appropriate trial of medical treatment (i.e., persistent seizures despite a trial of at least 2 antiepileptic drugs [AEDs]).⁴ Despite this recommendation, epilepsy surgery is underutilized in the United States. The number of operations performed for pediatric patients increased from 2000 to 2009,¹⁴ but the number of overall surgeries remains stagnant.^{5,16} A lack of access to surgically proficient medical centers and poor referral rates from nonsurgical epilepsy centers are possible causes. Studies have shown that patients with intractable epilepsy were referred for surgery later in the disease course than recommended,

which could have been due to a lack of awareness of current surgical referral guidelines.^{8,15}

We developed strategic partnerships with 2 nearby epilepsy centers to provide access to surgery for patients with medically refractory epilepsy. Preoperative workups were performed by the referring neurologist, and cases were presented via video-conference during a dedicated epilepsy surgery conference. We sought to examine how these partnerships affected patient access to surgery and what impact this had upon institutional profitability as well as to provide a model by which other institutions may increase epilepsy surgical volume.

Methods

Strategic Partnership

The National Association of Epilepsy Centers (NAEC)

ABBREVIATIONS AED = antiepileptic drug; MEG = magnetoencephalography; MOU = memorandum of understanding; NAEC = National Association of Epilepsy Centers; PET = positron emission tomography; RNS = responsive neurostimulation; SDG = subdural grid electrode; SEEG = stereo-encephalography; UCI = University of California, Irvine; vEEG = video electroencephalography; VNS = vagus nerve stimulation.

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TABLE 1. Formally agreed-upon terms of the memorandum of understanding

1. All preoperative surgical workup would be performed at referring center (e.g., vEEG, 3-T MRI, PET, MEG, neuropsychiatry evaluation, etc.); no preoperative studies would be repeated at UCI except for presurgical planning purposes (e.g., navigation imaging studies).
2. The referring epileptologist would present the case either via video-teleconference or in person, and would present all workup to date to entire UCI epilepsy team.
3. The outcome of the conference would be either surgical referral or further workup (performed at the primary referring site).
4. If referred for surgery, the patient would be seen by a UCI neurosurgeon (e.g., S.V. or F.P.K.H.), and informed consent for treatment would be obtained. The patient would also be evaluated by a UCI epileptologist for perioperative monitoring.
5. After surgery, the patient would be followed by a UCI epileptologist in house and for 6 weeks postoperatively. The neurosurgeon would follow in house and per individual surgeon protocol.
6. The patient would be transitioned back to the care of the primary epileptologist 6 weeks postoperatively.

designated the University of California, Irvine (UCI) the only adult level 4 epilepsy center with surgical capabilities in Orange County, California, one of the most populous counties in the United States. We developed partnerships with 2 outside epilepsy centers, Loma Linda and Kaiser Sunset, to surgically treat patients who were deemed surgical candidates. Both outside centers were performing fewer than 10 noncomplex surgeries per year (i.e., no complex or multiple-stage surgeries). A memorandum of understanding (MOU) was made with both partners based on formally agreed-upon terms (Table 1). This allowed our physicians to treat the patients from the partner centers and accept their insurance coverage. An official administrative meeting was held between us and each partner to ensure complete agreement upon the terms.

All patients considered for surgery from both institutions were referred—not only a subset—because the referring centers had a backlog of surgical candidates (i.e., epilepsy patients whose seizures were not adequately controlled with AEDs). The referring epileptologist had the ultimate decision in terms of prolonging medical treatment or referring for surgical intervention. The referring epileptologist then completed the entire presurgical workup, which included video electroencephalography (vEEG), imaging studies (e.g., 3-T MRI, positron emission tomography [PET], single-photo emission computed tomography [SPECT], magnetoencephalography [MEG], etc.), and medication management at the referring center, which maintained continuity of care and revenue for the outside center. Patients deemed surgical candidates were seen by UCI epilepsy surgeons (S.V. or F.P.K.H.) and underwent preoperative evaluation. During the surgical and perioperative periods, UCI epileptologists monitored the patients, adjusted medications, and assessed all encephalographic data. Patients were transitioned back to the referring center and epileptologist 6 weeks after surgery and continued to be followed by the epilepsy surgeon per routine.

Epilepsy Conference

Due to the geographical distance, a live video stream was developed to facilitate participation of clinicians from each center and UCI in the epilepsy surgical conferences. We utilized standard teleconference equipment freely available at our institution and the partner institutions, as well as online conference tools. The information technology department at our institution was in charge of main-

taining the equipment. No additional full-time employees were required. There was an epilepsy teleconference every 2 weeks with each referral site, and at each teleconference 3–5 cases were presented. UCI epileptologists, neurosurgeons, neuroradiologists, and neuropsychiatrists attended each conference, as well as the referring partner epileptologist who presented his or her patients. All imaging studies, vEEG data, neuropsychological testing data, and clinical findings were discussed. A treatment consensus was reached among all members of the group and tailored to the patient's unique clinical presentation. Surgical procedures included resective surgery, implantation of depth electrodes for stereo-encephalography (SEEG), implantation of subdural grid electrodes (SDGs) for SDG-based EEG, implantation of responsive neurostimulation (RNS) systems, implantation of vagus nerve stimulation (VNS) devices, laser ablation, and palliative surgeries such as corpus callosotomy. If the patient underwent electrode implantation, the UCI epileptologist caring for that patient presented the EEG findings to the teleconference group in a follow-up epilepsy conference prior to any treatment performed (e.g., RNS, VNS), which allowed the referring epileptologist to be a member of the decision-making team.

Data Collection

The study was conducted following STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines. We retrospectively collected and analyzed data from September 2012 through June 2016. All patients undergoing epilepsy surgery during this time frame were eligible for data collection. Referrals started in January 2015; thus the pre-MOU period was 28 months long and the post-MOU period 18 months. Data for the following variables were collected: 1) number of surgeries per patient, 2) whether the case was referred or primary to UCI, 3) the admission date, 4) length of stay in days, 5) seizure semiology (e.g., complex vs partial), 6) anatomical site of surgery, 7) whether invasive monitoring was used, 8) the final surgical therapy provided (e.g., neurostimulation, resection), and 9) complications. Financial data for the following variables were collected from the UCI financial department in US dollars: 1) total revenue, 2) contribution margins, 3) profit margins, and 4) total costs. The insurance provider was also noted. We combined continuous data (e.g., financial data) for separate admissions in

TABLE 2. Summary descriptive data for the 18-month period after partnership development

Variable	Post-MOU			p Value
	UCI (n = 36)	Partner 1 (Kaiser; n = 12)	Partner 2 (Loma Linda; n = 17)	
Patient age (yrs), mean	36.0 ± 2.2	37.5 ± 4.3	38.3 ± 3.6	0.809
LOS (days), mean	6.7 ± 0.8	8.6 ± 2.6	9.4 ± 1.5	0.218
Seizure semiology				0.170
Complex partial	33.3%	58.3%	50.0%	
Simple partial	44.4%	0.0%	5.6%	
Generalized	8.3%	16.7%	27.8%	
Unspecified	13.9%	25%	16.7%	
Invasive monitoring				0.024
Yes	63.9%	41.7%	88.9%	
No	36.1%	58.3%	11.1%	
Surgery site				0.007
Temporal	52.8%	100.0%	61.1%	
Extratemporal	36.1%	0.0%	11.1%	
Other	11.1%	0.0%	28.8%	
Surgical therapy				0.021
Resection	47.2%	91.7%	83.3%	
Neurostimulation	36.1%	8.3%	11.1%	
Other	16.7%	0.0%	5.6%	
Insurance				<0.001
Commercial/private	22.3%	75.0%	5.6%	
Government	69.4%	25.0%	88.9%	
HMO	8.3%	0.0%	5.5%	
Electrode type				0.166
SEEG (depth)	22.2%	25.0%	41.2%	
SDG	41.7%	16.7%	41.2%	
None	36.1%	58.3%	17.6%	

HMO = health maintenance organization; LOS = length of stay.

Data in the UCI column are from cases that were primary to UCI. Data in the partner columns are for cases referred from those institutions. Data are percentages of cases unless otherwise indicated. Means and standard deviations are provided for continuous data. Boldface type indicates statistical significance.

cases involving staged procedures requiring multiple admissions. The admission date and age were taken from the first admission. The study was approved by the UIC institutional review board.

Statistical Analysis

Differences in means were investigated via unpaired t-tests or analyses of variance (ANOVAs) for continuous data and chi-square tests for categorical. Fisher transformation tests were used to test for correlation between variables. Wizard Pro (v. 1.8.17) was used to analyze the data and create the figures. Statistical biases were considered, and none were identified.

Results

A total of 104 patients were treated during the overall study period (46 months), with 39 patients being treated during the pre-MOU period (28 months) and 65 during the post-MOU period (18 months). These 104 patients underwent a total of 200 surgeries—71 in the pre-MOU period and 129 in the post-MOU period. The descriptive statis-

tics for the post-MOU period, stratified by institution, are summarized in Table 2. Comparison of data for primary UCI cases and referrals from the 2 partner institutions showed no significant difference with respect to patient age, length of stay, or seizure semiology. There was a significant difference in use of invasive monitoring, anatomical site of surgery, surgical therapy, and type of insurance. The data for the average number of cases per month for both the prepartnership and postpartnership periods are summarized in Table 3. There was a significant difference between the pre- and postpartnership data for the number of single-surgery cases per month (i.e., cases in which patients underwent only a single-stage procedure), number of complex surgery cases per month (i.e., cases in which patients underwent surgery in 2 or more stages), and number of overall cases per month.

Table 4 shows the overall counts for cases in which patients underwent SDG electrode implantation and SEEG depth electrode implantation as well as the final therapy after ictal-onset localization. There was a significant positive correlation between length of stay and revenue ($r = 0.658$, $p < 0.001$). The complications and rates were in line

TABLE 3. Comparison of mean monthly numbers of cases and financial data for the pre- and post-MOU periods

Variable	Mean (95% CI)		p Value
	Pre-MOU	Post-MOU	
1 surgery, no. of cases per month	0.43 (0.11–0.75)	1.28 (0.52–2.04)	0.02
2+ surgeries, no. of cases per month	0.96 (0.62–1.30)	2.39 (1.85–2.93)	<0.01
Overall no. of cases per month	1.39 (0.98–1.81)	3.67 (2.83–4.50)	<0.01
Total monthly charge	\$597,007.01 (\$321,606.31–\$872,407.71)	\$1,007,488.65 (\$767,458.17–\$1,247,519.13)	0.04
Total monthly revenue	\$130,984.12 (\$58,264.53–\$203,703.71)	\$214,059.50 (\$137,394.45–\$290,724.55)	0.12
Total monthly contribution margins	\$58,476.77 (\$9,080.65–\$107,872.98)	\$76,689.85 (\$23,145.28–\$130,234.42)	0.62
Total monthly profit margins	\$15,662.63 (–\$27,850.93 to \$59,176.19)	–\$12,463.82 (–\$58,259.86–\$33,332.22)	0.38
Total monthly cost	\$115,321.48 (\$60,637.07–\$170,005.89)	\$226,523.28 (\$167,948.18–\$285,098.38)	<0.01

Boldface type indicates statistical significance.

with those reported in the literature and included postoperative bleeding (3.8%), infection (3.8%), and CSF leak (0.9%).

Discussion

The surgical partnership model provided benefit to all parties involved. Most importantly, patient access to surgery was increased and surgery was provided by an experienced team performing a high volume of complex epilepsy surgery procedures. Partnering epileptologists benefited because they were actively involved in decision making and retained their patients postoperatively. Referring institutions benefited from increased revenue associated with performing noninvasive preoperative workup. Our institution benefited from the experience and revenue associated with an increase in the volume of complex cases. During the post-MOU time frame, the overall case volume and monthly charges increased significantly; monthly revenue and contribution margin also increased, although not significantly.

Referrals of complex cases from epilepsy centers with limited surgical capabilities to centers with high surgical volumes makes sense, intuitively, but execution may be problematic. This study described outcomes associated with a formalized partnership between centers. Less than 1% of patients with intractable epilepsy are referred for surgery.³ The results of our investigation demonstrated that our institutional partnerships provided an increase in surgically complex cases, as there was an increase in patients undergoing invasive studies and staged procedures to localize and treat the ictal-onset zone. Our partners were capable of performing noninvasive presurgical workups but were unable to consistently provide epilepsy surgery because of staff limitations. The patients also benefited because they were treated at a high-volume, experienced center, which has been shown to improve patient outcomes.^{10,13}

The underutilization of epilepsy surgery is multifactorial. Despite high efficacy and low complication rates, only a small subset of epilepsy surgical candidates will undergo surgery, and often in a delayed manner.¹⁷ Poor referral patterns are likely not the only reason why appropriate candidates are not receiving surgical treatment. For example, a study showed that some patients simply decline

surgery due to costs or fear.¹ Indeed, a study performed at a tertiary epilepsy center in the United Kingdom showed that 32% of patients offered surgery declined to proceed,⁶ which may indicate that some appropriate candidates are not undergoing surgery because of personal preferences and preconceived notions regarding surgery. Another reason might be poor communication and relationships between community neurologists and surgical epilepsy centers. A survey of neurologists who treated patients with refractory epilepsy showed that approximately 50% of them were unsatisfied with the communication from epilepsy centers.⁷ To prevent that problem, we incorporated the referring epileptologists into our care; they presented their own cases in our epilepsy conferences, and patient care was transitioned back to the epileptologist after surgery. Thus our model of patients undergoing preoperative evaluation and postsurgical outpatient care at their original centers allowed for excellent continuity of care that fostered communication and involvement. The model streamlined the referral process, making it more efficient and effective.

Ultimately, the strategic partnerships benefited patients who were deemed appropriate candidates for surgery and might have had limited or no access to surgical treatment without these partnerships. A study of patients with temporal lobe epilepsy and hippocampal sclerosis showed that those who had longer duration of disease before undergoing resection also had poorer outcomes, implying that patients with medically refractory focal epilepsy should be considered for surgical treatment shortly after documented medication failure.⁹ Furthermore, patients who are seizure free after surgery have substantial increases in lifespan and quality of life in comparison to those receiving only medical treatment.² Our goal was to provide a framework for other epilepsy centers to establish similar partnerships and to demonstrate that insurance and geographic location were not barriers to care.

Conclusions

This study describes a novel means to create strategic partnerships with nearby epilepsy centers with limited epilepsy surgery capabilities, increasing access to surgical care for patients with refractory epilepsy. Our method fosters effective communication and better relationships

TABLE 4. Summary statistics of complex cases

Variable	No. of Cases*
Electrode type	
SEEG	25
SDG	44
Therapy after invasive monitoring	
RNS	21
VNS	2
Resection	39
Other	8

* Combined data for pre-MOU and post-MOU periods for UCI and partner institutions.

between centers, which may help overcome some referral barriers. Other centers may benefit from similar partnerships with nearby epilepsy centers, which would ultimately increase access to surgery and improve patient care.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Vadera, Mnatsakanyan, Sazgar, Lin, Hsu. Acquisition of data: Vadera, Chan. Analysis and interpretation of data: Vadera, Chan, Sen-Gupta, Hsu. Drafting the article: all authors. Critically revising the article: all authors. Reviewed submitted version of manuscript: Vadera, Chan, Mnatsakanyan, Sazgar, Lin, Hsu. Statistical analysis: Chan. Administrative/technical/material support: Vadera. Study supervision: Vadera, Hsu.

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