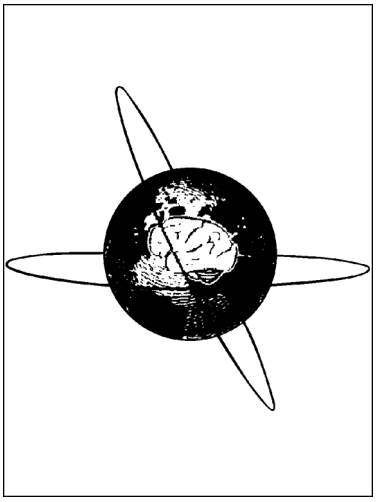
Accepted Manuscript



Letter to the Editor

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Emma Schleiger, Andrew Wong, Stephen Read, Alan Coulthard, Simon Finnigan

PII: S1388-2457(16)30429-1
DOI: http://dx.doi.org/10.1016/j.clinph.2016.06.001
Reference: CLINPH 2007864

To appear in: *Clinical Neurophysiology*

Accepted Date: 4 June 2016

Please cite this article as: Schleiger, E., Wong, A., Read, S., Coulthard, A., Finnigan, S., Resolution of cerebral pathophysiology immediately following thrombectomy in acute ischaemic stroke: Monitoring via quantitative EEG, *Clinical Neurophysiology* (2016), doi: http://dx.doi.org/10.1016/j.clinph.2016.06.001

Resolution of cerebral pathophysiology immediately following thrombectomy in acute ischaemic stroke: Monitoring via quantitative EEG

Emma Schleiger [1,2,3], Andrew Wong [2,3], Stephen Read [2,3], Alan Coulthard [4,5], Simon Finnigan [1,*]

[1] UQ Centre for Clinical Research, The University of Queensland, Brisbane, Australia

[2] School of Medicine, The University of Queensland, Brisbane, Australia

[3] Acute Stroke Unit, Neurology Department, Royal Brisbane and Women's Hospital, Brisbane, Australia

[4] Department of Medical Imaging, Royal Brisbane and Women's Hospital

[5] Discipline of Medical Imaging, University of Queensland, Australia

*** Corresponding Author:**

UQ Centre for Clinical Research

Royal Brisbane & Women's Hospital

Herston Qld 4029

Australia

Tel.: +61 7 33466015

Fax: +61 7 33465594

E-mail: finnigan.simon@gmail.com

Quantitative EEG (QEEG) has demonstrated value in assessment of cerebral pathophysiology following acute ischaemic stroke (AIS; e.g., (Finnigan et al. , 2013). Various reports indicate that EEG/QEEG can promptly detect cerebral responses to successful reperfusion therapy, even when this cannot be assessed clinically (Finnigan et al. , 2006, de Vos et al. , 2008, Finnigan et al. , 2013). Additionally QEEG can indicate lack of favourable response to therapy, (e.g. unsuccessful alteplase) and may help expedite decisions regarding intra-arterial interventions (e.g. thrombectomy; Sheikh et al., 2013). We reported marked QEEG changes between pre- and post-thrombectomy recordings (Sheikh et al. , 2013). In EEG acquired from 2 h post-recanalisation the delta/alpha power ratio (DAR) demonstrated significant improvement (3.3) relative to that assessed 4 h prior (10.8; pre-procedure), indicating relative normalisation of brain function and successful reperfusion. These changes accurately predicted an excellent outcome, whereas confirmation via post-procedure neurological assessment was not possible until 3 days post-stroke (due to sedation and intubation). Comparisons between AIS and controls indicate that DAR of 3.7 is an accurate criterion value to define abnormally slow EEG in AIS (Finnigan et al. , 2016). We now describe a case wherein EEG was recorded throughout a successful thrombectomy procedure.

A 56-year-old man, living independently with history of hypertension and type II diabetes, presented approximately 1h after acute onset of symptoms (“post-stroke”). These included right-sided hemiplegia and facial droop, expressive and receptive dysphasia (NIHSS = 23). CT Perfusion (CTP) showed a 115ml infarct core (estimated using RAPID software; iSchemaView), in the left middle cerebral artery (LMCA) territory, with diffuse penumbra (absolute mismatch difference 109ml). IV alteplase bolus commenced at 113 minutes post-ictus. Endovascular treatment was initiated given lack of clinical improvement, large estimated clot size, and the relatively short time since stroke symptom onset. Clot retrieval commenced in the angio suite under conscious sedation (remifentanil) at 155 minutes post-stroke. Thrombectomy was achieved at 193 minutes post-stroke with a single pass using a

4mm x 20mm Trevo stent retriever (Stryker Neurovascular) with immediate return of anterograde LMCA blood flow (TICI 3).

By 4 h post-thrombectomy there was return of full power in the right upper and lower limbs. Follow-up MRI at 24 h showed hyperintensity in LMCA territory (frontal and parietal cortical regions and basal ganglia). At 24 and 48 h post-thrombectomy, NIHSS scores were 11 and 9, respectively (severe dysphasia, mild dysarthria, facial droop, partial sensory loss). At two months the patient was independent in motor-based ADL tasks but remained moderately dysphasic (expressive and receptive) with some cognitive impairments.

Prior to therapy the patient was enrolled into an observational EEG study (www.anzctr.org.au; ACTRN12611000611921) approved by local University and Hospital Human Research Ethics Committees. Written, informed consent was obtained. EEG was acquired using a NicOne Monitor (CareFusion Healthcare) and standard International 10-20 electrode positions, albeit due to time pressures electrodes were not applied to sites C3, C4, O1, O2. Acquisition and offline QEEG analyses employed methods and parameters previously reported (Finnigan et al. , 2016). In brief, DAR measures absolute power of abnormal, slow delta (1-4 Hz) divided by that of normative alpha (8–12.5 Hz) frequency range. Discrete DAR measures were each computed from 82 seconds (20 epochs of 4096 ms duration) of artefact-free EEG, and times of these are noted below (Figure 1). DAR was computed for each electrode and “global” DAR averaged over all. DAR changes post-reperfusion were assessed via repeated-measures t-tests.

EEG electrodes were applied during alteplase infusion and recording commenced in the angiography suite. Prior to thrombectomy, global DAR remained abnormal (>6) however within 4 min of reperfusion it dropped to a value (4.4) approaching the proposed abnormality threshold (3.7). Repeated-measures t-tests revealed highly-significant DAR improvements

following reperfusion; between 193-194 and 194-195 min (t [18] = -4.23, p < .001) and between the latter and 195-197 min (t [18] = -7.21, p < .001). Individual fronto-temporal electrodes (overlying stroke-affected regions) demonstrated parallel DAR improvements (Figure 1). Recording ceased at 198 min before the patient was transferred to the stroke unit.

This is the first report of EEG (and QEEG) acquired continuously during thrombectomy. Novel observations include significant EEG improvement (reduction of DAR) within several minutes of LMCA reperfusion following thrombectomy. This preceded and was consistent with gradual, subsequent improvements in some symptoms, which began to become apparent by 4 h post-thrombectomy. Some symptoms (particularly dysphasia) remained at 2 months, hence it is unsurprising that more marked DAR reduction, into the normative range (<3.7), was not observed. We hypothesise that in cases of greater (subsequent) resolution of symptoms, global DAR would reduce below 3.7.

Post-reperfusion improvements in DAR occurred in both global (averaged over 14 electrodes) and individual electrodes overlying stroke-affected regions (Figure 1). These novel observations indicate that a 19-electrode montage may not be necessary as a reduced number of electrodes may provide adequate monitoring information. This is significant as a reduced montage is more feasible particularly when brief set-up time is vital.

These outcomes indicate that DAR can effectively and immediately index (partial) salvage of ischaemic penumbral tissue following successful AIS reperfusion therapy. Notably, the favourable response of cortical penumbra – indexed by DAR reduction – is additional to reperfusion (revealed by imaging) which is not always associated with tissue salvage, restored brain function and/or improved symptoms. Moreover these data are the first to demonstrate that substantial DAR improvement occurs within several minutes of radiologically-confirmed reperfusion. This is pertinent for monitoring during both IV and intra-

arterial, reperfusion therapy; for example lack of rapid DAR response to IV alteplase may in future assist decision-making regarding thrombectomy. We cannot presently determine whether or not sedation substantially affects DAR although these and other data (Sheikh et al., 2013; Finnigan et al., 2016) suggest not.

This novel case provides further evidence that QEEG – from a reduced electrode montage - can inform, and help expedite, AIS treatment and management decisions. Further studies in larger samples are warranted.

CONFLICT OF INTEREST

None of the authors have potential conflicts of interest to be disclosed.

ACKNOWLEDGEMENTS

This study was funded in part by the University of Queensland, the Royal Brisbane and Women's Hospital Foundation and the National Stroke Foundation (Australia).

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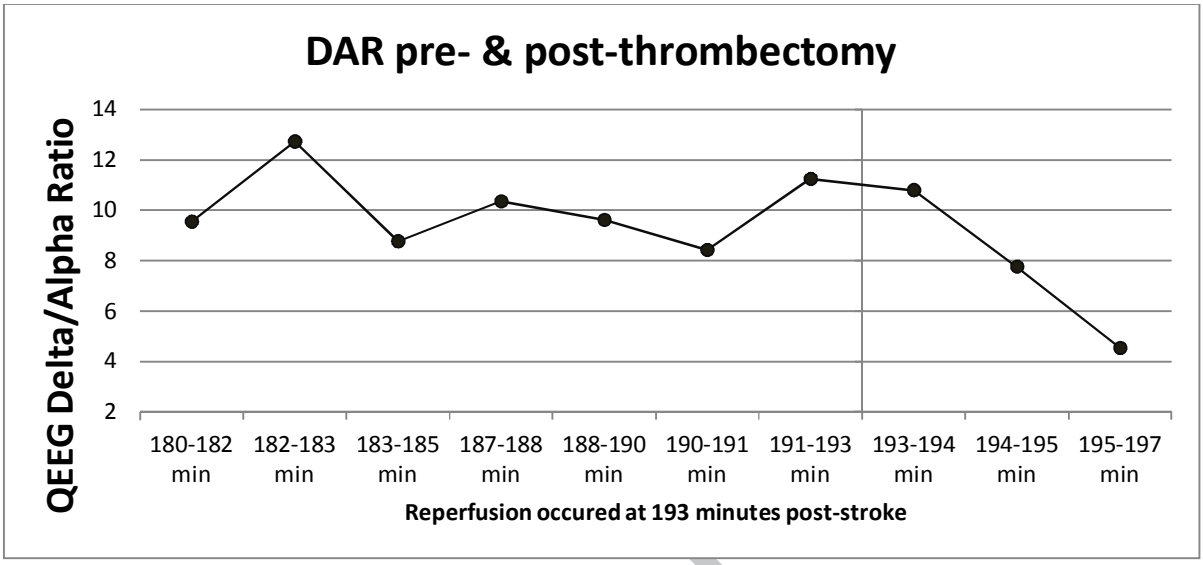

Figure 1: Delta/alpha power ratio. (DAR) values plotted over time throughout the thrombectomy procedure. The vertical line indicates time of reperfusion. DAR measures absolute power of abnormal, slow delta (1-4 Hz) divided by that of normative alpha (8–12.5 Hz) frequency range. Each data point plots DAR averaged across 20 epochs of artefact-free EEG data (each epoch is of 4096 ms duration). DAR measures from left temporal electrode (T3) are plotted; this and adjacent electrode sites (ipsilateral to stroke-affected hemisphere) characteristically demonstrate highest delta power, in cases of acute ischaemic stroke in the middle cerebral artery territory.