Yield and risk of prolonged presurgical video-EEG monitoring: a systematic review

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Abstract

Objective

Presurgical long-term video-EEG monitoring (LT-VEEG) is an important part of the presurgical evaluation in patients with focal epilepsy. Multiple seizures need to be recorded, often in limited time and with the need to taper anti seizure medication (ASM). The aim of this study was to systematically study the yield – in terms of success – and risks of presurgical LT-VEEG, and to identify all previously reported contributing variables.

Methods

A systematic review of the databases of PubMed Medline, Embase, Cochrane Central, and the Cochrane Database of Systematic Reviews were searched following the Preferred Reporting Items for Systematic Reviews (PRISMA) guideline. Publications about presurgical LT-VEEG reporting on variables contributing to yield and risk were included. Study characteristics of all included studies were extracted following a standardized template. Within these articles, studies presenting multivariable analyses of factors contributing to the risk of adverse events or the succes of LT-VEEGwere identified.

Results

We found 36 articles reporting on LT-VEEG, including 4.703 presurgical patients, both children and adults. Presurgical LT-VEEG monitoring has an average yield of 85%. Adverse events occurred with an averaged total event rate of 17%, but the type of included events was variable among studies. Factors reported to independently contribute to successful LT-VEEG were: baseline seizure frequency, shorter interval since most recent seizure, extra-temporal lobe epilepsy, ASM reduction not needed. Factors independently contributing to the occurrence of adverse event were: ASM tapering, history of status epilepticus, history of focal to bilateral tonic clonic seizures, psychiatric comorbidity, and ASM taper rate.

Conclusion

This study reveals that data on factors contributing to yield and risk of adverse events is significant variable and often with inadequate statistics. Future research is warrented to develop guidelines for ASM withdrawal during presurgical video-EEG monitoring, taking predefined factors for success and risks of adverse events into account.

Key words

Epilepsy, presurgical, video-EEG monitoring, anti seizure medication, medication withdrawal, adverse events

Introduction

Up to two-thirds of properly selected people with medically refractory focal epilepsy will be seizure-free (Engel class 1 outcome) five years after epilepsy surgery (1). Presurgical long-term video-EEG (LT-VEEG) monitoring is an essential part of the mapping of the seizure onset zone. In lesional neocortical epilepsy, a lateralised and localised seizure pattern on ictal scalp EEG is associated with a favourable individual outcome (2). The required number of seizures monitored to ensure a reliable assessment of seizure semiology and ictal onset EEG patterns varies, depending – among other factors – on the pretest probability of unifocal epilepsy (3-5). Presurgical LT-VEEG often involves controlled provocation of seizures, which increases its yield but not without risks. The most commonly used provocation method is anti-seizure medication (ASM) withdrawal (6), which may result in adverse events such as focal to bilateral tonic-clonic seizures (FBTCS), seizure clusters, or even status epilepticus (7). Little is known about independent determinants of yield and risk of LT-VEEG. Despite many reports of in-house provocation models, no standardised or best practice recommendation is available.

To mitigate these risks and infer a safe and successful presurgical LT-VEEG, we systematically reviewed the available evidence on variables that contribute to the success and adverse events of LT-VEEG.

Materials and Methods

This systematic review followed a predefined protocol guided by the Preferred Reporting Items for Systematic Reviews (PRISMA).

Search strategy:

We searched PubMed Medline, Embase, Cochrane Central, and the Cochrane Database of Systematic Reviews using terms related to presurgical LT-VEEG to find studies reporting variables that contribute to its success or risks (appendix A). Long-term monitoring was interpreted as every monitoring of a day or longer. We included retrospective and prospective observational studies and randomised controlled trials. We also screened the reference list of the identified articles to identify studies that our search strategy may have missed. The last search was done in December 2021.

Study selection and eligibility criteria

Two reviewers (CvA and RvR) independently screened the titles and abstracts. In case of disagreement, the full text was discussed. We deemed reports on fewer than twenty subjects not representative and excluded these. We also excluded studies in languages other than English, German or Dutch. In case of duplicate studies with overlapping populations from the same centre, only the report deemed most contributing was included. Surveys and guidelines for presurgical video-EEG monitoring were also excluded.

Data extraction and data collection

One reviewer (RvR) extracted data with a standardised form. A second reviewer (CvA) checked random sets of extracted data. Study characteristics were also collected (appendix B). Data were categorised into; 1) LT-VEEG logistical characteristics, such as mean length of stay, design of the epilepsy monitoring unit (EMU), and whether or not a nurse or technician is continuously present during the monitoring; 2) individual variables; age, gender, seizure frequency before admission, history of status epilepticus, seizure clustering, or focal to bilateral tonic-clonic seizures; 3) LT-VEEG variables; mean number of seizures recorded, yield, seizure onset localisation, provocation methods used, including the presence or absence of a predefined withdrawal protocol. We used the definition of the LT-VEEG "yield" as suggested in individual study reports. In general, LT-VEEG was considered successful when the clinical question was answered. If this was not explicitly reported, LT-VEEG was deemed successful when seizures or events were recorded. A standardised selection was made of the most common adverse events: non-habitual FBTCS or seizure clusters, status epilepticus, other events (for example: falls, postictal psychosis) and the total rate of adverse events. Focal to bilateral tonic-clonic seizures were only scored as adverse events when they occurred for the first time or were highly unusual for that individual. Seizure clusters were defined as three or more seizures in either 4 hours or 24 hours, since these different definitions of seizure clusters have both been applied in previously published studies. Preferably only non-habitual seizure clusters were scored as adverse events. However, in case this was not explicitly mentioned by authors of studies, all clusters were scored. We collected information on possibly contributing variables to yield and adverse events of the LT-VEEG, whenever such variables were identified in at least one of the individual studies as a significant determinant in multivariate analyses. When possible we looked at the difference between children and adults. We used the Strengthening in the Reporting of Observational Studies in Epidemiology (STROBE) checklist to assess study quality.

Results

Study selection and study characteristics:

We selected 36 reports from 2.679 identified articles (supplementary figure 1). These 36 reports included 13.603 individuals (1.351 children, a subset of 8.782 adults and children combined, and 3.470 adults), 4.703 were monitored for presurgical purposes and 3.976 for other diagnostic purposes. In 4.924 individuals, the LT-VEEG indication was not explicitly reported (table 1). All collected variables are presented in appendix B. Some studies reported their outcomes separately for the presurgical group, but not for all outcomes. The inclusion and exclusion criteria differed among the studies. Some studies excluded individuals when seizures were recorded, did not use ASM, or were not subjected to ASM withdrawal. It was not always clear whether individuals experienced habitual FBTCS or seizure clusters, neither whether or not these were considered adverse events. Some studies investigated only a single outcome event of (presurgical) VEEG, for example seizure clusters. The number of studies that included only surgical candidates was small. We pooled data from these studies with presurgical patient data extracted from mixed study cohorts, to describe the yield of LT-VEEG and its adverse event rates. To collect information on determinants of LT-VEEG yield and adverse events, we used all patient data from the 36 included studies – independent of whether the recording was for presurgical reasons or otherwise – as long as multivariate analysis techniques to identify independent predictors were used.

Yield of presurgical LT-VEEG

The yield of presurgical LT-VEEG was specifically addressed in nine studies with a total rate of success of 85% (N= 1.654/1.943) and a mean duration of LT-VEEG of 4.9 days (table 1). When looking specifically at children or adults the success rate was respectively 80% (N= 237/295, four studies) and 71% (N= 97/136, two studies). Definitions of success among studies varied between seizures recorded only, sufficient seizures recorded to proceed with the presurgical evaluation, and whether or not the referral question was answered. Some studies did not explicitly mention the yield or success rate but only noted the type and/or seizure frequency and whether any episode was recorded, these were categorized as not reported. In children medication was less often tapered than in adults, respectively 40% and 68% and mean duration of LT-VEEG was lower (4 days versus 5.2 days).

Factors determining odds of a successful LT-VEEG:

Eightteen studies investigated the determinants of LT-VEEG-yield with univariate and three with multivariate analyses. Nine factors (higher baseline frequency, shorter interval since most recent seizure, ASM reduction not needed, extra-temporal lobe epilepsy, ASM withdrawn during monitoring, use of hyperventilation provocation, length of stay, presurgical recording and younger age at onset) were reported as being univariately associated with successful monitoring. In multivariate analyses, only five factors were independently associated with the chance of a successful presurgical LT-VEEG; higher baseline seizure frequency, shorter interval since most recent seizure, extra-temporal lobe epilepsy, ASM reduction and ASM reduction not deemed necessary (table 3). The most frequently reported factor was baseline seizure frequency, associated with LT-VEEG success in nine out of eleven studies in univariate analyses and in both two studies that applied multivariable analyse.

All 36 studies reported ASM withdrawal as a seizure provocation method to be applied in most individuals during presurgical LT-VEEG. Most studies used a local protocol with individual adjustments based on specific clinical characteristics such as baseline frequency and history of adverse events (e.g. status epilepticus). ASM withdrawal was associated with the success of LT-VEEG in four out of eleven studies in univariate analyses, but only one confirmed this as an independent factor in multivariable analyses. Another study showed in a multivariable analyses that when ASM withdrawal was not needed, this was independently related with successful monitoring. In this study, however, baseline seizure frequency – presumably highly correlated with the consideration that ASM withdrawal was not needed – was not included in the model.

<u>Adverse events during presurgical LT-VEEG</u>

Eleven studies, including data from 951 individuals, reported the proportion of surgical candidates with one or more adverse events (table 2), with a total adverse event rate of 17 % (106 of 607 individuals). Comparison of adverse events in children and adults was not possible because of insufficient data. There was a large variety in the type of events investigated and documented as “adverse” event (supplementary figure 2). Not all studies reported each adverse event separately; some only provided the total proportion of individuals with one or more event. Non habitual FBTCS were reported in 5% of 473 individuals in six studies. Only one study reported explicitly the occurrence of non- habitual seizure clusters, most studies included all individuals with a seizure clusters without providing clarity on wether or not individuals with habitual clusters were excluded. Clusters defined as three or more seizures in four hours were reported in 15% of 444 individuals in four studies. Clusters defined as three or more seizures in 24 .

Factors that determine the risk of adverse events

Fourteen studies investigated factors that correlated with the risk of adverse events with univariate analyses, and eight with multivariate analyses. In total, 21 factors (supplementary figure 3) were ever reported as being univariably associated with adverse event rate. In multivariate analyses, twelve factors were independently associated; ASM tapering, history of SE, history of FBTCs, psychiatric comorbidity, hippocampal sclerosis, a higher number of seizures occurring during monitoring, history of seizure clusters, ASM taper rate, presurgical recording, history of seizure-related injury, treatment with Levetiracetam or Sulthiame (table 4). ASM tapering was reported in the highest number of studies. In case of ASM tapering, a distinction can be made between taper dose and taper rate. Two studies have shown in multivariate analyses that taper dose affected the risk of an adverse event more so than taper rate (8,9).

Discussion:

Presurgical LT-VEEG has an average yield – defined as sufficient seizures being recorded or the clinical question answered – of 85%. Adverse events are reported in less than a fifth of the individuals. Independent determinants of successful monitoring are a high baseline seizure frequency, shorter intervals since the most recent seizure, no need to reduce ASM, and extratemporal lobe epilepsy. Adverse events were associated with several independent variables: ASM withdrawal, a previous history of SE, FBTC or seizure clusters, and more events occurring during monitoring.

We observed a significant variation in the reported ASM withdrawal protocols, with notable differences in tapering speed. Most predefined protocols were individualised and based on characteristics such as baseline seizure frequency and history of SE or FBTC, which have been reported to influence the decision to withdraw or not and the speed and dose of tapering (9-15). Although several studies have shown that baseline frequency is an independent variable that determines the degree of success of LT-VEEG, another study suggested that there is no clinically significant relationship between the self-reported baseline frequency and time to first seizure. However, the role of medication withdrawal in this study was unclear (16). In our opinion, a minimal baseline seizure frequency should not be considered mandatory for referral for LT-VEEG, because ASM withdrawal allows successful monitoring also in many patients with a low baseline frequency. Low seizure frequencies could, however, influence the individualized ASM withdrawal protocol (17). In general, when deciding to apply seizure-provocation methods, benefits and risks need to be carefully balanced, and individuals and carers should be counselled. In this context, several studies have suggested that the dose amount reduction contributes to the risk of adverse events more than tapering speed, and that adverse events occurred more often during complete discontinuation or reduction to low ASM doses (8,9). FBTCS seemed to occur more often with an ASM dose reduction below 20-50%of the outpatient daily dose, depending on the history and frequency of FBTCS (8,9). Tapering speed with a mean of 20% dose reduction (range 0-100 %) during the first 24 hour had no effect on length of stay, time to first seizure, or on seizure type (8). Another study, using a new protocol during COVID-19 with 50% dose reduction in the morning and complete discontinuation in the evening of the day prior to admittance, yielded more seizures in first 24 hour, and led to a shorter length of stay, without a difference in complication rates, as compared to the authors' previously used protocol (when medication withdrawal was started the second day after admission) (18). This suggests there could be a threshold dosage for safe and efficient ASM withdrawal during presurgical LT-VEEG. How such threshold, including optimal taper rate, can be individually determined remains unclear. Since there are differences between children and adults, with regard to the frequency of medication withdrawal (more often in adults), duration of stay (longer in adults), and success rate (higher in children), it is advisable develop separate protocols for both age groups. Another factor that needs to be explored is the different ASM's pharmacokinetics and their specific effect on the withdrawal-related LTM yield and adverse event risk (19). One study has suggested that treatment with Sulthiam or Levetiracetam was an independent risk factor for adverse events (20). These ASM's were more often used in polytherapy in this study, suggesting that the type of epilepsy was more refractory in these patients. To our knowledge this finding has not yet been reproduced. Although tapering speed seems of less influence on the rate of adverse events than the absolute dose reduction, more rapid withdrawal will shorten the duration of LT-VEEG, which by itself has significant advantages concerning discomfort and available resources (9,11,18,21). The timing of ASM withdrawal is still underexplored. Often when the individual is hospitalised, ASM withdrawal is only started at the onset of monitoring. Three studies have suggested that tapering one till seven days before admission may contribute to successful monitoring without carrying additional risks (18,22,23).

This study has limitations, inherent to a retrospective systematic review. Not all included studies presented useful data on yield and adverse events. First, the populations differed among studies, some reporting only on children, adults or the elderly. This could have influenced the average results as children are reported to have a shorter length of stay, a higher seizure frequency, and less often require ASM withdrawal than adults (24). Second, most studies were descriptive or only applied univariate analyses. Only a few used multivariate analyses and the variables included in these prediction analyses differed. Some determinants were included as a continuous variable in one study and as categorised variable in another. Some of the variables were highly correlated but not reported as such. For example, many studies reported using the individual's baseline frequency when deciding whether or not ASM reduction was required, but do not present these data nor include them in their multivariable analysis. It is remarkable that hyperventilation and sleep deprivation – both often considered effective provocation methods to increase the yield of LT-VEEG – were not found to be independently predictive of success in any of the studies included. Systematic inclusion of these methods in multivariable prediction analyses of LT-VEEG success in large cohorts could further clarify their added value as provocation factors in this setting.Third, there is considerable inconsistency between study results. Relatively small cohort sizes may prevent relevant but rare predictors of success or adverse events to be appreciated as significantly related. Fourth, there is a difference in the interpretation of specific variables among studies. Most importantly, the observation that not all studies reported a seizure cluster as an adverse event can also explain part of the wide variation in the total adverse event rate.

In conclusion, to identify all factors that independently contribute to the yield and risk of adverse events of presurgical LT-VEEG, more extensive studies with individual participant data and more appropriate statistics and standardization approaches are needed. Future work is warranted to develop guidelines for ASM withdrawal, taking into account predefined factors for success and risks, such as the timing of the withdrawal, speed and degree of dose reduction, and specific ASM pharmacokinetics.

Acknowledgements

JWS is based at NIHR University College London Hospitals Biomedical Research Centre, which receives a proportion of funding from the UK Department of Health's Research Centres funding scheme. He receives research support from the Dr Marvin Weil Epilepsy Research Fund, the UK Epilepsy Society and the Christelijke Vereniging voor de Verpleging van Lijders aan Epilepsie, The Netherlands.

RvG, WO and KB gratefully received support by the MING fund of the "Vrienden van UMC Utrecht" foundation. The remaining author has no conflicts of interest

Disclosures;

JWS report fees as speaker or consultant from Eisai, UCB, GW, Arvelle and Zogenix outside the submitted work.

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Author (year)	Study period	Total number of indi-viduals	Presurgical LT-VEEG purpose	Population and study design	Mean age (yrs)	Mean length of stay (days)	Mean number of seizures recorded	Habitual Seizure frequency	Medication withdrawal (Yes/No) (%)	Yield of successful monitoring (all cases, %)	Yield of Successful monitoring in presurgical cases only (%)
Babtain, F. (2021) (18)	2018-2021	104	NR	All ages (>13)	30	5 (pre-COVID) 3 (post-COVID)	4/6	Daily 4 (6%)/ 4(10%) 2-4 /month 39 (63%)/ 25(60%) 1x/3-6 months 14 (23%)/ 10 (24%) 1x/12-18 months 4 (6%)/3 (7%)	Yes	81 (78%)	NR
Baheti, N. (2011) (25)	1996-2009	148	87	Elderly (>45) retrospective	51	2.9	3.2	NR	Yes, 109 (74%)	95%	NR
Chen L. (1995) (26)	1991-1992	226	24	Children retrospective	NR	NR	NR	daily 183 (81.%) weekly 35 (15.5%) less than weekly 8 (3.5%)	Yes 2 (8%)	80%	64%
Cox F. (2020)(15)	2018-2019	1062	83	All ages prospective	26	5 (presurgical)	NR	NR	Yes (presurgical) 73 (86%)	40%	75%
Craciun L. (2017)(13)	2012-2016	976	NR	All ages prospective	25	3.2	NR	NR	Yes 284 (29%)	62%	
Di Gennaro G (2012) (27)	2010	76	76	Adults retrospective	33	6	3.5	NR	Yes 54 (71%)	93%	93%
Dobesberger J. (2011) (28)	1999-2005	507	279	All ages retrospective	36	5	4	NR	Yes	81%	NR
Duy P. (2020) (8)	2016-2017	114	114	All ages retrospective	33	6.3	5	NR	Yes	NR	NR
Fahoum F. (2016) (20)	2011-2014	524	80	Adults retrospective	36	7.2	9.3 (no ASM) 17.2 (AE)	NR	Yes 260 (50%)	79%	NR
Fung F. (2018) (29)	2009-2011	69	69	Children retrospective	12	5	6	<1/month: 11 (16%)	Yes 63 (91%)	NR	NR

								<1/week: 22 (32%) >1/week: 36 (52%)			
Grau-Lopez L. (2020) (14)	2007-2019	411	NR	Adults retrospective	42	5.1	NR	NR	Yes	NR	NR
Griethuysen R. (2018) (22)	2005-2011	276	174	All ages retrospective	34	4	3	NR	Yes 182 (66%)	84%	NR
Guaranha M. (2005) (30)	1988-2001	97	97	All ages retrospective	30	3.3	7.3	NR	Yes 97 (100%)	NR	NR
Guld A. (2017) (11)	2011-2013	79	79	All ages retrospective	34	4.3	5.3	3.9/mth	Yes 79 (100%)	NR	NR
Harini C. (2013)(31)	2009-2011	95	95	Children retrospective	12	5.5	6	<1/month: 22 (23%) <1/week: 18 (19%) >1/week: 55 (58%)	Yes 95 (100%)	NR	NR
Haut S. (2002) (32)	1998-1999	91	91	Adults prospective	33	NR	NR	NR	Yes 49 (54%)	NR	NR
Henning O. (2014) (33)	2010-2011	60	60	Adults prospective	34	3	3.4	0.4 /day	Yes 60 (100%)	43%	43%
Jonas J. (2011) (34)	2007-2008	80	51	All ages prospective	32	NR	NR	NR	Yes. presurgical 51 (100%)	NR	NR
Kasab S. (2017) (35)	2012-2014	439	241	Adults retrospective	NR	3.1	1.7/day	0.7/day	Yes	NR	NR
Keller A. (2018) (36)	2014-2016	281	139	Children retrospective	10	2.6	NR	NR	Yes 108 (38%)	55%	NR
Kumar S. (2018) (21)	2016-2017	140	123	All ages Randomized controlled trial	9.1 (rapid taper) 11.3 (slow taper)	4.7 (rapid taper) 6.6 (slow taper)	5.1 (rapid taper) 4.6 (slow taper)	9.4/mnth (rapid taper) 8.2/mnth (slow taper)	Yes (100%)	96% (rapid taper) 97% (slow taper)	NR
Lampe, E. (2014) (10)	2010-2011	132	40	Adults retrospective	37	4.4	NR	< week: 52 (42%) >1/week and <1/day: 47 (38%) >1/day: 24 (20%)	Yes	82%	NR

Ley, M. (2014) (12)	2009–2012	175	119	All ages retrospective	36	5.8	4	6/month	Yes 132 (75%)	100%*	NR
Lim, K (2020) (37)	2012–2016	137	137	All ages retrospective	35	3	7	NR	Yes	80%	80%
Mann C. (2021) (38)	2016–2019	178	88	Children	11	5.4	NR	Daily: 48 (27%), >1 week: 27 (15%), 1/week: 10 (5,5%), 1–3/moth: 30 (17%), <1/month: 20 (11%)	NR	54%	84%
Moien-Afshari F. (2009) (39)	2006–2008	50	20	Adults prospective	36	4.4	5	12/mnth	Yes 49 (98%)	88%	NR
Noe, K (2009) (40)	2005–2006	149	89	Adults prospective	44	5.7	5.0	NR	Yes	73%	NR
Pensel, M (2020) (9)	2004–2005/ 2014–2015	391	391	Adults retrospective	36	NR	NR	NR	Yes	NR	NR
Riquet A. (2011) (23)	1999–2005	380	61	Children retrospective	7	1.5	NR	Yes	Yes 114 (36%)	59%	69%
Rizvi S. (2014) (41)	NR	158	52	All ages Prospective	37	4.5	9.1	8.0/mnth (presurgical)	Yes	90.5%	NR
Rose A. (2003) (42)	2000	514	NR	Adults retrospective	NR	NR	4.3	NR	Yes	NR	NR
Sauro K. (2014) (43)	2008–2011	396	162	Adults prospective	37	9.4	13.9	Yes	Yes 306 (79%)	79%	NR
Schulze-Bonhage (2022) (17)	2005–2020	1922 (UKF) 2919 (KCL)	1335 (UKF)	All ages retrospective	NR	5.2 (UKF, all) 5.9 (UKF, presurgical) 4.4 (KCL)	NR	NR	Yes (78.5%) (UKF)	73% (UKF) 42% (KCL)	1148/1292 88.9% (UKF)
Sun, P. (2015) (24)	2010–2013	122	122	Children retrospective	10	4	NR	Yes	Yes 67 (55%)	87%	87%
Swick C. (1996) (44)	1993–1994	36	36	NR prospective	NR	7.4 temporal group 5.6 extra-temporal group	5.5 temporal group 10.4 extra-temporal group	Yes	Yes 22 (61%)	NR	NR

Yen, D. (2001) (45)	1995-1997	89	89	Adults retrospective	31	6.4	4.8	NR	Yes 89 (100%)	NR	NR
Total		**13.603**	**4703**			All 4.9 Adults 5.2 Children 4.0			Adults 68% (976/1434) Children 40% (465/1173)	62%% (N = 6933/11.0 98)	85% (N= 1654/ 1943) Adults 71% (N= 97/136) Children 80% (N= 237/295)

Table 1. Characteristics of all included studies. NR= not reported. * in 1-3 recordings

Author (year)	Nr of presurgical cases	Nr of individuals with a non-habitual focal to bilateral tonic-clonic seizure during LT-VEEG	Nr of individuals with a seizure cluster during LT-VEEG (cluster definition; >=3 per 4 or 24h)	Nr of individuals with a status epilepticus during LT-VEEG	Nr of individuals with another seizure-related adverse event during LT-VEEG	Total rate of adverse events (nr of patients, %)
Cox F. (2020) (15)	83	1 (1%)	1 (1%) 24-h	0	2.0 (2%) Falls 1.0 (1%) post ictal psychosis	5 (6%)
Di Gennaro G (2012) (27)	54	4 (7%)	6 (11%) 4-h 21 (39%) 24-h	0	3 (6%) Falls 0 cardiac asystole	13 (24%) 28 (52%)
Duy P (2020) (8)	114	3 (3%)	26 (23%) 4-h	2 (2%)	NR	31 (27%)
Fahoum F. (2016) (20)	80	NR	NR	NR	NR	15 (19%)
Fung F. (2018) (29)	69	NR	26 (79%) 24-h 7 (21%) 24-h non habitual	2 (3%)	NR	NR
Guld A. (2017) (11)	79	3 (4%)	24 (30%) 4-h 25 (32%) 24-h	7 (9%)	4 (5%): 1 Bradycardia and respiratory arrest 1 first Todd's paresis. 1 capillary oxygen saturation drop to 30%. 1 postictal psychosis-like symptoms	13 (16%)
Harini C. (2013) (29)	95	NR	NR	2 (2%)	NR	NR
Haut S. (2002) (32)	91	NR	56 (62%) 24-h	NR	NR	NR
Henning O. (2014) (33)	60	2 (3%)	9 (15%) 4-h 25 (42%) 24-h	0	no seizure related injuries	11 (18%)
Lim, K (2020) (37)	137	NR	2 (2%) 2 in 1-h	1 (1%)	seizure cluster with postictal psychosis or dysphasia	3 (3%)
Yen, D. (2001) (45)	89	8 (9%)	43 (48%) 24-h	0	NR	NR

Total	951	24/473 (5%)*	67/444 (15%) 4-h 178/525 (34%) 24-h†	14/780 (2%)‡	12/413 (3%)§	106/607 (17%)¶

Table 2 Adverse events in presurgical cases only. Different definitions were used. * total no. of individuals with non-habitual focal to bilateral tonic-clonic seizures during LT-VEEG (%). † total no. individuals with seizure clusters during LT-VEEG based on three or more seizures during 4-hours and/ or three or more seizures in 24-hours. ‡ total no. of individuals with a status epilepticus during monitoring LT-VEEG. § total no. of individuals with other adverse events during LT-VEEG. ¶ cumulative total rate individuals with one or more adverse eventsh . NR = not reported

Factors that determine the chance of success:	***Nr of studies showing a significance/total nr of studies***	***References of significant findings***
Baseline seizure frequency	2/2	(10,24,37)
ASM withdrawal	1/1	(18)
Shorter interval since most recent seizure	1/1	(24)
Extra-temporal lobe epilepsy	1/1	(37)
ASM reduction not needed	1/1	(24)

Table 3. Independent determinants of LT-VEEG success show significant findings based on multivariable models. The number of studies that found the variable to be independently correlated with successful monitoring is listed, relative to the total number of studies that included the variable in multivariable analyses.

Factors that determine the risk of an adverse event:	*Nr of studies showing a significance/total nr of studies*	*References of significant findings*
ASM tapering	2/7	(8,9)
History of SE	1/3	(28)
History of FBTCS	1/3	(9)
Psychiatric comorbidity	1/3	(28)
ASM taper rate	1/2	(9)
Hippocampal sclerosis	1/2	(32)
More events/seizures during monitoring	1/2	(20)
History of Seizure cluster	1/1	(32)
Event/presurgical recording	1/1	(20)
History of seizure-related injury	1/1	(32)
Treatment with ASM in general:		
Levetiracetam	1/1	(20)
Sulthiame	1/1	(20)

Table 4. Risk factors shown to be independently related with the occurrence of adverse events during LT-VEEG.

The number of studies that reported the variable is listed, relative to the total number of studies that included the variable in multivariable analyses.

Test yourself:

1. Which of the following factors has been reported to be an independent predictor of successful presurgical long-term video-EEG monitoring?
    a. ASM withdrawal
    b. Hyperventilation
    c. High baseline frequency
2. How high is the average risk of an adverse event during presurgical long-term video-EEG monitoring?
    a. ~ 5%
    b. ~ 15%
    c. ~50%
3. What contributes more to the risk of an adverse event during ASM withdrawal?
    a. Dose amount reduction
    b. Taper speed
    c. No difference