Outpatient Smartphone Videos for Classifying Epileptic and Nonepileptic Seizures

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Abstract

BACKGROUD: Epilepsy is a clinical diagnosis though a variety of seizure mimics exist that can result in misdiagnosis and mistreatment. Video-EEG monitoring (VEM) is the gold standard to obtain a definitive diagnosis in patients with suspected seizures. However expertise availability, cost and resource utilization for diagnosis are limited.[1,2]

RATIONALE: New tools beyond routine E & M are necessary to assist with the diagnosis of paroxysmal neurological disorders to ensure accurate treatment. Home videos and hand-held camcorders are promising surrogates.[3,4] Smartphones are a ubiquitous part of a global society with cameras capable of high definition. We sought to determine the usefulness of outpatient smartphone videos in epilepsy (OSmartViE) and report extended data from our preliminary findings of a multi-center prospective study.

METHODS: A prospective, multi-center, blinded trial of outpatient smartphone video analysis was performed. Patient-generated outpatient smart-phone videos (SV) were acquired and reviewed prior to VEM. Forced choice diagnosis of 1) ES, 2) PNES, or 3) PhysNEE and a corresponding degree of certainty (0-10) was assigned. Epileptologists and senior general neurology residents without special interest in epilepsy were surveyed for a blinded SV diagnosis. Data sharing was performed via HIPPA-protected data transfer utilizing a web-based software application (CaptureProof®). The H&P, SV, and VEM results were obtained using survey forms and compared. Sensitivity, specificity, PPV, NPV was analyzed.

RESULTS: 41 patients [28 F, age 43.7 yrs.; R= 20-81] had H & P, SV and diagnostic VEM. SV were reviewed in 2.15 mins compared to 60 mins with routine H & P and 3,657.6 minutes (2.54 days) with VEM. Most semiology was convulsive and most ES non-convulsive A final diagnosis of PNES 26, ES 11, PhysNEE in 3 and 1 with dual diagnosis (PhysNEE + PNES). No difference in the level of confidence between experts and residents was found (p= NS). SV quality was adequate for interpretation in > 3/4th of cases. Inter-subject differences were present largely based upon technical limitations as opposed to video quality. The primary technical limitation was lack of focus on the area of interest/whole body view.

CONCLUSIONS: Most SV are volunteered by patients with PNES. No significant differences were present between the PPV of a SV for the final diagnosis among experts and trainees. The widespread availability of SV makes them a useful adjunct in the H & P in the diagnosis of PNES[3-5]. We suggest that SV are a complementary addition to H & P in the outpatient epilepsy clinic and can help triage hospital admission for VEM.

Methods

We prospectively evaluated 41 (38 new) consecutive patients with uncontrolled seizures. Routine H & P, smartphone video (SV) and video-EEG monitoring (VEM) were performed 7/2014-11/2017. Treating physicians reached a final clinical diagnosis of 1) ES, 2) PNES, 3) PhysNEE with a degree of certainty (scale: 0-10). Representative SVs for a typical event underwent blinded review by 10 experts and 8 general Neurology residents who were not planning to specialize in epilepsy. Surveys were sequentially completed for SV (reviewer) and for once for surveys covering H & P and VEM data (treating physician). SV data collection and sharing was done after 2 training sessions using a HIPPA-secure web-based software application (CaptureProof®).

Inclusion criteria: voluntary consent, age 18, completed H & P (before VEM), representative event on SV, and VEM performed, trained to utilize CaptureProof®, and technically evaluable OSV recording.

Exclusion criteria: younger than 18 years, incomplete H & P, atypical event, inadequate SV, VEM unconfirmed diagnosis, absent consent.

Figure 1: VEM Diagnosis

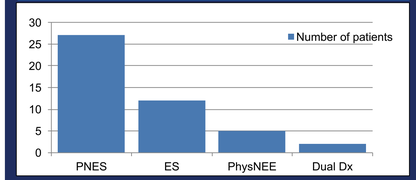


Figure 2: Semiology

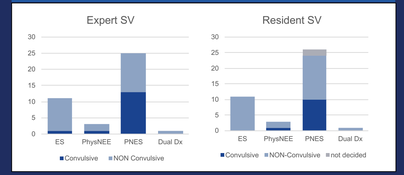


Figure 3: SV Correct Diagnosis

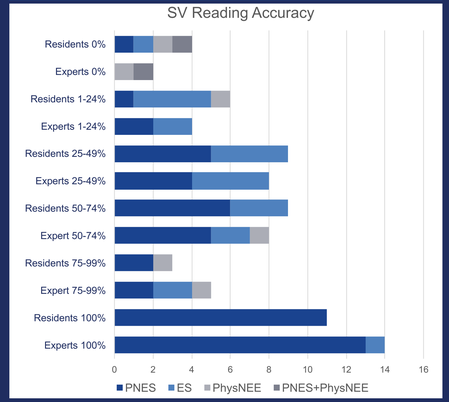
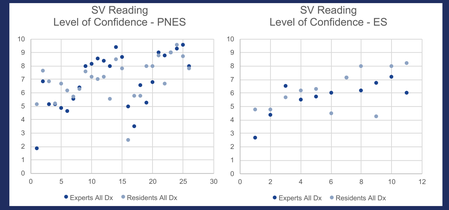


Figure 4: Level of Confidence



Results

- 41 patients (13 males; mean age 43.7 years, range 20-81) had recurrent paroxysmal events and submitted a SV for evaluation **(Table 1).**
- All patients were evaluated by H & P, SV, and VEM for a final diagnosis.
- The submitted SV was scored for ES, PNES, or PhysNEE by 10 experts and 8 residents participating in the trial.
- 310 expert SV reads and 230 resident SV reads were performed.
- Overall 74,167 sec. (20.6 hrs.) of SV were viewed by the study participants.
- The final diagnosis after VEM had 26/41 (63.4%) with PNES, 11/41 (26.8%) with ES, 3/41 (7.3%) with PhysNEE and 1/41 (2.4%) was dual diagnosed (PhysNEE + PNES) **(Figure 1).**
- The majority of the events were non-convulsive (36.5% convulsive) and most consisted of PNES **(Figure 2).**
- 100% concordance for a diagnosis was present in 14/41 SV (34.1%) for experts and 11/41 (26.8%) by residents; nearly all PNES **(Figure 3).**
- The level of confidence was similar (6.4/10 experts vs 6.5/10 residents). Those with a correct diagnosis were slightly more confident; 7.5/10 for residents and 6.8/10 for experts (p= NS). Using a level of confidence of at least 5, 78% provided correct identification (experts) vs 68% with residents (see **Figure 4).**
- H & P predicted a definitive diagnosis by VEM in 31/41 (75.6%) .
- The median correct response for a SV was 71.4% for experts and 66.7% for residents (p = NS). Overall, SV review correctly differentiated ES from PNES in 68% of SVs evaluated by experts and 58% assessed by residents.
- Inter-rater variability according to the final diagnosis by SV was moderate for experts (0.6) and poor (0.3) for residents. An overall Kappa score was 0.5.
- The overall quality of the SV was judged to be adequate for interpretation in nearly 32/41 (77%) patients **(Figure 5).**
- The mean duration of SV was 2m15s (R: 9s- 9m3s); median 1m28s
- Compared with 1 hour for H & P and 60.96 hours (2.54 days) of VEM, time savings for SV diagnosis vs VEM was significant (p= <0.0001).
- No safety concerns or complications arose by taking a SV.

Table 1: Demographics

Features	ES	PNES	OVERALL
Age (mean in years)	45.6	41.8	43.7 (r: 20-81)
Gender (#/%)	8/11 F	20/26 F	29 female (70.7%)
# experts participating and mean # of responses/patient	8	8	10 (8)
# residents participating and mean # of responses/patient	6	6	8 (6)
Final diagnosis	11/41 (26.8%)	26/41 (63.4%)	-
Adequate quality SV (#/%) mean	9 (81.8%)	20 (76.9%)	31/41 (75.6%)
Convulsive events (#/%) on SV	1 (9.1%)	13 (52%)	15 (36.5%)
SV Length (average)	2m18s	2m20s	2m15s

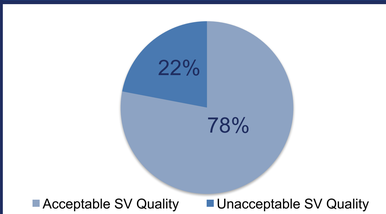
Discussion

Newer techniques are needed given that 20-30% of patients admitted to VEM units are misdiagnosed as epilepsy (1). We found that most patients bringing SV to clinic are ultimately diagnosed with PNES and likewise nearly 70% are women. VEM is the most specific procedure to reach a definitive diagnosis in patients with suspected seizures, however availability, cost and resource allocation/utilization are limited. H & P is the standard method of diagnosis and treatment though agreed with the final diagnosis after VEM even in expert hands in this cohort only 75.6% of the time (n= 41 patients). Smartphones are ubiquitous worldwide with cameras capable of high- definition. In this study > 3/4th were judged as adequate on clinical grounds and limited by the user quality. Most diagnoses are made in isolation without sharing of information related to paroxysmal neurological behaviors though diagnosis can be challenging with non-convulsive seizures even by experts correctly predicted 76% of the time. The reliability of an ES diagnosis is good when a reliable witness is able to provide an adequate history though the accuracy for PNES is much less (2). We suggest that SV are therefore a useful adjunct given median correct response of 71.4% predicted by experts (3,4). Non-experts were less though reflected similar outcomes supporting widespread applicability for an under-utilized, under recognized form of tele-medicine with diagnostic potential for world-wide impact. The level of diagnostic confidence was similar for experts and non-experts despite differences in accuracy and poor inter-rater reliability for non-experts. This suggests that a gap exists in training relative to viewing semiology for diagnostic implications and supports ongoing need for education in patients with “events”. We suggests SV are a useful adjunct to standard H & P for evaluation of patients with seizures and spells and provides best medical practice for patients similar to prior reports in developing countries (5) and those comparing home video and EEG (4). Patients with paroxysmal events and limited access to care may be able to obtain a semiology-based expert opinion at low cost by HIPPA-secured transfer of information.

Table 2 ES vs PNES SV

	PNES	ES
VEM Final diagnosis (%)	26 (63%)	11 (27%)
SV Expert correct diagnosis	80%	43%
SV Resident correct diagnosis	82%	31%
H & P Expert correct diagnosis	65%	60%
SV expert Sensitivity/Spec	80/54	43/83
SV Resident Sensitivity/Spec	82/53	32/83
H & P Sensitivity/Specificity	79/53	43/82
Accuracy of HP for final Dx	67%	67%
Accuracy of SV for final Dx (experts & residents)	70%	69%

Figure 5: SV Quality



Conclusion

- Secure uploading, exchange, and analysis of SV data in patients with paroxysmal neurological events is feasible.
- Most patients volunteering SV will have a final diagnosis of PNES.
- The majority submitting SV are women in line with most PNES patients.
- Most SVs were non-convulsive though those with the highest concordance among raters were PNES almost exclusively differing from H & P.
- Inter-rater reliability was greater for experts than for residents but was only moderate overall.
- The median duration of SV was 1min 28sec vs 60 mins with routine H & P and 2.54 days with VEM (p= < 0.0001).
- Supplementing the H & P with a SV provides objective support for a clinical diagnosis of PNES but does not replace the need for VEM in all cases.

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Acknowledgements

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