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Establishment of low cost epilepsy surgery centers in resource poor setting

Anis Jukkarwala[a], Neeraj N. Baheti[b], Amit Dhakoji[b,c], Bhagwati Salgotra[d], Girish Menon[e], Aditya Gupta[f], Sanjay Prakash[d], Chaturbhuj Rathore[d,*]

[a] Department of Neurology, Geetanjali Medical College and Hospital, Udaipur, Rajasthan, India
[b] Department of Neurology, Central India Institute of Medical Sciences, Nagpur, Maharashtra, India
[c] Department of Neurosurgery, Sahyadri Super Speciality Hospital, Pune, Maharashtra, India
[d] Department of Neurosciences, Smt. B. K. Shah Medical Institute and Research Center, Sumandeep Vidyapeeth, Vadodara, Gujarat, India
[e] Department of Neurosurgery, Kasturba Medical College, Manipal, Karnataka, India
[f] Department of Neurosurgery, Artemis Hospital, Gurugram, Haryana, India

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ABSTRACT

Purpose: To prospectively assess the feasibility of establishing low cost epilepsy surgery programs in resource poor settings.
Method: We started epilepsy surgery centers in Tier 2 and Tier 3 cities in India in private hospitals. This model is based on the identifying and operating ideal epilepsy surgery candidates on the basis of clinical history, interictal and ictal video-EEG data, and 1.5 T MRI without other investigations and without regular involvement of other specialists. Trained epileptologists formed the fulcrum of this program who identified ideal candidates, offered them counseling, and read video-EEG and MRI. We also spread epilepsy awareness among locals and physicians and established focused epilepsy clinics. The expenses were subsidized for deserving patients and policies were devised to keep video-EEG duration and staff requirement to minimum. Difficult epilepsy surgery cases were referred to established centers. Initial surgeries were performed by invited epilepsy surgeons and subsequently by local neurosurgeons.
Results: A total of 125 epilepsy surgeries were performed at three centers since 2012. This included 81(64.8%) temporal lobe resections, 26 (20.8%) extratemporal focal resections, and 13 (10.4%) hemispherotomies. Of the 93 patients with more than 1 year of postoperative followup, 86 (92.5%) had Engel class IA outcome. There were minor complications in 5% patients. Average cost of presurgical evaluation and surgery was Rs. 92,707 (USD 1,324).
Conclusions: It is possible to establish successful epilepsy surgery programs in resource poor setting with reasonable costs. This low cost model can be replicated in other parts of world to reduce the surgical treatment gap.

1. Introduction

Epilepsy is one of the commonest neurological diseases with a prevalence of 5 per 1000 person-years [1,2]. Treatment with anti-epileptic drugs remains the primary therapy for all types of epilepsies. However, approximately one third of patients with newly diagnosed epilepsy do not adequately respond to antiepileptic drugs [3,4]. In selected patients with drug resistant epilepsy, epilepsy surgery remains the most effective treatment option [5–7].

In spite of its proven effectiveness, epilepsy surgery remains largely underutilized in developing countries such as India. Currently, only 2 in 1000 eligible patients undergo epilepsy surgery in India [8]. In addition to multiple social and economical factors, lack of well organized epilepsy surgery centers in remote areas of country is one of the main reasons for underutilization of epilepsy surgery [8,9]. Starting and sustaining a successful epilepsy surgery program is a cost and labor intensive proposition. It requires specifically trained personnel, a close collaboration between multiple specialities, and specialized and cost intensive equipments. Due to these reasons, epilepsy surgery in India has remained confined to few major centers in large cities. Of these, centers in government setup usually have long waiting lists for epilepsy surgery and are unable to cater to the large number of patients in spite of their best intentions. On the other hand, centers in private setup are usually not affordable to large majority of patients. Moreover, these centers are not accessible to patients living in remote areas of country. To make epilepsy surgery accessible to all the eligible people, we need

* Corresponding author at: Smt. B. K. Shah Medical Institute and Research Center, Sumandeep Vidyapeeth, Vadodara, Gujarat, India.
E-mail address: cbrathore@rediffmail.com (C. Rathore).

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to establish epilepsy surgery centers in remote areas and need to make them cost effective. Here we share our experience of starting epilepsy surgery programs in private sector in relatively small cities in Western India and discuss the framework for a low cost strategy of presurgical evaluation and epilepsy surgery.

2. Methods

2.1. Location and outline of centers

After completing one year epilepsy fellowship at Sree Chitra Tirunal Institute of Medical Sciences and Technology (SCTIMST), Trivandrum, Kerala, the authors (AJ, NB) returned to tier 2 cities in Western India (Udaipur in the state of Rajasthan and Nagpur in the state of Maharashtra respectively) with an aim to start comprehensive epilepsy care centers. In addition, the senior author (CR) also returned to Vadodara located in Western India in the state of Gujarat after working for 9 years at the same institute. We joined hospitals attached with medical colleges and not-for-profit trusts. At that time, there was no comprehensive epilepsy care center in the states of Gujarat and Rajasthan while all the centers in Maharashtra were located in the main city of Mumbai (Fig. 1). Lack of resources and trained support staff appeared a huge hindrance towards starting a specialized epilepsy surgery program. Moreover, services of trained neuroradiologist, neurosurgeon, and neuropsychologist were not readily available.

2.2. Training of personnel

Realizing that all the sophisticated equipments and other specialists will not be available, we decided to take on ourselves to start comprehensive epilepsy care centers. Initially, we recruited EEG technicians and either provided them in house training or sent them for one month training in video-EEG monitoring at established centers. They were particularly trained in the technical aspects of video-EEG monitoring including data acquisition and archiving, secure scalp and special electrode placement, montage reformatting, patient response testing during seizures, and first aid management of generalized seizures. Apart from the technicians, we also trained ward nurses in electrode placement, response testing and management of generalized seizures to minimize the need of extra personnel in nights. These ward nurses are available round the clock and have the ability to take additional charge of epilepsy monitoring unit. Subsequently, we procured 32 channel digital video-EEG machines after convincing the hospital management about its feasibility and sustainability.

2.3. Selection of ideal candidates and process of presurgical evaluation

To spread the awareness of epilepsy and epilepsy surgery in local population, we started holding free treatment camps and public lectures in and around the respective cities. At the same time, we started epilepsy clinics at our hospitals with an aim of providing focused medical care, neuropsychological counseling, and for the early identification and counseling of patients with drug resistant epilepsy. Due to the availability of single video-EEG machines, we decided to restrict video-EEG monitoring to only those patients who had high likelihood of undergoing surgery with minimal presurgical evaluation. In this regard, we decided to offer presurgical evaluation and epilepsy surgery to patients with well defined surgically remediable syndromes [10]. These included patients with unilateral mesial temporal sclerosis, well circumscribed noneloquent lesions such as focal cortical dysplasias, low grade tumors, gliosis, and vascular lesions, and unihemispheric large lesions. Other patients with drug resistant epilepsy especially those with normal MRI or multifocal lesions were managed medically or referred to other established epilepsy centers.

In addition, we designed epilepsy protocol for 1.5 T MRI with the help of our radiologists and technologists. We specifically included T2-weighted and Fluid Attenuated Inversion Recovery (FLAIR) coronal sequences optimized for hippocampal assessment, 3D FLAIR sequences, and Susceptibility Weighted Images (SWI) [11]. Those patients with high likelihood of focal cortical dysplasia and normal 1.5 T MRI were sent for 3 T MRI to nearby radiology centers. We decided to read the MRI images ourselves without relying on the radiologist reports and this was helped by the knowledge of likely site of seizure origin on the basis of clinical semiology and routine EEG data. We trained our nurses for neuropsychological counseling. Only those patients who required specialized neuropsychological and neuropsychiatric services were referred to specialists.

Patients with drug resistant epilepsy and apparent surgically remediable epilepsy syndromes who were willing for epilepsy surgery were admitted for long-term video-EEG monitoring. We used standard 10–20 system of electrode placement with additional anterior temporal electrodes. We tapered antiepileptic drugs in all patients except those with daily or frequent seizures. We tapered one third of antiepileptic doses every 24 h while barbiturates and benzodiazepines were tapered in the end. Anterior and mid-temporal interictal discharges were classified as temporal discharges and more than 70% of interictal epileptiform discharges confined to one side were considered as unilateral interictal discharges. We recorded only one seizure in patients who has unequivocal history of single seizure semiology, single well defined MRI lesion, concordant interictal data, and concordant ictal semiology and ictal EEG. This helped us in minimizing the video-EEG stay. To further minimize costs, we used locally made scalp electrodes and used cotton and crepe bandages for securing electrodes. Patients with concordant clinical, electrical, and radiological data were selected for epilepsy surgery. If there was any uncertainty in interpreting initial video-EEG recordings, then data were sent to an experienced epileptologist (CR) for second opinion.

We used locally made portable EEG machine for intraoperative electrocorticography. We procured two 4 contact strip and depth electrodes for intraoperative electrocorticography. These electrodes were reused multiple times after proper sterilization. As a last step, we invited experienced epilepsy surgeons (GM, AG) for performing initial surgeries. This was done as a part of epilepsy surgery workshop to train our neurosurgeons.

2.4. Epilepsy surgery and postoperative followup

All surgeries were performed as per standard protocols. Following surgery, we followed patients at 3 months, at 1 year and then at yearly intervals. Interictal EEGs were done at initial 4 followup visits. We continued preoperative antiepileptic drugs for one year following surgery and then gradually tapered as per the standard protocol [12]. We classified the seizures outcome according to the Engel seizure outcome scale [13]. We used descriptive statistics to describe the patient characteristics and seizure outcome at three centers.

2.5. Cost of presurgical evaluation and epilepsy surgery

All the three centers are privately run trust hospitals which do not receive any grant from the government. While hospitals at Vadodara and Nagpur are charitable teaching hospitals, the one at Udaipur is a private teaching cum corporate hospital. For this study, we calculated provider based direct costs of presurgical evaluation and epilepsy surgery. We calculated cost estimates on the basis of cost charge ratios generated by the financial department of these hospitals for all medical services including presurgical consultations, video-EEG monitoring, MRI, and epilepsy surgery [14]. We estimated costs for the following services: preadmission evaluation (neurology and neurosurgery consultations and MRI), video-EEG monitoring (3 day video-EEG monitoring, hospitalization costs, neurological consultations), and epilepsy surgery (hospitalization costs for 7 days, operation theater and consumable costs, neurosurgeon and anesthetic services, intraoperative

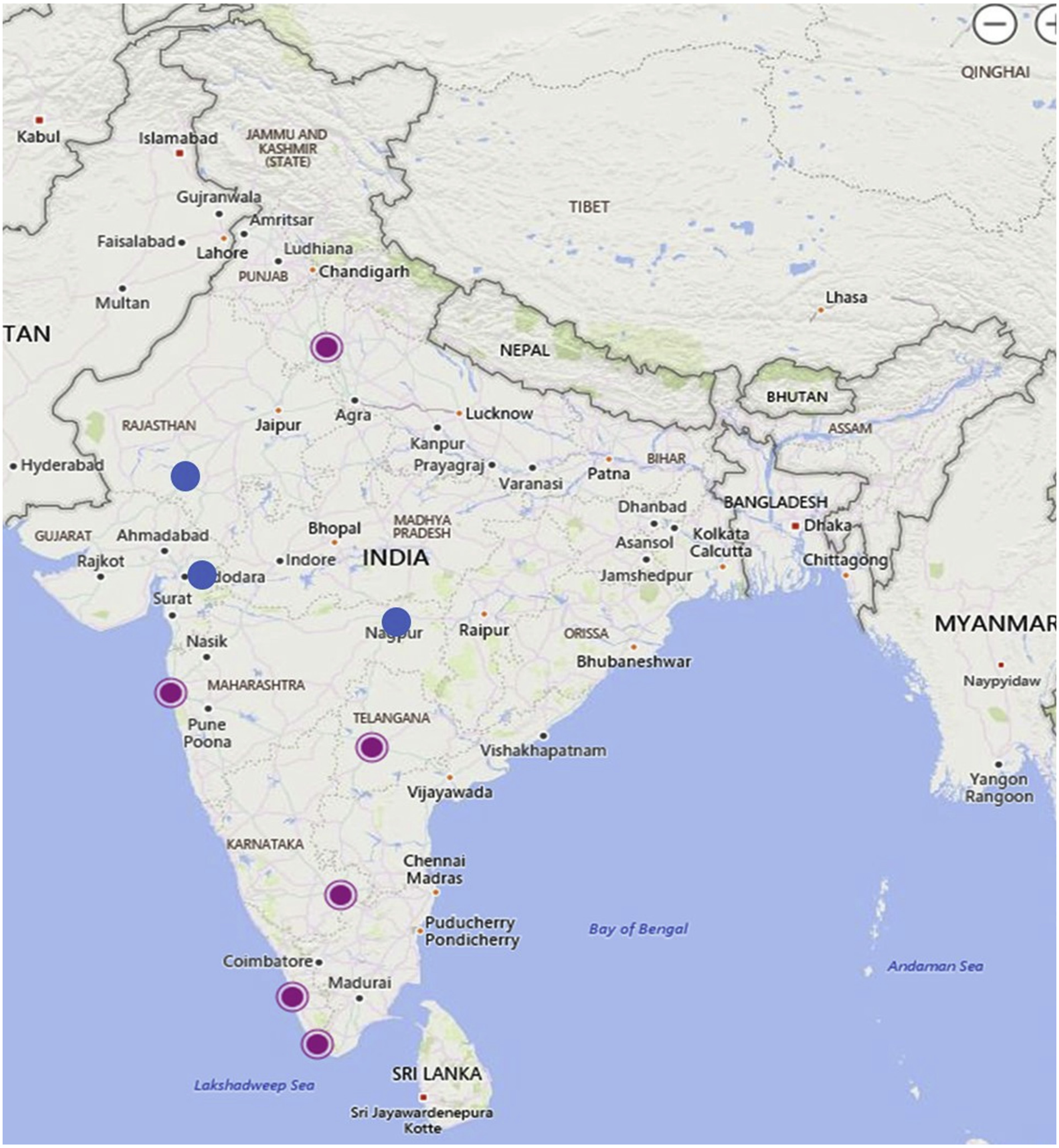

Fig. 1. Map of India showing location of three study centers (single circles) and other six major epilepsy surgery centers at Trivandrum, Delhi, Mumbai, Bengaluru, Hyderabad, and Cochin (double circles).

electrocorticography, and postoperative CT scan). Costing for neuropsychological consultations was obtained directly from the providers. Based upon this, we calculated the cost of presurgical evaluation and epilepsy surgery for each patient and then calculated the average cost at each centre.

3. Results

The first epilepsy surgery was performed in June 2012 at Nagpur, September 2015 at Vadodara, and December 2017 at Udaipur. Since then we have performed total 125 epilepsy surgeries (56 males) at three centers: 69 at Nagpur, 47 at Vadodara, and 9 at Udaipur. We have combined the outcome results from three centers as we have followed a common practice of presurgical evaluation, epilepsy surgery, and postoperative followup at these centers. The details of surgeries and postoperative outcomes are provided in Table 1.

3.1. Types of surgeries and pathologies

Median duration of video-EEG stay at the three centers was 3 days (Range, 1–12 days). Overall, two third of patients had temporal lobe surgeries while 20% had focal extratemporal lesionectomies and 10% had hemispherotomies. There are minor variations in the type of surgeries across the centers as hemispherotomy, callosotomy, and multilobar resections were performed only at one center. Half of the patients had hippocampal sclerosis while gliosis and focal cortical dysplasias were other common pathologies.

Table 1
Details of epilepsy surgeries conducted at three centers.

Characteristic	Nagpur	Vadodara	Udaipur	Combined
Total surgeries	69	47	9	125
Mean age at surgery, years	21.9 ± 11.6	29.1 ± 10.6	18.3 ± 8.5	24.3 ± 11.6
Mean age at epilepsy onset, years	8.3 ± 5.7	12.6 ± 7.8	6.8 ± 5.2	9.8 ± 6.9
Mean duration of epilepsy, years	13.5 ± 9.6	16.4 ± 8.4	11.5 ± 6.4	14.4 ± 9.1
Type of surgeries, n(%)				
Temporal surgeries	35 (50.7)	39 (83)	7 (77.8)	81 (64.8)
Extratemporal lesionectomy	17 (24.6)	8 (17)	1 (11.1)	26 (20.8)
Hemispherotomy	13 (18.8)	–	–	13 (10.4)
Multilobar resesction	2 (2.9)	–	1 (11.1)	3 (2.4)
Callosotomy	2 (2.9)	–	–	2 (1.6)
Pathologies, n(%)				
Hippocampal sclerosis	24 (34.8)	35 (74.5)	5 (55.6)	64 (51.2)
Gliosis	17 (24.6)	3 (6.4)	2 (22.2)	22 (17.6)
Focal cortical dysplasia	13 (18.8)	4 (8.5)	–	17 (13.6)
Low grade tumors	5 (7.2)	2 (4.3)	2 (22.2)	9 (7.2)
Cavernoma	2 (2.9)	2 (4.3)	–	4 (3.2)
Calcified granuloma	2 (2.9)	1 (2.1)	–	3 (2.4)
Others	6 (8.7)	–	–	6 (4.8)
Mean postoperative followup, years	2.3 ± 1.3	2.0 ± 1.1s	0.7 ± 0.3	2.1 ± 1.2
Patients with more than 1 year postoperative followup, n(%)	52 (75.4)	37 (78.7)	4 (44.4)	93 (74.4)
Seizure outcome, Engel class IA, n(%)	50 (96.2)	32 (86.5)	4 (100)	86 (92.5)
Complications, n(%)	6 (8.7)	1 (2.1)	–	7 (5.6)

3.2. Seizure outcome

Of the 125 patients, 93 (74.4%) patients had more than one year of postoperative followup. Of these, 86 (92.5) patients were completely seizure free and aura free during last one year of followup (Engel class IA outcome). Three patients from Vadodara had Engel class II outcome while two patients had class III outcome. These included two patients with frontal focal cortical dysplasia and gliosis adjacent to motor cortex and one patient with bilateral hippocampal sclerosis. Of the two patients with unfavorable outcome at Nagpur, one had focal cortical dysplasia adjacent to motor cortex while other had parietal gliosis.

3.3. Complications

Overall, complications were noted in 7 patients (5.6%): three patients had meningitis which required antibiotics for two weeks, one patient with parieto-occipital gliosis developed hydrocephalus after posterior disconnection which required ventriculoperitoneal shunt, and one patient with occipital lobectomy developed superior saggital sinus thrombosis requiring anticoagulants. Two patients developed hemiparesis following anterior temporal lobectomy, of which one improved completely in 2 days while other had persistent deficit (Medical research council Grade 4) at 3 months.

3.4. Cost of presurgical evaluation and epilepsy surgery

We have provided the cost of presurgical evaluation and epilepsy surgery at each center in Table 2. The average direct cost of presurgical evaluation including video-EEG monitoring and MRI is Rs. 14,266 (USD 204). The cost of presurgical evaluation is almost similar among the three centers. The average cost for the epilepsy surgery is Rs. 78,450 (USD 1121). The cost of surgery at the private teaching hospital is higher than the two of the charitable hospitals. Thus overall average cost of presurgical evaluation and epilepsy surgery is Rs. 92,707 (USD 1,324), amounting to 73% of per capita GNI of India (GNI 1,800 per capita in December 2017). We have also tabulated the approximate direct charges for presurgical evaluation and temporal lobectomy at Sree Chitra Tirunal Institute of Medical Sciences and Technology, Trivandrum, a government run hospital which are comparable to the costs at three centers. However, these charges at government hospital are calculated based upon our previous experience and not on the basis of cost charge ratios.

4. Discussion

Our results show that it is feasible to successfully establish cost-effective comprehensive epilepsy care and epilepsy surgery centers with limited resources and personnel and without state support. Our surgery outcome results and complications are comparable to other established centers with a fraction of the usual cost at other centers [5,6,15]. However, our aim is not to discuss the outcome results but the process of establishing epilepsy surgery centers in resource poor settings.

Comprehensive epilepsy care centers and epilepsy surgery are largely at nascent stage in India and large majority of low and middle

Table 2
Estimated direct costs for presurgical evaluation and epilepsy surgery at three centers (All cost in Indian Rupees; One USD = 70 Indian Rupees).

Procedure	Nagpur	Vadodara	Udaipur	Average	SCTIMST*
Neurology consultation: New (1) and old (2)	1,500	1,100	1,500	1367	500
MRI, without gadolinium	4,000	2,000	5,000	3667	5,000
Neurosurgical consultation: New (1) and old (1)	1,500	1,000	1,500	1334	400
Neuropsychological/Neuropsychiatric testing	1,050	666	850	856	300
In patient video-EEG monitoring (including in patient consultations)	8,650	4,225	8,250	7,042	6,000
Epilepsy surgery (including hospital stay, neurosurgical and anesthetist professional fees, electrocorticography, drugs and consumables, postoperative CT scan)	81,650	51,445	1,02,255	78,450	70,000
Total, Rs (USD)	98,350 (1405)	60,436 (864)	1,19,355 (1705)	92,707 (1324)	82,200 (1175)

* Approximate charges for presurgical evaluation and temporal lobectomy at Sree Chitra Tirunal Institute of Medical Sciences and Technology, Trivandrum based on author's experience.

income countries. A 2006 survey found that epilepsy surgery was available in only 13% of low and middle income countries as compared to 66% of high-income countries [16]. In India, less than 1% of eligible patients undergo epilepsy surgery [8]. Lack of awareness about the epilepsy surgery among the physicians, strong stigma associated with epilepsy and surgery in general population, lack of trained personnel and resources, and few established surgery centers are some of the major factors contributing to underutilization of epilepsy surgery in India [17]. All these factors need to be overcome through a multi-pronged approach to make epilepsy surgery accessible to a large number of patients.

We describe a low cost model of comprehensive epilepsy care and epilepsy surgery which can be replicated even in remote parts of the country and without utilization of government resources. This model is based on identification and selection of ideal candidates with surgically remediable syndromes for epilepsy surgery by a trained epileptologist with basic minimum investigations and personnel. These syndromes represent more than two third of patients with drug resistant epilepsy and these can be easily identified and managed surgically [10]. These patients with surgically remediable syndromes usually have good postoperative outcomes. Selection of only these patients during the initial part of epilepsy program will help the center to develop a good will among the local population and physicians. By operating only on these patients at peripheral centers, surgical treatment gap in the country can be significantly reduced. In the initial stages, patients with difficult substrates or normal MRI can be referred to advanced centers thus creating a model where advanced centers are left with managing difficult cases which can help in reducing waiting lists at these centers [18]. Gradually, as the experience grows these peripheral centers can start selecting and operating more difficult cases.

A neurologist with at least one year of training in epilepsy and epilepsy surgery forms the fulcrum of this model. The epileptologist should be able to understand the finer nuances of drug resistant epilepsy and epilepsy surgery and identify the ideal candidates for epilepsy surgery from a large pool of patients with drug resistant epilepsy. One should also be able to determine, based on the clinical history and MRI, which patients will require advanced evaluation or are not surgical candidates which can help avoiding video-EEG locally in such patients. Such neurologist should be able to read video-EEG data and epilepsy MRI images independently and should be able to undertake informed counseling for patients thus avoiding the need for neuroradiologist and neuropsychologist in large number of cases. However, one should be able to seek these expert services on case to case basis. Ideally, an in house trained epilepsy surgeon should be a part of the team even in these remote centers. Considering the limited availability of trained epilepsy surgeons, these centers can adopt a policy of assembling a group of eligible patients who can be operated together over 2–3 days by a trained epilepsy surgeon from an advanced center thus reducing the costs significantly. Subsequently, the in house surgeon can start performing surgeries as the experience mounts. Nurses can be trained in basic technical aspects of video-EEG monitoring and seizure management to reduce the number of required neuro-technologists. All these factors can significantly reduce the number of personnel required for epilepsy surgery program. Similarly, the cost of video-EEG monitoring and surgery can be reduced by using locally available technologies and innovative techniques. In addition, epilepsy surgery centers can develop a strategy of charging according to the economic status of the patient thus creating a model where affording patients can be charged full cost while the care can be subsidized for less privileged patients. However, we agree that many of the developing countries may not have trained epileptologists. In this regard, our article provides a frame work for the neurologists in these countries to have training from established centers from other countries and start epilepsy surgery program in their countries. This model also needs to be replicated in other geographical areas for further standardization.

Majority of physicians feel that it requires cost intensive modalities such as 3 T MRI, functional-MRI, positron emission tomography (PET), single photon emission computed tomography (SPECT), magnetoencephalography, and intracranial monitoring to establish an epilepsy surgery center. However, as we have shown that a significant proportion of patients with drug resistant epilepsy can be evaluated and managed with minimal evaluation including clinical history, video-EEG monitoring and a good quality MRI. An initial investment of not more than Rs. 1–1.5 million (USD 15,000–20,000) is required to establish a well functioning comprehensive epilepsy care center. Similarly, as our results show, it is possible and viable to offer presurgical evaluation and epilepsy surgery at Rs. 60,000–100,000 (USD 860–1650) which is 10% of the cost involved in developed countries [19,20]. These costs are also comparable to that of Sree Chitra Tirunal Institute of Medical Sciences and Technology, a major government run epilepsy center. Still, many patients in India cannot afford even these low costs. Less than five government hospitals in India also offer epilepsy surgery with minimal or no cost. However, these centers are unable to cater to large patient population of drug resistant epilepsy in India. This further emphasizes the need to develop low cost epilepsy surgery centers which can cater to patients from lower middle and middle income groups while patents from poor income groups can avail the benefits of free surgery at government hospitals (Table 3).

The cost-effectiveness of epilepsy surgery programs in developing countries is debatable where even the medical treatment gap is high. Majority of patients in India do not have health insurance and pay out of their own pocket. It can be argued that the resources required for establishing epilepsy surgery programs through public funding may be channelized at peripheral health centers to improve the basic medical care of epilepsy. Similarly, the state resources in developing countries are largely directed towards more pressing issues such as high burden of communicable diseases and high maternal and infant mortality rates. Hence, it is very difficult to have state sponsored epilepsy surgery programs in all parts of a large country like India. Although there are excellent state run epilepsy surgery programs in India which are providing epilepsy care either free or at minimal expenses to patient, these are in government supported hospitals and are hugely overburdened. In this scenario, our model demonstrates that it is possible to establish and sustain low cost epilepsy surgery centers even in private sector with minimal resources and personnel.

Table 3
Salient features of establishing low cost epilepsy surgery centers in resource poor setting.

- Initiation of the program by a trained epileptologist with clear understanding of finer nuances of drug resistant epilepsy and epilepsy surgery with an ability to provide counseling, read video-EEG data, and read MRI images independently
- Establishment of regular epilepsy clinics
- Spreading awareness about epilepsy and epilepsy surgery among the locals and physicians
- In house training for epilepsy nurses who can additionally serve as EEG technologists
- Identification of ideal surgical candidates with surgically remediable syndromes from a large pool of patients with drug resistant epilepsy
- Reduce the cost of video-EEG by minimizing the duration of monitoring, using locally produced electrodes and using innovative technique for securing electrodes
- Reducing cost of intraoperative electro-corticography by using local EEG machines and reusing the electrodes
- Selection of patients for epilepsy surgery on the basis of clinical history, 1.5 T MRI, and video-EEG data
- Performing initial surgery by invited epilepsy surgeons and subsequently by local neurosurgeons
- Subsidizing the expenses in deserving candidates
- Outsourcing of other specialist, such as neuropsychologists and neuro-radiologists, in selected cases
- Referring difficulty surgery cases to established epilepsy centers
- Selection of difficult cases as the experience grows

5. Conclusion

We describe a low cost model of establishing epilepsy surgery centers in resource poor settings. This model is based on the presurgical evaluation and epilepsy surgery in well described surgically remediable syndromes by a trained epileptologist without the need for the sophisticated and cost intensive investigations and without involving too many trained personnel. Other patients with difficult epilepsy surgery candidacy can be referred to advance centers. This two tier model involves minimal basic investigations and minimum number of personnel at peripheral centers and has the potential to significantly reduce the epilepsy surgery treatment gap in developing countries.

Disclosure of conflicts of interest

None of the authors have any conflict of interest related to this work.

References

[1] Sander JWAS, Shorvon SD. Epidemiology of the epilepsies. J Neurol Neurosurg Psychiatry 1996;61:433–43.
[2] Sridharan R, Murthy BN. Prevalence and pattern of epilepsy in India. Epilepsia 1999;40:631–6.
[3] Kwan P, Brodie MJ. Early identification of refractory epilepsy. N Engl J Med 2000;342:314–9.
[4] Sillanpaa M, Schmidt D. Natural history of treated childhood-onset epilepsy: prospective, long-term population-based study. Brain 2006;129:617–24.
[5] Wiebe S, Blume WT, Girvin JP, Eliasziw M, Effectiveness and Efficiency of Surgery for Temporal Lobe Epilepsy Study Group. A randomized, controlled trial of surgery for temporal lobe epilepsy. N Engl J Med 2001;345:311–8.
[6] Engel Jr. J, Wiebe S, French J, Sperling M, Williamson P, Spencer D, et al. Practice parameter: temporal lobe and localized neocortical resections for epilepsy. Neurology 2003;60:538–47.
[7] Rathore C, Jeyaraj MK, Dash GK, Wattamwar P, Baheti N, Sarma SP, et al. Outcome after seizure recurrence on antiepileptic drug withdrawal following temporal lobectomy. Neurology 2018;91:e208–16.
[8] Rathore C, Radhakrishnan K. Epidemiology of epilepsy surgery in India. Neurol India 2017;65(Supplement):S52–9.
[9] Radhakrishnan K. Challenges in the management of epilepsy in resource-poor countries. Nat Rev Neurol 2009;5:323–30.
[10] Engel JJr. Surgery for seizures. N Engl J Med 1996;334:647–52.
[11] Saini J, Singh A, Kesavadas C, Thomas B, Rathore C, Bahuleyan B, et al. Role of three-dimensional fluid-attenuated inversion recovery (3D FLAIR) and proton density magnetic resonance imaging for the detection and evaluation of lesion extent of focal cortical dysplasia in patients with refractory epilepsy. Acta Radiol 2010;51:218–25.
[12] Rathore C, Panda S, Sarma PS, Radhakrishnan K. How safe is it to withdraw antiepileptic drugs following successful surgery for mesial temporal lobe epilepsy? Epilepsia 2011;52:627–35.
[13] Engel Jr. J, Van Ness PC, Rasmussen TB, Ojemann LM. Outcome with respect to epileptic seizures. In: Engel J, editor. Surgical treatment of the epilepsies. New York: Raven Press; 1993. p. 609–21.
[14] Langfitt JT. Cost-effectiveness of anterotemporal lobectomy in medically intractable complex partial epilepsy. Epilepsia 1997;38:154–63.
[15] Tellez-Zenteno JF, Dhar R, Wiebe S. Long-term seizure outcomes following epilepsy surgery: a systematic review and meta-analysis. Brain 2005;128:1188–98.
[16] Dua T, de Boer HM, Prilipko LL, Saxena S. Epilepsy care in the world: results of an ILAE/IBE/WHO global campaign against epilepsy survey. Epilepsia 2006;47:1225–31.
[17] Iyer RS, Rekha M, Kumar TS, Sarma PS, Radhakrishnan K. Primary care doctors' management behavior with respect to epilepsy in Kerala, southern India. Epilepsy Behav 2011;21:137–42.
[18] Rathore C, Rao MB, Radhakrishnan K. National epilepsy surgery program: realistic goals and pragmatic solutions. Neurol India 2014;62:124–9.
[19] Platt M, Sperling MR. A comparison of surgical and medical costs for refractory epilepsy. Epilepsia 2002;43(Suppl 4):25–31.
[20] Schiltz NK, Kaiboriboon K, Koroukian SM, Singer ME, Love TE. Long-term reduction of health care costs and utilization after epilepsy surgery. Epilepsia 2016;57:316–24.