Nicklaus Children's Hospital
Brain Institute

At What Point Do You Suggest Surgery?

February 5th, 2023

Matt Lallas, MD

3rd Bi-Annual Florida Pediatric Neuroscience Network Conference:
The Epileptic Encephalopathies: Does Early Diagnosis and Treatment Make a Difference?

Disclosures

- I have no relevant disclosures to this topic

Nicklaus Children's Hospital
Brain Institute

Outline

- Intractable Epilepsy
- Epileptic Encephalopathies
- Types of Surgeries
- When to Suggest Surgery

Nicklaus Children's Hospital
Brain Institute

Outline

- Intractable Epilepsy
- Epileptic Encephalopathies
- Types of Surgeries
- When to Suggest Surgery

Nicklaus Children's Hospital
Brain Institute

So far…

- What is an epileptic encephalopathy
- Genetics in EE
- Predicting epilepsy in TSC
- Medication choices
- Ketogenic diet
- Super refractory status

Today

- When to consider surgery
- How soon and what kind of surgery
- Neuromodulation

Nicklaus Children's Hospital
Brain Institute

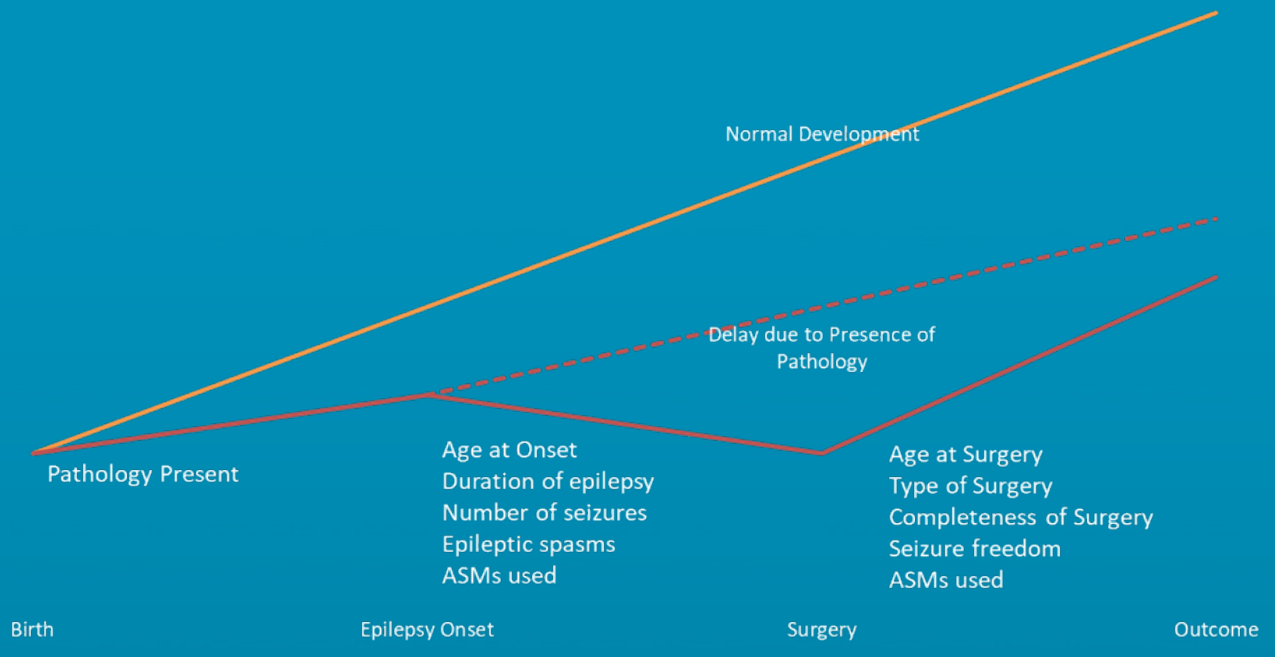
Epilepsy and Intractability

- One in 26 people will be diagnosed with epilepsy in their life[1]
  - More common than Autism, Cerebral Palsy, Multiple Sclerosis, and Parkinson's Disease combined
- Intractable epilepsy is defined as failure to achieve sustained seizure freedom from[2]
  - Adequate trials of two tolerated medications
  - Appropriately chosen for the seizure type
  - Whether as monotherapies or in combination
- About one in three patients with epilepsy will be classified as having intractable epilepsy[3]

Impact of Epilepsy

- Children and adults are at different risks cognitively from refractory epilepsy with greater vulnerability in children thought related to ongoing development and learning in this group[4]
- Some effects on cognition and behavior in epilepsy may be independent of the condition or its treatment, and be related to family adaptation to the diagnosis[5]
- Often some neurodevelopmental changes exist at baseline before the onset of epilepsy[6]

Impact of Surgery on Cognition



Adapted from Van Schooneveld and Braun, 2013

- A variety of factors impact a child's individual developmental trajectory
- In one study, 20% of children had ≥ 15 IQ/DQ point gain[8]
- Improvement would be expected when the epileptogenic zone removed was leading to large network abnormalities and a widespread functional deficit zone[9]

Nicklaus Children's Hospital
Brain Institute

Outline

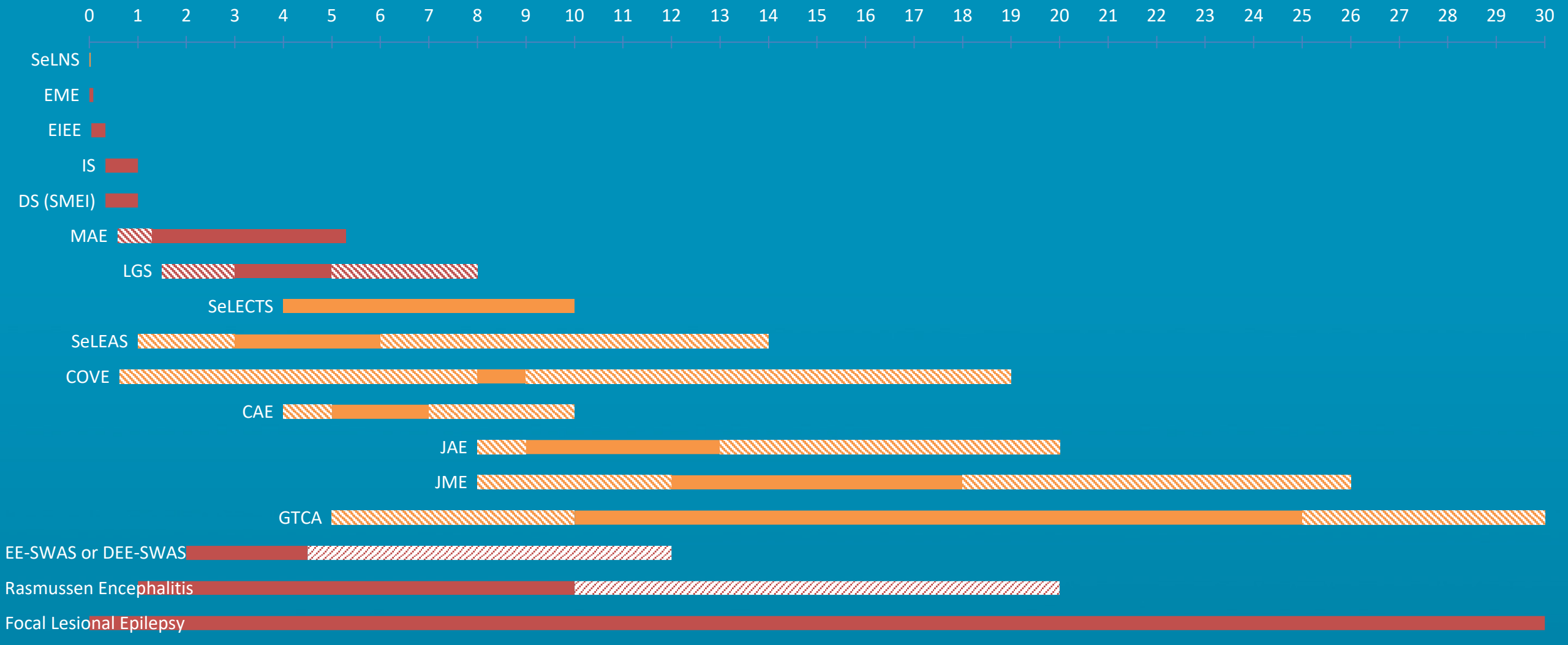
- Intractable Epilepsy
- Epileptic Encephalopathies
- Types of Surgeries
- When to Suggest Surgery

Nicklaus Children's Hospital
Brain Institute

Developmental and Epileptic Encephalopathies

- In 2017 the term was updated to reflect that the brain function is altered by both the epilepsy and the underlying pathology[10]
  - A patient with a developmental encephalopathy may have a predisposition to seizures, but this is considered different from a DEE
  - The magnitude of developmental impact caused by epilepsy may be difficult to distinguish
- Long term developmental outcome is severely impaired though may vary based upon etiology[11]

Age of Onset of Epilepsy Syndromes including Epileptic Encephalopathies



Nicklaus Children's Hospital
Brain Institute

Response of DEE to Surgery

- Compared to medical treatment, surgery may lead to
  - 52% seizure free at three years from surgery, 15.7% from medical treatment[16]
  - Improved Developmental Quotient at 3 years in surgical group[16]
- Earlier surgical treatment may lead to improved developmental outcome[17]
  - Seen in a study of surgery outcomes comparing infantile EE without spasms versus infantile EE with spasms
  - Treated Spasms group went to surgery earlier and did better* while non-spasms group went to surgery later and had worse development
- Palliative surgeries can also provide a benefit
  - Earlier time to VNS improves long term response and QOL[18]

Outline

- Intractable Epilepsy
- Epileptic Encephalopathies
- Types of Surgeries
- When to Suggest Surgery

Nicklaus Children's Hospital
Brain Institute

Surgery

Resective

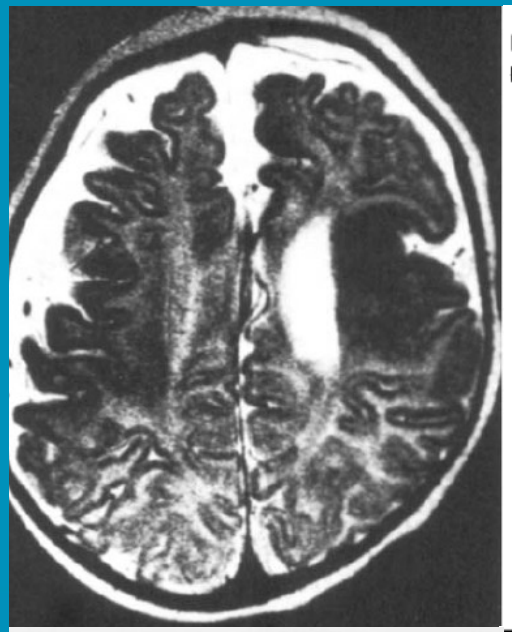
- Corticectomy
- Lesionectomy
- Lobectomy

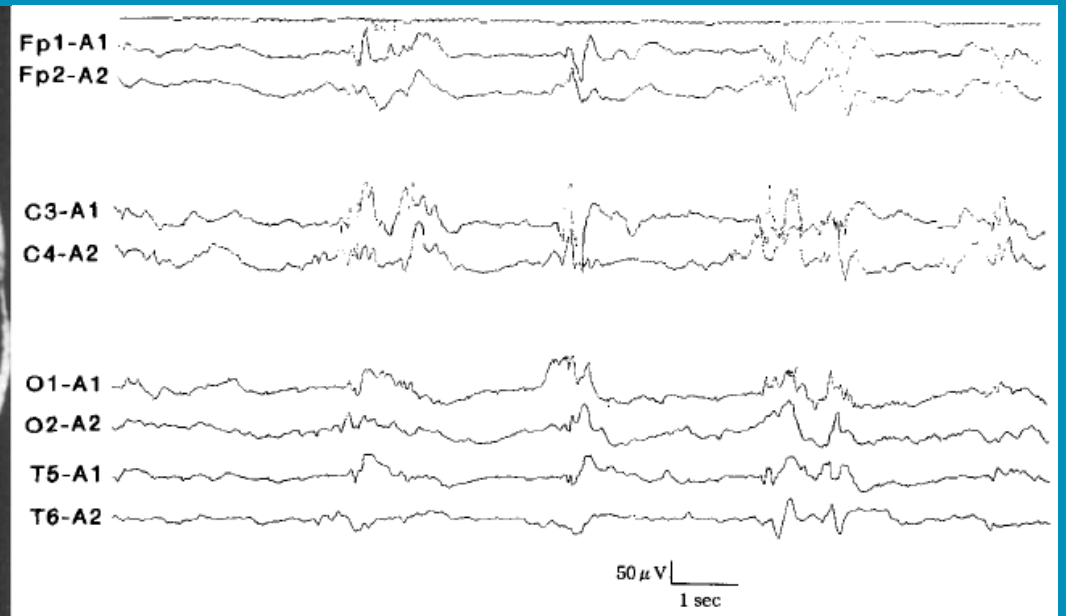
Nicklaus Children's Hospital
Brain Institute

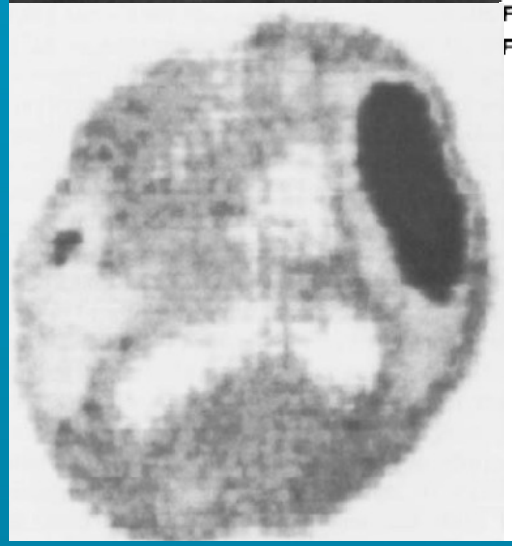
Candidacy for Focal Procedures

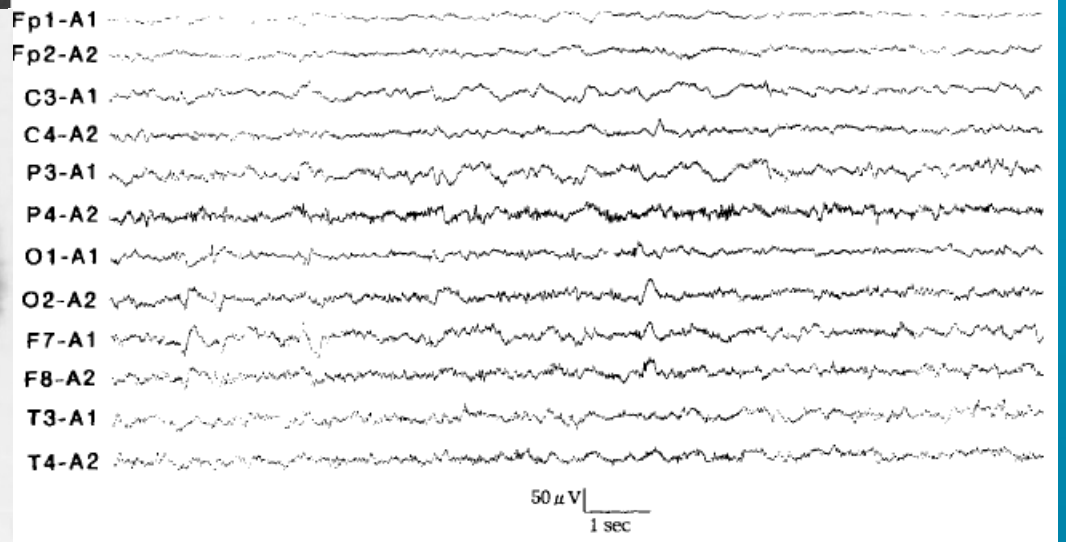
- Epileptic encephalopathies may present with a variety of focal features clinically that could suggest candidacy including[19]
  - Focal seizures
  - Hemiparesis
  - Asymmetric spasms
  - Focal imaging findings
  - Focal EEG features

Nicklaus Children's Hospital
Brain Institute

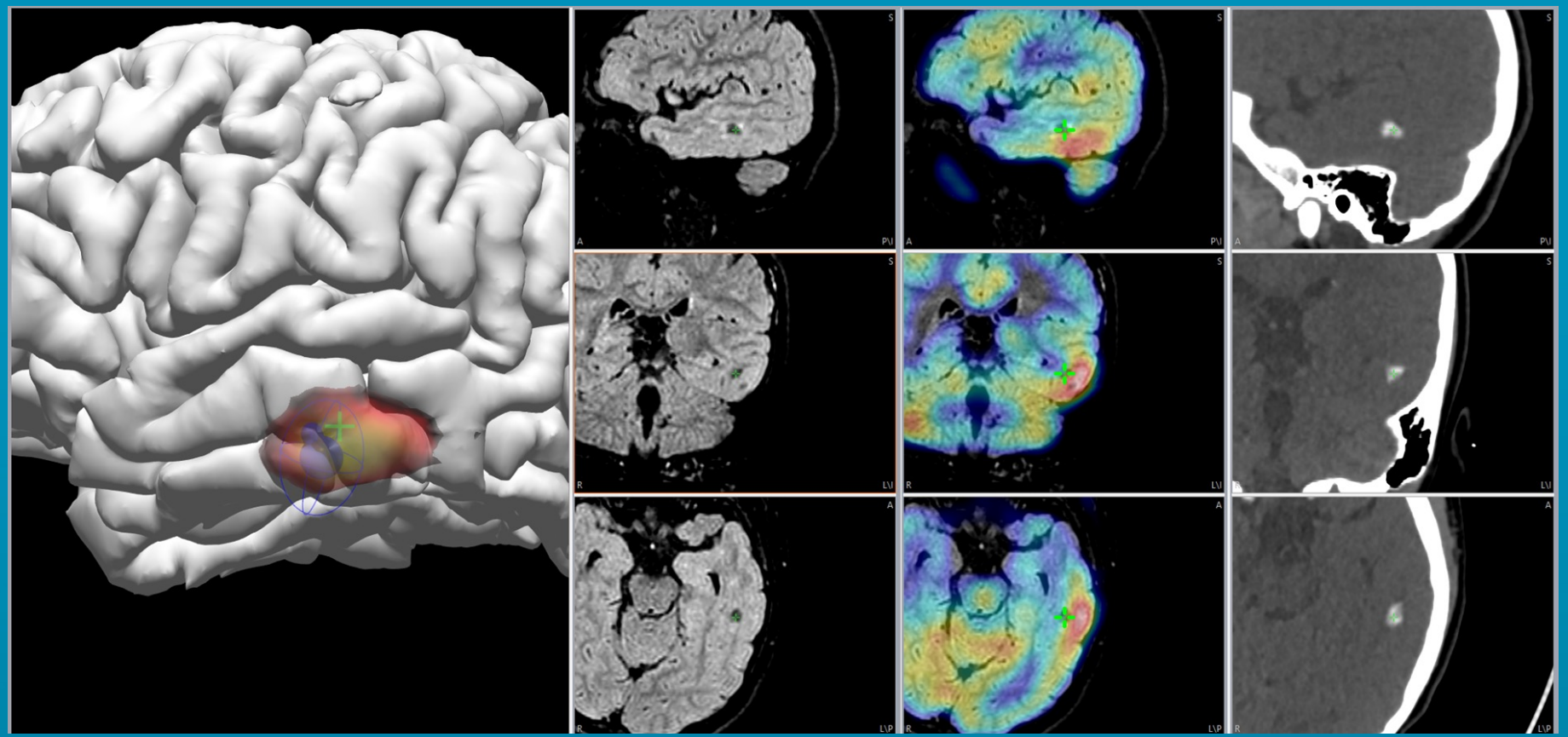








Nicklaus Children's Hospital
Brain Institute



Nicklaus Children's Hospital
Brain Institute

Candidacy for Focal Procedures

- Epileptic encephalopathies may present with a variety of focal features clinically that could suggest candidacy including[1]
  - Focal seizures
  - Hemiparesis
  - Asymmetric spasms
  - Focal imaging findings
  - Focal EEG features
- Especially below age 2 years children can have generalized appearing seizures and generalized EEG patterns secondary to focal epilepsy[22]

Surgery

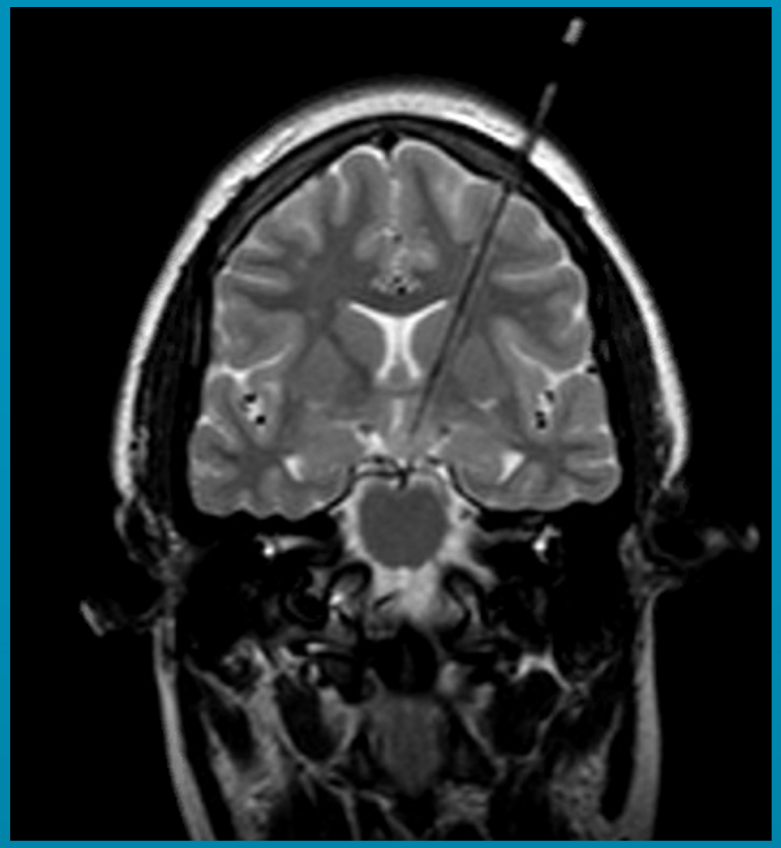
- Resective
  - Corticectomy
  - Lesionectomy
  - Lobectomy
- Ablative
  - LITT
  - RFTT
  - MRgFUS

Nicklaus Children's Hospital
Brain Institute

LITT

- Laser energy delivered by fiberoptical catheter placed by the Neurosurgeon
  - Precise targeting with Neuronavigation
  - MRI monitoring of temperature changes
  - Result is targeted tissue destruction that is controllable and predictable
- Rates of seizure reduction and developmental improvement in TSC may be comparable to open resection[23]
- May require a staged approach in multifocal cases, such as TSC[24]

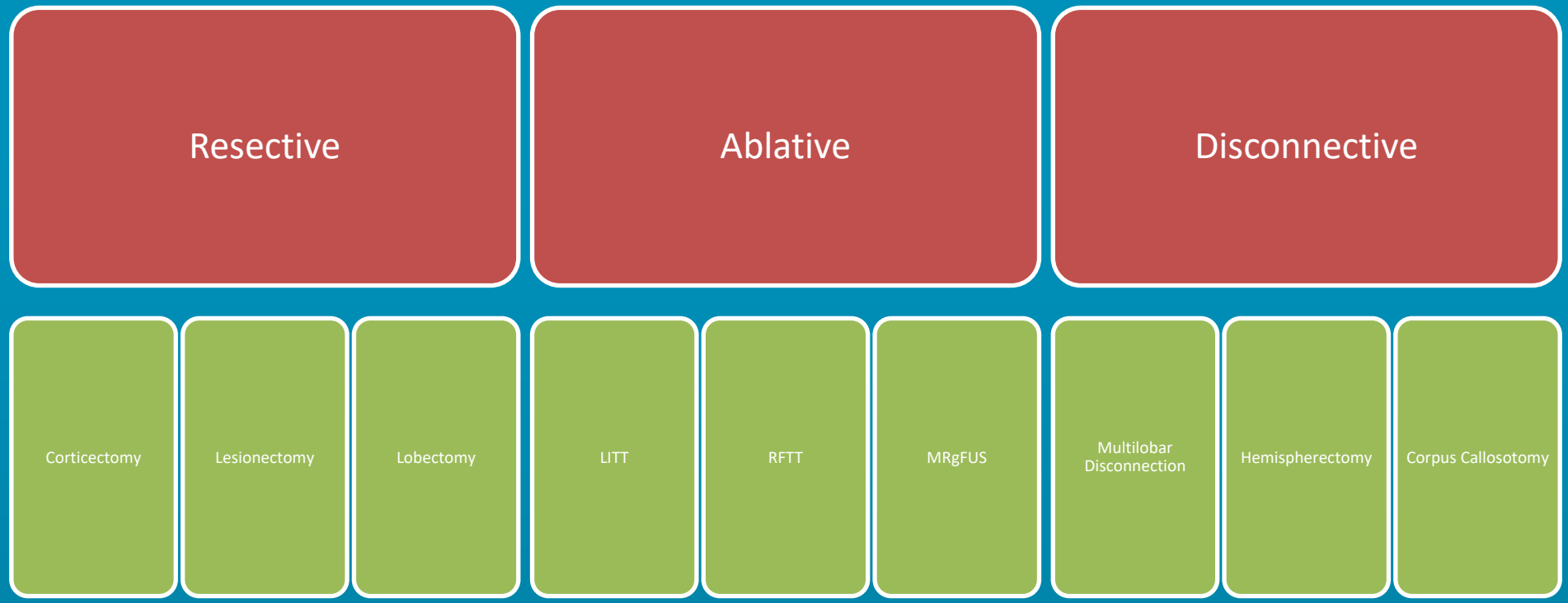
Hypothalamic Hamartoma



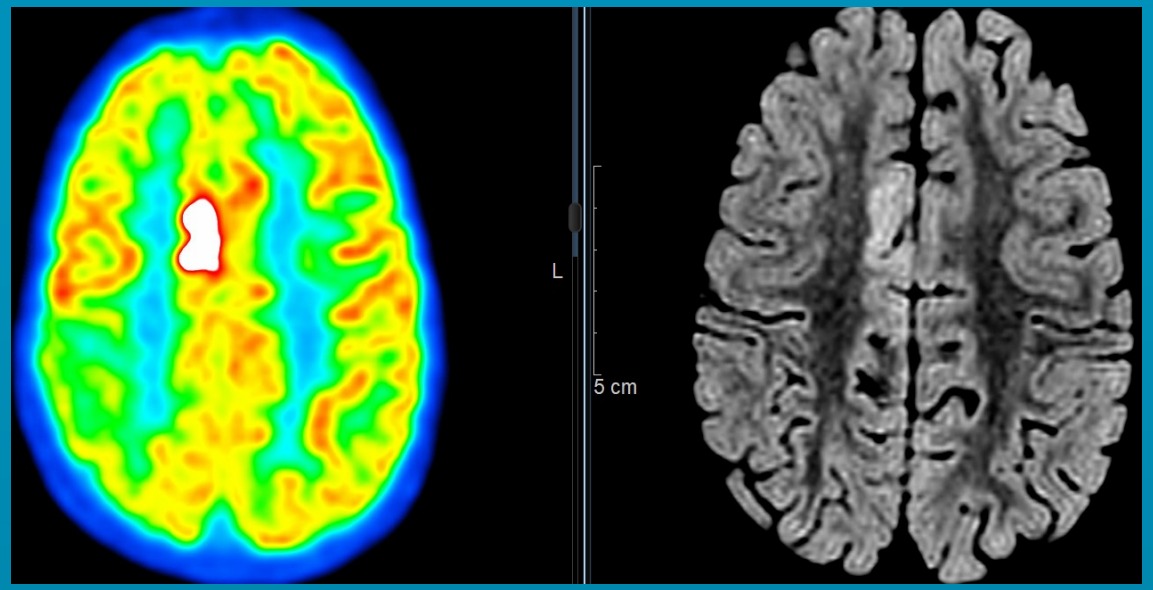
- HH causes Gelastic Seizures and Epileptic Encephalopathy[25]
  - Generalized and Focal seizures may also develop
  - Surgical treatment may resolve the encephalopathy and stop the seizures
- A 93% success rate has been reported at 1 year, though with 23% reporting repeat ablation[26]

Nicklaus Children's Hospital
Brain Institute

Surgery



Nicklaus Children's Hospital
Brain Institute



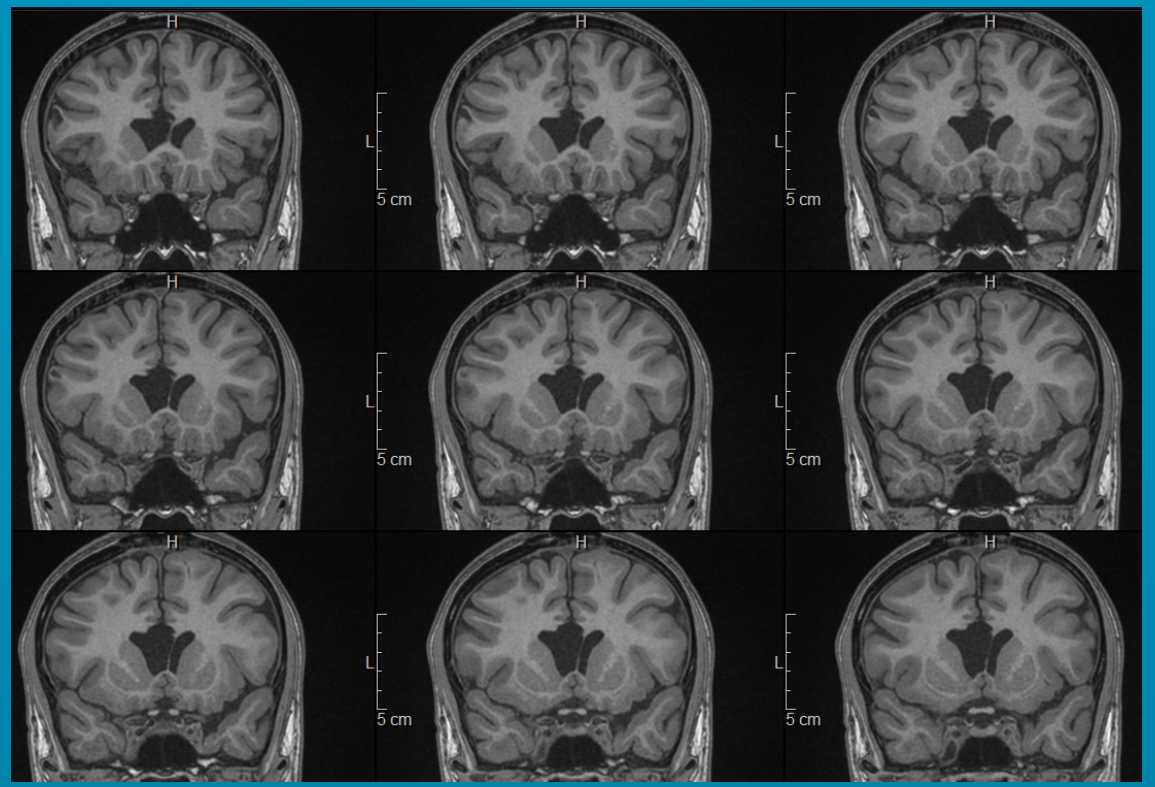
- Child presented with left body Epilepsia Partialis Continua
- Video EEG captured seizures independently from right temporal, right frontal/central regions
- PET performed during EPC with focal hypermetabolism as well as hemispheric hypometabolism
- Biopsy of the hypermetabolism consistent with Rasmussens Encephalitis
- Underwent right functional hemispherectomy and is seizure free

Nicklaus Children's Hospital
Brain Institute

Hemispherectomy

- Has been utilized for congenital and acquired pathologies for epileptic encephalopathies
  - Hemimegalencephaly
  - Sturge Weber Syndrome
  - Rasmussen Encephalitis
  - Hypoxic Ischemic Injury
- In Hemimegalencephaly, seizure freedom and epilepsy duration correlate with developmental outcomes[27]
  - Developmental Quotient declined with each month's delay in surgery
- Seizure freedom rates typically higher with unilateral pathology

- Nonverbal patient with chromosomal abnormality and Lennox Gastaut Syndrome
- Most disabling seizure type were drop seizures, proven atonic drops
- Underwent Corpus Callosotomy with resolution of drops for 4 years
- Other generalized seizure types remained, treated with medications



Nicklaus Children's Hospital
Brain Institute

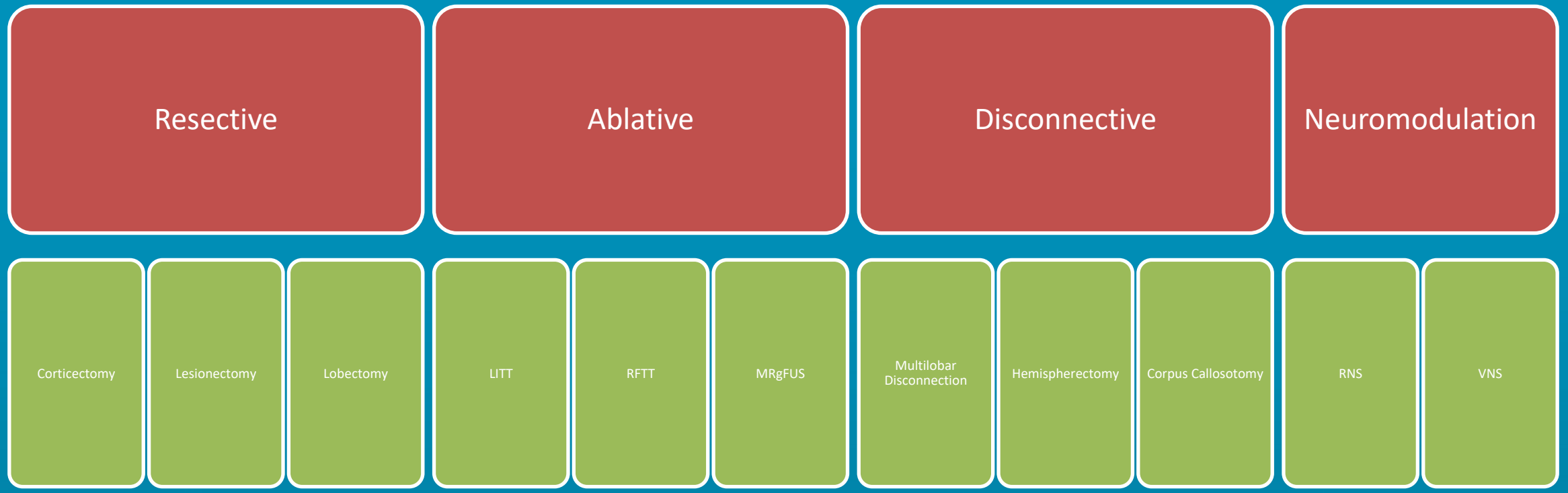
Callosotomy

- Corpus Callosotomy can have a profound effect on drop attacks associated to epileptic encephalopathies
  - One study had 94% with freedom or <90% reduction in drop attacks from total disconnection, only 65% with partial resection[28]
  - Children tend to have better response than adults[2]
- In a study of children with generalized epilepsy after infantile spasms[29]
  - 8 of 9 had cessation of drops with completion of callosotomy
  - 7 of 10 with epileptic spams at time of callosotomy had resolution of the spasms

Callosotomy

- Partial callosotomy is often attempted with option to complete callosotomy if response is insufficient
  - Higher rates of complications are seen with initial total callosotomy than are seen with partial followed by completion[30]
- Corpus callosotomy is suggested to be more effective for drop attacks than Vagus Nerve Stimulation[31-32]
  - Need to weigh the risks of each procedure
  - If drop attacks are the predominant seizure type, CC is preferred[32]

Surgery



Nicklaus Children's Hospital
Brain Institute

Vagus Nerve Stimulation

- Stimulation of the vagus nerve results in activation of a vago-solitario-parabrachial pathway which has widespread innervation to the limbic system, thalamus, and cortex[33]
- Response may be predictable for patients with higher preoperative EEG spectral symmetry or stronger thalamocortical functional connectivity[34-35]

Nicklaus Children's Hospital
Brain Institute

Vagus Nerve Stimulation

- VNS is often recommended over CC in Lennox Gastaut syndrome due to perceived differences in risks[32]
- Earlier time to VNS improves long term response and QOL[18,36]
- Settings may be best optimized if titrated rapidly to a current of 1.65 mA or higher in less than 3 months[36-37]
  - Progressively higher current amplitudes may be less effective (inverted U shaped curve)
- Response rate seems to improve with time and may be better for generalized seizures than focal in seizures associated to HIE[38]

Outline

- Intractable Epilepsy
- Epileptic Encephalopathies
- Types of Surgeries
- When to Suggest Surgery

Nicklaus Children's Hospital
Brain Institute

Key Considerations

- Understand the patient's Seizure type being targeted from surgery
- Imaging findings and clinical features will help determine possibility of resection, ablation, or disconnection procedures
- Long term cognitive impacts from underlying condition may be intrinsically limiting, but patients may still gain much from seizure reduction
- Earlier intervention is often associated with better responses

Special Cases

- An 8 month old underwent a right occipital disconnection and multiple subpial transection in the right temporal lobe despite normal MRI but supportive EEG and clinical features[39]
  - Immediately had a 95% seizure reduction and improved quality of life
  - Found to have FCD type 1A
  - 6 months after surgery was found to have STXBP1 mutation

Special Cases

- A 2 year old with seizures since 10 months, developmental stagnation, left temporal lobe seizures, and MRI subtle lesion with concordant PET hypometabolism in the left temporal lobe underwent temporal lobecomty[40]
  - PCDH19 de novo mutation was discovered prior to surgery
  - She had her longest seizure freedom of 10 months after surgery
  - Severity was reduced – pre-operatively requiring bag-mask ventilation with many seizures, not required post-operatively
  - Development has begun to improve following the surgery

The Lesson

- Genetic information could have precluded either of these patients from surgery
- Despite the genetic findings, some benefit was obtained for each
- The majority of information regarding genetic features and surgery comes from case reports or small cohort studies, limiting direct conclusions
- If epilepsy surgery is to be considered in these cases, it should be done cautiously as outcome data from literature may not apply

References

1. D. Hirtz, D. J. Thurman, K. Gwinn-Hardy, M. Mohamed, A. R. Chaudhuri, R. Zalutsky How common are the “common” neurologic disorders? Neurology Jan 2007, 68 (5) 326-337; DOI: 10.1212/01.wnl.0000252807.38124.a3
2. Kwan P, Arzimanoglou A, Berg AT, Brodie MJ, Allen Hauser W, Mathern G, Moshé SL, Perucca E, Wiebe S, French J. Definition of drug resistant epilepsy: consensus proposal by the ad hoc Task Force of the ILAE Commission on Therapeutic Strategies. Epilepsia. 2010 Jun;51(6):1069-77. doi: 10.1111/j.1528-1167.2009.02397.x. Epub 2009 Nov 3. Erratum in: Epilepsia. 2010 Sep;51(9):1922. PMID: 19889013.
3. Téllez-Zenteno JF, Hernández-Ronquillo L, Buckley S, Zahagun R, Rizvi S. A validation of the new definition of drug-resistant epilepsy by the International League Against Epilepsy. Epilepsia. 2014 Jun;55(6):829-34. doi: 10.1111/epi.12633. Epub 2014 May 14. PMID: 24828683.
4. Bjørnaes H, Stabell K, Henriksen O, Løyning Y. The effects of refractory epilepsy on intellectual functioning in children and adults. A longitudinal study. Seizure. 2001 Jun;10(4):250-9. doi: 10.1053/seiz.2000.0503. PMID: 11466020
5. K. J. Oostrom, H. van Teeseling, A. Smeets-Schouten, A. C. B. Peters, A. Jennekens-Schinkel, on behalf of the Dutch Study of Epilepsy in Childhood (DuSECh), Three to four years after diagnosis: cognition and behaviour in children with ‘epilepsy only’. A prospective, controlled study, Brain, Volume 128, Issue 7, July 2005, Pages 1546–1555, https://doi.org/10.1093/brain/awh494
6. Oostrom KJ, Smeets-Schouten A, Kruitwagen CL, Peters AC, Jennekens-Schinkel A; Dutch Study Group of Epilepsy in Childhood. Not only a matter of epilepsy: early problems of cognition and behavior in children with "epilepsy only"--a prospective, longitudinal, controlled study starting at diagnosis. Pediatrics. 2003 Dec;112(6 Pt 1):1338-44. doi: 10.1542/peds.112.6.1338. PMID: 14654607
7. Van Schooneveld MM, Braun KP. Cognitive outcome after epilepsy surgery in children. Brain Dev. 2013 Sep;35(8):721-9. doi: 10.1016/j.braindev.2013.01.011. Epub 2013 Feb 21. PMID: 23434294.
8. Freitag, H. and Tuxhorn, I. (2005), Cognitive Function in Preschool Children after Epilepsy Surgery: Rationale for Early Intervention. Epilepsia, 46: 561-567. https://doi.org/10.1111/j.0013-9580.2005.03504.x
9. Moosa ANV, Wyllie E. Cognitive Outcome After Epilepsy Surgery in Children. Semin Pediatr Neurol. 2017 Nov;24(4):331-339. doi: 10.1016/j.spen.2017.10.010. Epub 2017 Oct 25. PMID: 29249513.
10. Scheffer IE, Liao J. Deciphering the concepts behind "Epileptic encephalopathy" and "Developmental and epileptic encephalopathy". Eur J Paediatr Neurol. 2020 Jan;24:11-14. doi: 10.1016/j.ejpn.2019.12.023. Epub 2019 Dec 31. PMID: 31926847
11. Katherine C. Nickels, Elaine C. Wirrell, Cognitive and Social Outcomes of Epileptic Encephalopathies, Seminars in Pediatric Neurology, Volume 24, Issue 4, 2017, Pages 264-275, ISSN 1071-9091, https://doi.org/10.1016/j.spen.2017.10.001.
12. Zuberi, SM, Wirrell, E, Yozawitz, E, Wilmshurst, JM, Specchio, N, Riney, K, et al. ILAE classification and definition of epilepsy syndromes with onset in neonates and infants: Position statement by the ILAE Task Force on Nosology and Definitions. Epilepsia. 2022; 63: 1349– 1397. https://doi.org/10.1111/epi.17239
13. Specchio, N, Wirrell, EC, Scheffer, IE, Nabbout, R, Riney, K, Samia, P, et al. International League Against Epilepsy classification and definition of epilepsy syndromes with onset in childhood: Position paper by the ILAE Task Force on Nosology and Definitions. Epilepsia. 2022; 63: 1398– 1442. https://doi.org/10.1111/epi.17241
14. Riney, K, Bogacz, A, Somerville, E, Hirsch, E, Nabbout, R, Scheffer, IE, et al. International League Against Epilepsy classification and definition of epilepsy syndromes with onset at a variable age: position statement by the ILAE Task Force on Nosology and Definitions. Epilepsia. 2022; 63: 1443– 1474. https://doi.org/10.1111/epi.17240
15. Hirsch, E, French, J, Scheffer, IE, Bogacz, A, Alsaadi, T, Sperling, MR, et al. ILAE definition of the Idiopathic Generalized Epilepsy Syndromes: Position statement by the ILAE Task Force on Nosology and Definitions. Epilepsia. 2022; 63: 1475– 1499. https://doi.org/10.1111/epi.17236
16. Otsuki T, Kim HD, Luan G, Inoue Y, Baba H, Oguni H, Hong SC, Kameyama S, Kobayashi K, Hirose S, Yamamoto H, Hamano S, Sugai K; FACE Study Group. Surgical versus medical treatment for children with epileptic encephalopathy in infancy and early childhood: Results of an international multicenter cohort study in Far-East Asia (the FACE study). Brain Dev. 2016 May;38(5):449-60. doi: 10.1016/j.braindev.2015.11.004. Epub 2015 Dec 10. PMID: 26686601.
17. R. Jonas, R. F. Asarnow, C. LoPresti, S. Yudovin, S. Koh, J. Y. Wu, R. Sankar, W. D. Shields, H. V. Vinters, G. W. Mathern Surgery for symptomatic infant-onset epileptic encephalopathy with and without infantile spasms Neurology Feb 2005, 64 (4) 746-750; DOI: 10.1212/01.WNL.0000151970.29205.70
18. Russo A, Hyslop A, Gentile V, Boni A, Miller I, Chiarello D, Pellino G, Zenesini C, Martinoni M, Lima M, Ragheb J, Cordelli DM, Pini A, Jayakar P, Duchowny M. Early vagus nerve stimulator implantation as a main predictor of positive outcome in pediatric patients with epileptic encephalopathy. Epileptic Disord. 2021 Aug 1;23(4):563-571. doi: 10.1684/epd.2021.1299. PMID: 34184987.
19. Kramer U, Sue WC, Mikati MA. Focal features in West syndrome indicating candidacy for surgery. Pediatr Neurol. 1997 Apr;16(3):213-7. doi: 10.1016/s0887-8994(97)00013-1. PMID: 9165511
20. Komaki H, Sugai K, Sasaki M, Hashimoto T, Arai N, Takada E, Maehara T, Shimizu H. Surgical treatment of a case of early infantile epileptic encephalopathy with suppression-bursts associated with focal cortical dysplasia. Epilepsia. 1999 Mar;40(3):365-9. doi: 10.1111/j.1528-1157.1999.tb00719.x. PMID: 10080520.

Nicklaus Children's Hospital

Brain Institute

References

21. M Lallas, M Fajardo, A Hyslop, Ictal SPECT of Focal Myoclonic Seizure Cluster Identifies a Target Tuber - Case Report, American Epilepsy Society Annual Meeting 2021, Abstract 1.203, Presented on 12/4/2021
22. Park JT, Fernandez-Baca Vaca G. Epileptic seizure semiology in infants and children. Seizure. 2020 Apr;77:3-6. doi: 10.1016/j.seizure.2019.10.015. Epub 2019 Oct 24. PMID: 31708348.
23. Ravindra VM, Karas PJ, Lazaro TT, Coorg R, Awad AW, Patino I, McClernon EE, Clarke D, Cairampoma Whitehead L, Anderson A, Diaz-Medina G, Houck K, Katyayan A, Masters L, Nath A, Quach M, Riviello J, Seto ES, Sully K, Agurs L, Sen S, Handoko M, LoPresti M, Ali I, Curry DJ, Weiner HL. Epilepsy Surgery in Young Children With Tuberous Sclerosis Complex: A Novel Hybrid Multimodal Surgical Approach. Neurosurgery. 2023 Feb 1;92(2):398-406. doi: 10.1227/neu.0000000000002214. Epub 2022 Nov 10. PMID: 36637274.
24. Tovar-Spinoza Z, Ziechmann R, Zyck S. Single and staged laser interstitial thermal therapy ablation for cortical tubers causing refractory epilepsy in pediatric patients. Neurosurg Focus. 2018 Sep;45(3):E9. doi: 10.3171/2018.6.FOCUS18228. PMID: 30173608.
25. Berkovic SF, Arzimanoglou A, Kuzniecky R, Harvey AS, Palmini A, Andermann F. Hypothalamic hamartoma and seizures: a treatable epileptic encephalopathy. Epilepsia. 2003 Jul;44(7):969-73. doi: 10.1046/j.1528-1157.2003.59102.x. PMID: 12823582.
26. Curry DJ, Raskin J, Ali I, Wilfong AA. MR-guided laser ablation for the treatment of hypothalamic hamartomas. Epilepsy Res. 2018 May;142:131-134. doi: 10.1016/j.eplepsyres.2018.03.013. Epub 2018 Apr 7. PMID: 29631919.
27. Honda R, Kaido T, Sugai K, Takahashi A, Kaneko Y, Nakagwa E, Sasaki M, Otsuki T. Long-term developmental outcome after early hemispherotomy for hemimegalencephaly in infants with epileptic encephalopathy. Epilepsy Behav. 2013 Oct;29(1):30-5. doi: 10.1016/j.yebeh.2013.06.006. Epub 2013 Aug 7. PMID: 23933627
28. Maehara T, Shimizu H. Surgical outcome of corpus callosotomy in patients with drop attacks. Epilepsia. 2001 Jan;42(1):67-71. doi: 10.1046/j.1528-1157.2001.081422.x. PMID: 11207787
29. Pinard JM, Delalande O, Chiron C, Soufflet C, Plouin P, Kim Y, Dulac O. Callosotomy for epilepsy after West syndrome. Epilepsia. 1999 Dec;40(12):1727-34. doi: 10.1111/j.1528-1157.1999.tb01590.x. PMID: 10612336.
30. Markosian C, Patel S, Kosach S, Goodman RR, Tomycz LD. Corpus Callosotomy in the Modern Era: Origins, Efficacy, Technical Variations, Complications, and Indications. World Neurosurg. 2022 Mar;159:146-155. doi: 10.1016/j.wneu.2022.01.037. Epub 2022 Jan 13. PMID: 35033693.
31. Rolston JD, Englot DJ, Wang DD, Garcia PA, Chang EF. Corpus callosotomy versus vagus nerve stimulation for atonic seizures and drop attacks: A systematic review. Epilepsy Behav. 2015 Oct;51:13-7. doi: 10.1016/j.yebeh.2015.06.001. Epub 2015 Aug 3. PMID: 26247311; PMCID: PMC5261864.
32. Lancman G, Virk M, Shao H, Mazumdar M, Greenfield JP, Weinstein S, Schwartz TH. Vagus nerve stimulation vs. corpus callosotomy in the treatment of Lennox-Gastaut syndrome: a meta-analysis. Seizure. 2013 Jan;22(1):3-8. doi: 10.1016/j.seizure.2012.09.014. Epub 2012 Oct 12. PMID: 23068970; PMCID: PMC3655762
33. Abdullahi, A., Etoom, M., Badaru, U. M., Elibol, N., Abuelsamen, A. A., Alawneh, A., ... & Truijen, S. (2022). Vagus nerve stimulation for the treatment of epilepsy: things to note on the protocols, the effects and the mechanisms of action. International Journal of Neuroscience, 1-10
34. de Vos CC, Melching L, van Schoonhoven J, Ardesch JJ, de Weerd AW, van Lambalgen HC, van Putten MJ. Predicting success of vagus nerve stimulation (VNS) from interictal EEG. Seizure. 2011 Sep;20(7):541-5. doi: 10.1016/j.seizure.2011.04.002. Epub 2011 Apr 21. PMID: 21514181.
35. Ibrahim GM, Sharma P, Hyslop A, Guillen MR, Morgan BR, Wong S, Abel TJ, Elkaim L, Cajigas I, Shah AH, Fallah A, Weil AG, Altman N, Bernal B, Medina S, Widjaja E, Jayakar P, Ragheb J, Bhatia S. Presurgical thalamocortical connectivity is associated with response to vagus nerve stimulation in children with intractable epilepsy. Neuroimage Clin. 2017 Sep 22;16:634-642. doi: 10.1016/j.nicl.2017.09.015. PMID: 28971013; PMCID: PMC5619991.
36. Fahoum, Firas, Massimiliano Boffini, Lennart Kann, Silvia Faini, Charles Gordon, Michal Tzadok, and Riëm El Tahry. "VNS parameters for clinical response in Epilepsy." Brain stimulation 15, no. 3 (2022): 814-821.
37. Tzadok M, Verner R, Kann L, Tungala D, Gordon C, El Tahry R, Fahoum F. Rapid titration of VNS therapy reduces time-to-response in epilepsy. Epilepsy Behav. 2022 Sep;134:108861. doi: 10.1016/j.yebeh.2022.108861. Epub 2022 Aug 10. PMID: 35963047.
38. Mengyi Guo, Jing Wang, Chongyang Tang, Jiahui Deng, Jing Zhang, Zhonghua Xiong, Siqi Liu, Yuguang Guan, Jian Zhou, Feng Zhai, Guoming Luan, and Tianfu Li, Effectiveness of vagus nerve stimulation therapy in refractory hypoxic-ischemic encephalopathy-induced epilepsy Therapeutic Advances in Neurological Disorders 2022 10.1177/17562864221144351
39. Weckhuysen S, Holmgren P, Hendrickx R, Jansen AC, Hasaerts D, Dielman C, de Bellescize J, Boutry-Kryza N, Lesca G, Von Spiczak S, Helbig I, Gill D, Yendle S, Møller RS, Klitten L, Korff C, Godfraind C, Van Rijckevorsel K, De Jonghe P, Hjalgrim H, Scheffer IE, Suls A. Reduction of seizure frequency after epilepsy surgery in a patient with STXBP1 encephalopathy and clinical description of six novel mutation carriers. Epilepsia. 2013 May;54(5):e74-80. doi: 10.1111/epi.12124. Epub 2013 Feb 14. PMID: 23409955.
40. Nagarajan L, Ghosh S, Dyke J, Lee S, Silberstein J, Azmanov D, Richard W. Epilepsy surgery in PCDH 19 related developmental and epileptic encephalopathy: A case report. Epilepsy Behav Rep. 2022 Jul 6;19:100560. doi: 10.1016/j.ebr.2022.100560. PMID: 35856042; PMCID: PMC9287778

Nicklaus Children's Hospital

Brain Institute

Thank You

Nicklaus Children's Hospital
Brain Institute

End of slide show, click to exit