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# Rapid and efficient treatment of post-traumatic stress disorder induced by anaesthesia awareness with recall using reconsolidation therapy

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**Keywords:** anaesthesia; awareness; electroconvulsive therapy; post-traumatic stress disorder; propranolol; recall; reconsolidation therapy

Editor—Recall of intraoperative events, including sights, sounds, and sensations occurring during surgery or care under general anaesthesia (GA), is a rare but serious complication, also called anaesthesia awareness with recall (AAWR).<sup>1</sup> There is a wide range in the incidence of AAWR reported in the literature, which appears to depend on the method used for detection. The most rigorous method is to question the patient directly using the Brice questionnaire, which carries a reported incidence of 1:800.<sup>1,2</sup> AAWR can occur during the different phases of GA including induction (2/3 of cases), maintenance, or emergence.<sup>1,2</sup> Factors associated with AAWR include inadequate GA, lack of use or misuse of neuromuscular monitoring, type of surgery (obstetrics, cardiac, thoracic, emergency), human error, device malfunction, pharmacogenetic variations, and individual factors (female sex, young age, obesity).<sup>1,2</sup> AAWR can be experienced as a psychological trauma leading to post-traumatic stress disorder (PTSD).<sup>3</sup> AAWR-induced PTSD can have serious consequences for patients who might refuse required treatments, including electroconvulsive therapy (ECT), a safe and effective non-pharmacological treatment for severe or treatment-resistant mood disorders.<sup>4</sup> It is therefore essential to provide rapid and effective treatments for AAWR-induced PTSD to avoid patients refusing or withdrawing from care.

According to reconsolidation theory, under certain conditions a recalled memory will reconsolidate in long-term memory.<sup>5</sup> During this process, the memory is labile and sensitive to effects of pharmacological agents such as the  $\beta$ -adrenergic blocker propranolol, a lipid-soluble molecule that can diffuse into the brain. Near the peak plasma concentration (~60 min after intake), propranolol produces a reduction in the emotional charge of the actively recalled memory under reconsolidation. Precise molecular mechanisms for the propranolol effect on memory reconsolidation are not well understood. By repeating this process with propranolol, reconsolidation therapy<sup>6,7</sup> is an emerging treatment involving a rapid (6 weekly, 25-min sessions) and effective management of PTSD by blocking memory reconsolidation of an actively

recalled traumatic event, using a narrative script of the traumatic event, subsequently reducing the negative emotional charge of the memory and ensuing PTSD symptoms.<sup>8</sup> Reconsolidation therapy is a rapid, well-tolerated, and 80% effective treatment for acute (from 1 month) and chronic (>6 months) PTSD from a single major psychological trauma such as AAWR in the absence of contraindications to propranolol and psychiatric contraindications such as decompensated psychotic or bipolar disorder, substance use disorder, acute suicidal ideation, strong dissociative tendency, or severe personality disorder.<sup>6,7</sup> Reconsolidation therapy is at least as effective as antidepressant treatment but with no theoretical risk of relapse, better tolerated, with good compliance, and feasible in all countries including low-income countries.<sup>9</sup> Here, with the patient's consent, we present the first known case of an AAWR rapidly and effectively treated by reconsolidation therapy.

A 46-yr-old White outpatient woman with treatment-resistant bipolar disorder characterised by persistent hypomanic or mixed states was difficult to treat as a result of comorbidities such as autoimmune diseases, chronic pain, and metabolic syndrome with severe obesity (weight, 125 kg; body mass index, 45.4 kg m<sup>-2</sup>) requiring noninvasive ventilation to treat a sleep apnoea syndrome. Psychotropic treatment included valproic acid, lithium, and olanzapine. In this context, we performed a course of ECT (MECTA spECTrum 5000Q device, MECTA Corp, Tualatin, OR, USA), with two weekly sessions, for a total of 12 ECT sessions. ECT was performed with propofol anaesthesia (average dose 1.16 mg kg<sup>-1</sup>) and suxamethonium neuromuscular block (average dose 0.26 mg kg<sup>-1</sup>). The seizure threshold was determined by titration. Electrode placement was bipitemporal until the ninth session, then changed to a right unilateral placement to minimise ECT-induced memory impairment. Considering the ECT course effectiveness, consolidation ECT as one weekly ECT session was performed to limit the risk of relapse.<sup>10</sup>

During the first ECT session, the patient emerged from anaesthesia in a state of paralysis under the effect of the neuromuscular blocker, experiencing AAWR, which generated strong feelings of fear about ECT. As a result of the use of low

doses of anaesthetic with neuromuscular blockers, and also considering potential interactions between psychotropic and anaesthetic drugs,<sup>11</sup> ECT is a risk factor for AAWR. Cases of AAWR during ECT are limited in the literature,<sup>12,13</sup> but invariably share the memory of paralysis which we refer to as 'sarcophagus syndrome' to describe the feeling that patients have of being trapped in their own paralysed body as in a sarcophagus. The patient was nevertheless able to continue ECT, thanks to an anxiolytic premedication before each session (sedative antipsychotic cyamemazine) and a dose reduction in suxamethonium from 0.4 mg kg<sup>-1</sup> to 0.24 mg kg<sup>-1</sup>. During the first session of ECT continuation (13th session), a noninvasive ventilation device dysfunction caused a suffocation sensation, which echoed the suffocation sensation felt during the AAWR. From then on, the patient presented with severe PTSD related to her paralysed and suffocated state from the first ECT session, and she could not approach the ECT room. The patient therefore suspended her ECT treatment. In this context, and considering ECT as an effective treatment, we proposed to treat her PTSD with reconsolidation therapy. After ensuring that there were no psychiatric and propranolol contraindications, including a normal cardiac examination with a normal electrocardiogram, we prescribed propranolol 60 mg p.o. to be taken with a snack 1 h before each weekly 25 min reconsolidation therapy session.<sup>14</sup>

Before the first reconsolidation therapy session, the patient's total score on the PTSD Checklist for DSM-5 (PCL-5)<sup>15</sup> was 69/80 (PCL-5 cut-off score >32) with a PCL-5 intrusive symptoms subscore of 18/20 and an avoidance symptoms subscore of 5/8. During the first reconsolidation therapy session, the patient wrote a trauma narrative in which she mentioned: 'I wake up unable to breathe, I feel my chest completely blocked, I am suffocating, I am very afraid to literally die. I panic. I am obsessed by the absence of air, I do not feel my body anymore'. Before the second reconsolidation therapy session, the PCL-5 total score had decreased to 42/80 (-40%). Before the third session, the PCL-5 total score was 22/80 (-68%), with a PCL-5 intrusive symptoms subscore of 6/20 (-67%) and an avoidance symptoms subscore of 0/8 (-100%). Given her important clinical improvement, we conducted the fourth session inside the ECT room. At the end of the sixth session, the patient was considered in remission with a PCL-5 total score of 19/80 (-72%). No propranolol adverse effects were reported by the patient at any time. After the completion of reconsolidation therapy, the patient was able to resume the ECT.

We present a case of AAWR-induced PTSD that was effectively and rapidly treated with reconsolidation therapy. If replicated, the efficiency, tolerance, and ease of use make reconsolidation therapy an essential treatment of choice to be developed further for the treatment of AAWR-induced PTSD. Collaboration between anaesthetists, psychiatrists, and psychologists is important to establish treatment for AAWR-induced PTSD. Reconsolidation therapy also has the advantage of being accessible to specialist nurses who could play a key role in patient management.

### Declarations of interest

AB teaches reconsolidation therapy for a fee. The other authors declare that they have no conflicts of interest or financial disclosures to report.

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## Smartphone-based automatic assessment of left ventricular ejection fraction with a silicon chip ultrasound probe: a prospective comparison study in critically ill patients

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**Keywords:** echocardiography; ejection fraction; intensive care; point-of-care; silicon chip; smartphone; ultrasound

Editor—The portability and cost of ultrasound devices, and operator skills, remain significant barriers to the adoption of point-of-care echocardiography.<sup>1–3</sup> Recent hardware and software ultrasound innovations include crystal-free pocket probes and algorithms designed to facilitate and automate echocardiographic measurements, and connectivity to smartphones.<sup>3,4</sup> We designed the present study to compare automatic measurements of left ventricular ejection fraction (LVEF) taken with a silicon chip ultrasound probe and a smartphone (LVEF<sub>SMART</sub>) to reference manual measurements (LVEF<sub>REF</sub>) taken with a high-end ultrasound device.

We prospectively studied patients who required an echocardiographic evaluation during their ICU stay and in whom it was possible to obtain transthoracic images with a cart-based high-end ultrasound device (institutional review board approval # TI 71/2021). LVEF<sub>SMART</sub> measurements were taken with a software application (Butterfly IQ - Ultrasound, Butterfly Inc., Burlington, MA, USA) installed on a smartphone (iPhone 7, Apple, Cupertino, CA, USA) connected to a silicon chip ultrasound transducer (IQ, Butterfly Inc.) (Fig 1). The IQ transducer stands out in handheld ultrasound technology by replacing traditional piezoelectric crystal-based transducers with a single silicon chip containing a 2D array of capacitive micromachined ultrasound transducers. Each single micro-transducer consists of a thin, conductive membrane that, when a voltage is applied, acts like a small drum to generate and receive ultrasound vibrations.

The software application (App) detects left ventricular endocardial borders on 3-s video clips of apical four-chamber images (Fig 1). The end-diastolic and end-systolic frames are detected automatically by the App (Fig 1 and Supplementary

online video at <https://doi.org/10.1016/j.bja.2023.02.032>) and LVEF<sub>SMART</sub> is calculated using the monoplane Simpson formula (fully automatic mode). When images do not meet sufficient quality, a message is displayed and the user has to review images from the video clip to select end-diastolic and end-systolic images. Then the App calculates LVEF<sub>SMART</sub> (semi-automatic mode).

LVEF<sub>SMART</sub> measurements were compared with LVEF<sub>REF</sub> measurements taken by the same echocardiographic expert with manual tracing of endocardial borders on apical four-chamber images obtained with a high-end ultrasound device (Venue, GE HealthCare, Chicago, IL, USA). Both LVEF<sub>SMART</sub> and LVEF<sub>REF</sub> measurements were taken in triplicate and averaged for comparisons. Intra-operator reproducibility was assessed by calculating intraclass correlation coefficients.

We studied 95 patients over a 9-month period; 32 (34%) were mechanically ventilated at the time of the ultrasound evaluation (Supplementary Table S1). LVEF<sub>REF</sub> and LVEF<sub>SMART</sub> ranged from 26% to 80% (mean 54% [12%]) and from 28% to 79% (mean 54% [12%]), respectively. The intraclass correlation coefficients were 0.80 (95% confidence interval [CI] 0.74–0.86) and 0.86 (95% CI 0.81–0.90) for LVEF<sub>REF</sub> and LVEF<sub>SMART</sub>, respectively. We observed a significant relationship ( $r=0.75$ ,  $P<0.001$ ) between LVEF<sub>REF</sub> and LVEF<sub>SMART</sub> (Supplementary Fig. S1). The average difference (bias) between LVEF<sub>SMART</sub> and LVEF<sub>REF</sub> was 0% (8%) with 95% limits of agreement of –17% to +16% (Supplementary Fig. S1). Thirty patients (32%) had LVEF<sub>REF</sub> <50% (left ventricular systolic dysfunction). The sensitivity and specificity of LVEF<sub>SMART</sub> to detect systolic dysfunction were 70% and 89%, respectively.