

Surgical treatment of epilepsy in Vietnam: program development and international collaboration

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OBJECTIVE The purpose of this report was to describe an international collaboration model to facilitate the surgical treatment of children with epilepsy in Vietnam.

METHODS This model uses three complementary methods to achieve a meaningful expansion in epilepsy surgery capacity: US-based providers visiting Hanoi, Vietnam; Vietnamese providers visiting the US; and ongoing telecollaboration, including case review and real-time mentorship using internet-based communication platforms.

RESULTS Introductions took place during a US neurosurgeon's visit to Vietnam in 2014. Given the Vietnamese surgeon's expertise in intraventricular tumor surgery, the focus of the initial visit was corpus callosotomy. After two operations performed jointly, the Vietnamese surgeon went on to perform 10 more callosotomy procedures in the ensuing 6 months with excellent results. The collaborative work grew and matured in 2016–2017, with 40 pediatric epilepsy surgeries performed from 2015 through 2017. Because pediatric epilepsy care requires far more than neurosurgery, teams traveling to Vietnam included a pediatric neurologist and an electroencephalography (EEG) technologist. Also, in 2016–2017, a neurosurgeon, two neurologists, and an EEG nurse from Vietnam completed 2- to 3-month fellowships at Children's of Alabama (COA) in the US. These experiences improved EEG capabilities and facilitated the development of intraoperative electrocorticography (ECoG), making nonlesional epilepsy treatment more feasible. The final component has been ongoing, i.e., regular communication. The Vietnamese team regularly sends case summaries for discussion to the COA epilepsy conference. Three patients in Vietnam have undergone resection guided by ECoG without the US team present, although there was communication via internet-based telecollaboration tools between Vietnamese and US EEG technologists. To date, two of these three patients remain seizure free. The Vietnamese team has presented the results of their epilepsy experience at two international functional and epilepsy surgery scientific meetings.

CONCLUSIONS Ongoing international collaboration has improved the surgical care of epilepsy in Vietnam. Experience suggests that the combination of in-country and US-based training, augmented by long-distance telecollaboration, is an effective paradigm for increasing the capacity for highly subspecialized, multidisciplinary neurosurgical care.

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KEYWORDS global health; neurosurgery; drug resistant epilepsy; epilepsy surgery; international collaboration; continuing medical education

THE essential role of surgical services in global health has recently been highlighted,³⁰ with 11% of the global disease burden attributed to surgical problems.²¹ While historically perceived as an unaffordable luxury, surgical care is now recognized as an essential

and cost-effective component of healthcare even in the developing world.¹⁵ Neurosurgery, because of its lengthy training and perceived cost inefficiency, has lagged behind other surgical services, and calls for expanding neurosurgical capacity have grown increasingly urgent.^{6,18,32}

ABBREVIATIONS AED = antiepileptic drug; COA = Children's of Alabama; ECoG = electrocorticography; EEG = electroencephalography; SSEP = somatosensory evoked potential.

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Epilepsy results from a highly diverse group of congenital and acquired conditions, affecting roughly 50 million people worldwide.³⁷ Failure to adequately manage seizures increases the risk of sudden death and frequently leads to life-long functional disability, as well as impairment in psychosocial adjustment, social integration, and employment.^{12,23} With the exception of stroke, epilepsy is the leading cause of years of life lost (due to sudden unexplained death) among all neurological disorders worldwide.⁴¹ Many patients with lesional epilepsy are imminently treatable with resection, and the consequences of failing to treat these patients is a significant burden on low-income countries.³⁸

Here, we describe one model for the expansion of multidisciplinary pediatric epilepsy care in Hanoi, Vietnam.

Methods

Local Context

All cases were performed at the Viet Duc Hospital, the National Cancer Hospital, or the National Hospital of Pediatrics in Hanoi, Vietnam, between 2014 and 2018. Established in 1904 as part of the French Indochina Medical College, Viet Duc Hospital has developed into one of the more important surgical hospitals in Vietnam, with more than 1000 beds and 30 operating rooms. The National Cancer Hospital, or K Hospital, was established in 1923 and is the largest hospital specializing in oncology in Vietnam, including three campuses with over 1500 beds. The National Hospital of Pediatrics, established in 1969, performs 6000 major surgeries annually and is the largest children's hospital in the northern region of Vietnam.

In-Country Training Programs

In 1997, there were approximately 60 neurosurgeons in Vietnam.³⁶ Neurosurgical training has expanded dramatically over the past 20 years, and while an accurate census of currently practicing neurosurgeons is difficult to obtain, there are an estimated 260 neurosurgeons practicing in Vietnam, providing care for a population of more than 96 million people.⁴⁰ The northern district of Vietnam, centered around Hanoi, has four pediatric neurosurgeons, serving a population of over 50 million. There are two adult and two pediatric neurosurgery training programs for all of Vietnam, located in either Ho Chi Minh City or Hanoi.²⁴ Adult neurosurgery is a separate track from pediatric neurosurgery training, each involving a 3-year program. Graduates pursuing academic careers also practice under supervision for an additional 4–5 years.²⁴

Equipment and Supply

To support a comprehensive epilepsy program, equipment and supply needs must be met. Computed tomography and MRI facilities were available on-site at each hospital, as were operating microscopes and neuroendoscopy equipment. Electroencephalography (EEG) had been widely used. The necessary equipment for intraoperative electrocorticography (ECoG) was available, though ECoG had not been used prior to this collaboration. Advanced imaging modalities used for nonlesional epilepsy workup such as single-photon emission CT (SPECT) or magnetoencephalography (MEG) were not available. However,

positron emission tomography (PET) was available and was helpful in selecting suitable candidates for surgical treatment with intraoperative ECoG.

Three complementary methods were used to achieve a meaningful expansion in epilepsy surgery capacity: 1) US-based providers visiting Hanoi, Vietnam; 2) Vietnamese providers visiting the US; and 3) ongoing telecollaboration, including case review and real-time mentorship using internet-based communication platforms.

Results

The history of the collaboration is shown in Table 1.

Early Collaborative Period

Introductions took place during a US neurosurgeon's visit to Ho Chi Minh City, Vietnam, in 2014, during which time discussions were held with neurosurgeons from Hanoi regarding further collaborations with their hospitals.

Epilepsy Surgery Training in Vietnam

In 2015, neurosurgeons from Children's of Alabama (COA) traveled to Hanoi, Vietnam, to provide in-country training on epilepsy surgery techniques. Given the Vietnamese surgeon's (N.D.L.) expertise in intraventricular tumor surgery, the focus of the initial visit was corpus callosotomy. Particular attention was paid to surgical indications and patient selection. After two operations performed jointly, the Vietnamese surgeon went on to perform 10 more callosotomy procedures in the ensuing 6 months with excellent results.

The COA team returned to Hanoi for weeklong visits in 2016 and 2017 to provide additional support and training. Because pediatric epilepsy care requires far more than neurosurgery, teams traveling to Vietnam included a pediatric epileptologist (P.K.) and EEG technologist (D.T.K.). In 2016, the visit to Vietnam focused on epilepsy electrodiagnostics and patient selection for disconnection procedures. The team conducted lectures and hands-on training in fine-tuning EEG equipment, display techniques for EEG recording, EEG electrode application, and intraoperative monitoring. The main surgical focus of the 2016 visit was functional hemispherotomy. In 2017, the visit focused on the surgical treatment of nonlesional, nonhemispheric epilepsy, with a special emphasis on resection based on ECoG. Technologists and neurologists gained additional experience with phase reversal somatosensory evoked potentials (SSEPs) to localize the central sulcus. In addition, the National Hospital of Pediatrics in Vietnam hosted an all-day didactic course attended by EEG nurses and technologists from around the region. Finally, three patients underwent resection of epileptogenic foci performed by a surgical team of both US and Vietnamese surgeons, with intraoperative ECoG performed by a joint team of US and Vietnamese EEG technologists, nurses, and neurologists. Two of these patients remained seizure free at the most recent follow-up.

US-Based Training Program

The Global Surgery Program at COA was established to facilitate and coordinate the development of compre-

TABLE 1. Five-year history of Vietnam–COA epilepsy surgery collaboration

Year	Specific Event
2013	Initial visit from COA neurosurgery to neurosurgeons in Ho Chi Minh City, Vietnam
2014	Introduction to neurosurgeons in Hanoi interested in expanding epilepsy surgery experiences Ongoing discussions w/ neurosurgeons in Hanoi about expanding collaboration
2015	First visit to Hanoi by COA neurosurgeons Operative focus: corpus callosotomy
2016	Continued visits from COA team Vietnamese neurosurgeon, two neurologists, & EEG nurse complete focused training at COA Operative focus: functional hemispherotomy
2017	Two research abstracts on epilepsy program presented by Vietnamese team at international conferences First long-distance telecollaboration on intraop ECoG Continued visits from COA team & review of Vietnamese epilepsy cases at multidisciplinary epilepsy conference Creation of dedicated epilepsy monitoring unit for long-term EEG monitoring in Hanoi Operative focus: nonlesional, nonhemispheric epilepsy w/ special emphasis on resection based on ECoG
2018	Self-sufficient epilepsy program established w/ reduced need for case review at COA epilepsy conferences Ongoing collaboration & research initiatives

hensive, multidisciplinary programs for surgical diseases based on strong, collaborative relationships with large pediatric hospitals in low- and middle-income countries. Subspecialty fellowship training at COA is an established component of this effort. Over the last 4 years, eight international neurosurgeons from five countries have undergone dedicated pediatric neurosurgery training at COA hospital, ranging in duration from 3 months to 1 year.

As part of this program, in 2016–2017, a neurosurgeon, two neurologists, and an EEG nurse from Vietnam completed 2- to 3-month fellowships at COA in the US. For neurologists and EEG nurses, clinical neurophysiology lectures and hands-on video-EEG review with an emphasis on how to identify pertinent lateralizing seizure semiology were conducted throughout their visit. The visiting neurosurgeon participated in daily case conferences and served as an observer in the operating theater and clinic. These experiences improved EEG capabilities and facilitated the development of intraoperative ECoG, making nonlesional epilepsy treatment more feasible. Upon the neurosurgeon's return to Hanoi, an epilepsy monitoring unit, based on the COA epilepsy monitoring unit, was established at the National Hospital of Pediatrics.

Ongoing Telecollaboration

The final component is ongoing, regular communication. The Vietnamese team regularly sends case summaries for discussion at the COA epilepsy conference. Seven cases were reviewed in 2015–2016, 13 in 2017 (three of which underwent surgery during the 2017 visit of the US team), and, to date, 14 in 2018.

Finally, three additional patients in Vietnam underwent resection guided by ECoG without the US team present, although there was communication via internet-based telecollaboration tools between the Vietnamese and US EEG technologists. Constant, live feedback between the EEG technologists in Vietnam and those in Alabama facilitated intraoperative ECoG and phase reversal SSEP. To date, two of these patients have remained seizure free.

Clinical Outcomes

Results from one portion of the epilepsy program described above were presented in abstract form at the 11th Scientific Meeting for the Asian Australasian Society of Stereotactic and Functional Neurosurgery held in Sun-Moon Lake, Taiwan, on April 20, 2018. From January 2015 through August 2017, a prospective study was conducted of all pediatric patients undergoing surgery for medically refractory epilepsy at Viet Duc Hospital and the National Cancer Hospital. Forty cases were treated during the study period. The median patient age was 9.1 years (range 2–17 years) for patients undergoing temporal lobectomy and 8.1 years (range 4–15 years) for patients undergoing surgery for extratemporal lobe epilepsy. Thirty-five percent of the patients underwent surgery for temporal lobe epilepsy and 37.5% for extratemporal lobe epilepsy, whereas 22.5% underwent corpus callosotomy and 5% underwent functional hemispherotomy. At 12 months postoperatively, 85.7% of the patients who had undergone surgery for temporal lobe epilepsy were seizure free, while 77.8% of those who had undergone extratemporal lobe resection were seizure free. Among the callosotomy patients, 66% experienced a reduction in seizure frequency. Of the two patients who underwent functional hemispherotomy, one was seizure-free and the second had decreased seizure frequency. There were no deaths, and the only morbidity was one case of a postoperative wound infection requiring antibiotics.

Sustainability and Research Productivity

At the time of writing this paper, the epilepsy program in Vietnam is approaching self-sufficiency. Neurosurgeons from COA continue to provide clinical and surgical expertise through short-term trips and as-needed remote telecollaboration between visits. Patients under consideration for surgical epilepsy treatment are reviewed by the Vietnamese team as well as remotely at the COA epilepsy conference.

The Vietnamese team has presented the results of their epilepsy experience at two international functional and

epilepsy surgery annual scientific meetings and continues to collect clinical outcomes data on their epilepsy surgery patients.

Discussion

Epilepsy Surgery in the Developing World

At least 80% of the roughly 50 million people with epilepsy in the world live in developing countries, with 90% of them failing to receive adequate medical treatment.³⁷ In Vietnam, knowledge about epilepsy among many of its citizens remains limited. Negative attitudes toward people with epilepsy are prevalent. In one study conducted in rural Vietnam, 82% of respondents would object to their child marrying someone with epilepsy, and 36% would not want their child to play with someone with epilepsy.⁴²

While the clinical outcomes achieved by the Vietnamese team are outstanding relative to those in the epilepsy surgery literature, surgical failure remains a significant challenge in epilepsy surgery.^{25,48} This is particularly true in pediatric epilepsy, where localized epilepsy is almost inherently neocortical, with cortical dysplasia as the most common pathological finding¹⁹ and failure rates often approaching 50%. As a result, epilepsy surgery, particularly cases without a clear anatomical correlate to scalp EEG and seizure semiology, has historically been viewed as too time and resource intensive to be a priority in the developing world.

It is reasonable to consider whether such emphasis on high-complexity care is prudent in areas where access to even basic surgical services is limited.^{5,33} In many cases of epilepsy surgery, however, equipment needs are comparably modest, hospital stays short, and the long-term psychological and productivity impacts large. We suggest that epilepsy surgery should be considered alongside such interventions as endoscopic third ventriculostomy for hydrocephalus and craniotomy for acute extraaxial hematoma when discussing interventions worthy of early introduction to increase neurosurgical capacity in developing countries.

Antiepileptic Drugs in Vietnam

The medical management of epilepsy faces multiple challenges in Vietnam, emphasizing the potential role for surgical intervention. In a recent study performed in rural Vietnam, only 15% of people with active epilepsy were on appropriate antiepileptic drug (AED) treatment despite the existence of a national program that provides phenobarbital and phenytoin free of charge.⁴³ The 85% treatment gap observed in Vietnam is comparable to the estimated 56% treatment gap worldwide, with 80%–90% of people with epilepsy in developing countries lacking access to adequate treatment.²⁹ Regional variations are dramatic, with a recent study from Tibet reporting a treatment gap of 97%.⁴⁹ Patients in Vietnam who did not receive appropriate AEDs most commonly stated that the number of seizures were insufficient to justify the expense, stigma, and difficulty of obtaining the drugs. While two AEDs are free of charge, patients can only obtain the “free” medication by attending monthly appointments with specified physicians. Additionally, the quality and availability

of AEDs in Vietnam is inconsistent. In 2006, only 57% of Vietnamese pharmacies had any AED available, with most offering only one or two.²⁸ Carbamazepine, phenytoin, valproate, and diazepam were most commonly available. Monthly treatment costs ranged from US\$3.30 to US\$22.50. However, quantities and options at any given pharmacy remain very limited, and only 35% of the tablets for carbamazepine and phenytoin were correctly dosed—perhaps because of the variable sensitivity of AEDs to storage conditions and environmental factors.²⁷

Multidisciplinary Program Development and Training Model

In low-resource settings, high-complexity surgical care requiring a multidisciplinary team poses particular challenges but is not without precedent. Awake craniotomy has been successfully taught and implemented in Ghana and has been promoted as safe, resource sparing, and sustainable.²⁰ Creative solutions and adaptations of local technology can also overcome limitations in equipment and facilities.^{4,44}

In many developing countries, the expansion of subspecialty neurosurgical care is assisted by a combination of nonprofit organizations, the sustained presence of visiting teams, and both in- and out-of-country training.^{1,10,17,26,35,46} Providing a neurosurgeon with the technical training to perform a procedure is insufficient. To successfully establish an epilepsy surgery program, epileptologists, EEG technologists, nurses, and biomedical support team members must all receive additional training.

Formal out-of-country fellowship training is common among many surgical subspecialists in low- and middle-income countries⁸ and is an essential component of this model. Such out-of-country training has been advocated as a means of rapidly increasing neurosurgical capacity in low-resource settings.¹¹ While short-term visitations can provide valuable training and medical supplies, sustainable training efforts are required to break the cycle of dependence on foreign aid.⁴⁷

Finally, as has been demonstrated here, novel telecollaboration tools have been effectively used for long-distance neurosurgical training and capacity building in the developing world,⁹ and visiting professorships have been advocated to enhance the level of neurosurgical training.⁷ As a result of these considerations, we believe a multi-pronged approach to training is a viable and generalizable mechanism for enhancing neurosurgical capacity.

Future Refinements

A fundamental paradigm shift in the management of medically refractory epilepsy is currently underway. Evolving technologies are allowing ever-greater precision in localization, while the number of new techniques for localization, lesioning, and stimulation has grown substantially. A number of centers are moving to a stepwise approach of progressively invasive interventions, taking a staged, palliative, and minimally invasive approach in difficult cases. While these advances have expanded the armamentarium of epilepsy surgeons, diffusion of these techniques to the less-developed world has been limited.

Many of these technological innovations are unavailable to most patients in Vietnam, including MRI-guided laser interstitial thermal therapy,³¹ responsive neurostimulation,^{16,22} and vagus nerve stimulation.¹⁴ However, the development of a comprehensive epilepsy program does not require the availability of every technological product at the outset. As the program grows, these and other new technical advancements will continue to be incorporated.

Local Practice Environment

Neurosurgical services and neurosurgical training is highly developed in Vietnam, with a wide range of neurosurgical services offered. In such an environment, collaborations with neurosurgeons in other countries can provide refinements and offer new techniques. For neurosurgeons in high-income countries looking to form international partnerships, a full understanding of local capacity and the local practice environment is essential. Neurosurgeons in Vietnam are highly trained in microsurgical techniques and face a remarkable breadth and complexity of neurosurgical cases on a daily basis. Therefore, collaborations with international teams are most valuable when focusing on specific, highly subspecialized techniques that are not currently available.

Brain Drain and Training Considerations

The global shortage of surgeons is only expected to worsen.^{39,45} In Vietnam today, there is an estimated ratio of one neurosurgeon per 369,000 people. By contrast, the optimum neurosurgeon-to-population ratio is broadly cited as 1:100,000,⁵⁰ and the ratio in the US is nearer to 1:55,000.²

Permanent emigration of physicians following training is a significant strain on healthcare systems in developing countries.³ In-country postgraduate training decreases the risk of physician emigration.¹³ Furthermore, local training emphasizes the regional, socioeconomic, and cultural framework to successfully retain graduates.³⁴ Groups such as the Foundation for International Education in Neurological Surgery (FIENS) and the World Federation of Neurosurgical Societies (WFNS), among many others, have large and active programs to augment local neurosurgical training across the globe. Newer internet-based matching services like InterSurgeon.org may also facilitate similar clinical and educational partnerships outside of the traditional academic neurosurgical community. The model described here provides benefits in the transfer of technology, knowledge, and skill, while the risk of permanent emigration is decreased by the provision of subspecialty, highly focused training.

Conclusions

Here, we describe an ongoing multidisciplinary collaboration between neurosurgeons in Vietnam and those at COA for expanding the capacity in epilepsy surgery in Hanoi, Vietnam. Given the need for multidisciplinary teams and the large number of international nongovernmental organizations focusing on epilepsy, we believe this model of building on a nascent epilepsy program is highly generalizable. With the addition of relevant surgical skills, equipment, and neurological and EEG support, a large

multidisciplinary epilepsy surgery center can be successfully established.

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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: Rocque, Tuan, King, Kankirawatana, Nam Thang, Johnston, Duc Lien. Acquisition of data: Rocque, McClugage, Tuan, King, Huong, Thi Bich Van, Kankirawatana, Vu Hung, Nam Thang, Johnston, Duc Lien. Analysis and interpretation of data: Davis, Huong, Nam Thang, Duc Lien. Drafting the article: Davis, McClugage. Critically revising the article: Rocque, Davis, McClugage, Tuan, King, Thi Bich Van, Kankirawatana, Vu Hung, Nam Thang, Johnston, Duc Lien. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Rocque. Administrative/technical/material support: Rocque, Davis, Tuan, King, Thi Bich Van, Kankirawatana, Vu Hung, Nam Thang, Johnston, Duc Lien. Study supervision: Rocque, Johnston, Duc Lien.

Supplemental Information

Previous Presentations

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