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Continuous EEG of memories of Near-death and mystical experiences: Preliminary research

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Abstract

We recently recorded, processed, and published brain activity by quantitative electroencephalography (QEEG) and quantitative electroencephalography (QEEGt), comparing separate subjects remembering their near-death experience (NDE) and mystical experience. Our studies refer to a mystical experience as a spiritual contemplative experience (SCE). We found neural and Greyson Scale (GS) correlations between them. This study is a real-time enhancement of that study using the emerging technology of continuous EEG monitoring (CEEG), which intensive care unit (ICU) professionals use to identify malignant EEG patterns quickly and provide care effectively. EEG monitoring encompasses a wide range of technical and clinical issues in successfully monitoring critically ill patients to detect significant changes in cerebral function and prevent serious neuronal injury over time. Because the brain undergoes continuous and dynamic changes, CEEG was considered an important method for real-time monitoring of functional brain changes while remembering near-death experiences (NDE) and spiritual contemplative experience (SCE). The CEEG envelope showed an incremental amplitude coinciding with NDE and SCE remembering the time, but an increase of amplitude was greater for SCE. CEEG also demonstrated a greater amplitude in frontal lobes for SCE. Statistical increments of absolute power for alpha and gamma bands were demonstrated during both NDE and SCE. We conclude that CEEG is a useful method for continuously assessing dynamic changes while remembering NDE and SCE.

Keywords: Near-death experiences; Spiritual contemplative experiences (SCE); Mystical experiences; Continuous EEG monitoring (CEEG); Grayson Scale; intensive care unit (ICU)

1. Introduction

Over the centuries, the wisdom literature in most faith traditions has reported SCEs and NDEs, with these altered states of consciousness having similar attributes that have been scarcely studied by neuroscience.[1-9]

Several reports indicated that NDE and SCE are associated with marked thermodynamic and neuroelectric changes in brain regions involved in positive emotions, visual mental imagery, attention, or spiritual experiences. The temporoparietal junction is the possible anatomic substrate for out-of-body experience (OBE). Hence several authors have reported repetitively induced OBE by subcortical stimulation near the left temporoparietal junction during awake

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craniotomy. Diffusion tensor imaging tractography implicated the posterior thalamic radiation as a possible substrate for autoscopic phenomena.[9-11]

We recently published an article in which we recorded and processed brain activity by QEEGt methodology. There was a clear correlation between brain activation in delta, alpha, and gamma bands and calculated frontal lobe activation for both NDE and SCE subjects. Although there was a greater activation for the SCE subjects.[12]

The emerging technology of CEEG in intensive care units allows practitioners to identify malignant EEG patterns quickly and provide more effective care. *EEG monitoring* encompasses a wide range of technical and clinical issues in successfully monitoring critically ill patients to detect significant changes in cerebral function and prevent serious neuronal injury. CEEG is a rapidly evolving technology, and this statement addresses only current consensus-based recommendations for CEEG.[13-29]

Hence, as the brain undergoes continuous and dynamic changes, CEEG should be an important method for real-time monitoring of the brain's functional changes during remembering NDE and SCE.

Objective

Compare the continuous real-time neural correlates of subjects who are in the process of remembering a prior NDE or SCE using CEEG.

2. Material and methods

We chose a protocol to assess by CEEG the memories of two groups who previously had a NDE and separately a SCE. CEEG allows continuous monitoring of bioelectrical activity, with a high temporal resolution, during NDE and SCE remembering. We used the CEEG system for neuromonitoring in intensive care units developed in Cuba (Neuronic S. A.)

2.1. Sample Groups

Two groups were studied, each having five subjects from 19 to 65 years of age, both male and female, paired in age and gender. The NDE group was selected from cases who had suffered a cardiac arrest (C-AR) inside the ICU. The SCE group was selected from subjects who described having a SCE during their practice of Centering Prayer (CP), an interdenominational Christian form of prayer.

All subjects, both NDE and SCE, had neurological examinations, and the Grayson Scale (GS) applied[4] was used as an objective measure of a valid NDE and SCE. The subjects who did not describe a NDE or SCE using the GS were excluded from the study.

2.2. Experimental Design

Every subject was studied with both CEEG during remembering NDE and SCE. CEEG was assessed during 7 minutes of basal recording and 7 minutes of remembering their NDE and SCE.

2.3. CEEG Assessment [23-25, 30-33]

Subjects were studied inside our laboratory with controlled temperature from 24 to 26^0 Celsius, noise attenuation, and dimmed lights. The CEEG was recorded from 19 standard locations over the scalp according to the 10-20 system: Fp1, Fp2, F3, F4, F7, F8, T3, T4, C3, C4, P3, P4, T5, T6, O1, O2, Fz, Cz, and Pz. After carefully cleaning the skin, discoidal EEG tin electrodes were fixed using a conductor paste and connected to the input box of the digital Continuous EEG Monitoring system (Neuronic, SA). Monopolar leads were recorded using linked ears as a reference. Technical parameters for EEG were: gain 20,000; pass-band filters 0.1 - 70 Hz; "notch" filter at 60 Hz; noise level of 2 μV (root mean squared); sampling frequency 200 Hz; and electrode-skin impedance never higher than 5 KΩ. A bipolar chest electrocardiogram (ECG) lead was recorded with 0.5 to 30 Hz EEG filters for monitoring purposes.

CEEG processing was performed by using the CEEG system for neuromonitoring in intensive care units developed in Cuba (Neuronic S. A.)

2.4. Ethical Issues

Written informed consent was obtained from each subject with a form approved by IRB of the Institute of Neurology and Neurosurgery, Havana, Cuba.

3. Results

The following Figures 1-3 show the CEEG relative incremental amplitudes coinciding with remembering NDE and SCE, with red arrows indicating the start and finish of remembering over seven minutes. The total amplitude was always greater for SCE. Figure 1 shows the CEEG leads separately from the left and right hemispheres as a grand average over all subjects. Figure 2 shows the CEEG leads as a grand avegage over both hemispheres and all subjects. Figure 3 shows the CEEG leads as a grand average over both hemispheres but separetly for each of the 10 subjects.

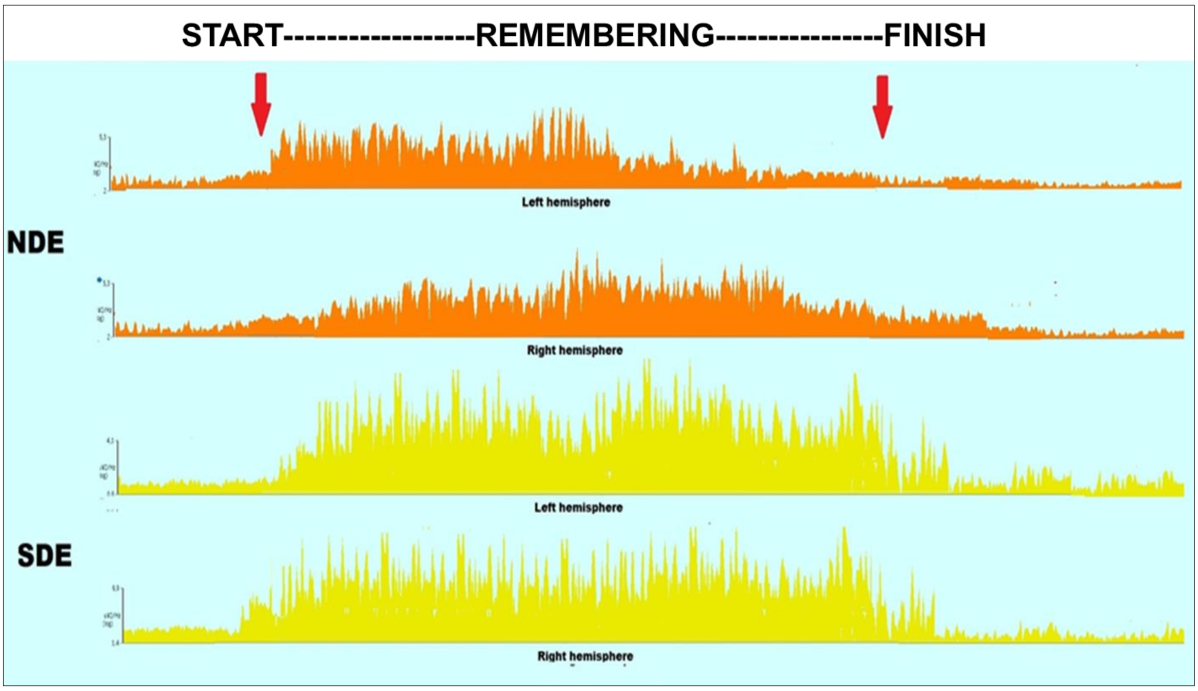

Figure 1 CEEG Grand Average of All Subjects for Separate Hemispheres - Plot

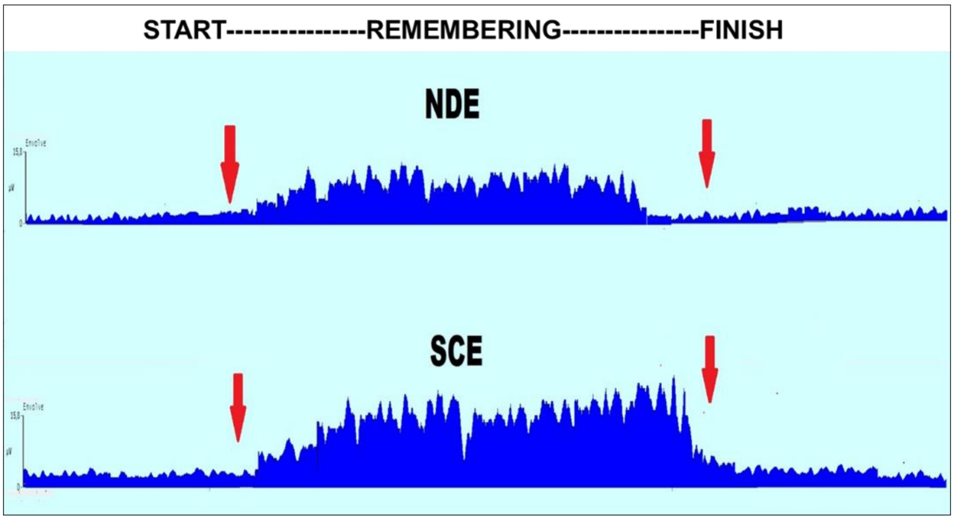

Figure 2 CEEG Grand Average of Both Hemispheres and All Subjects - Plot

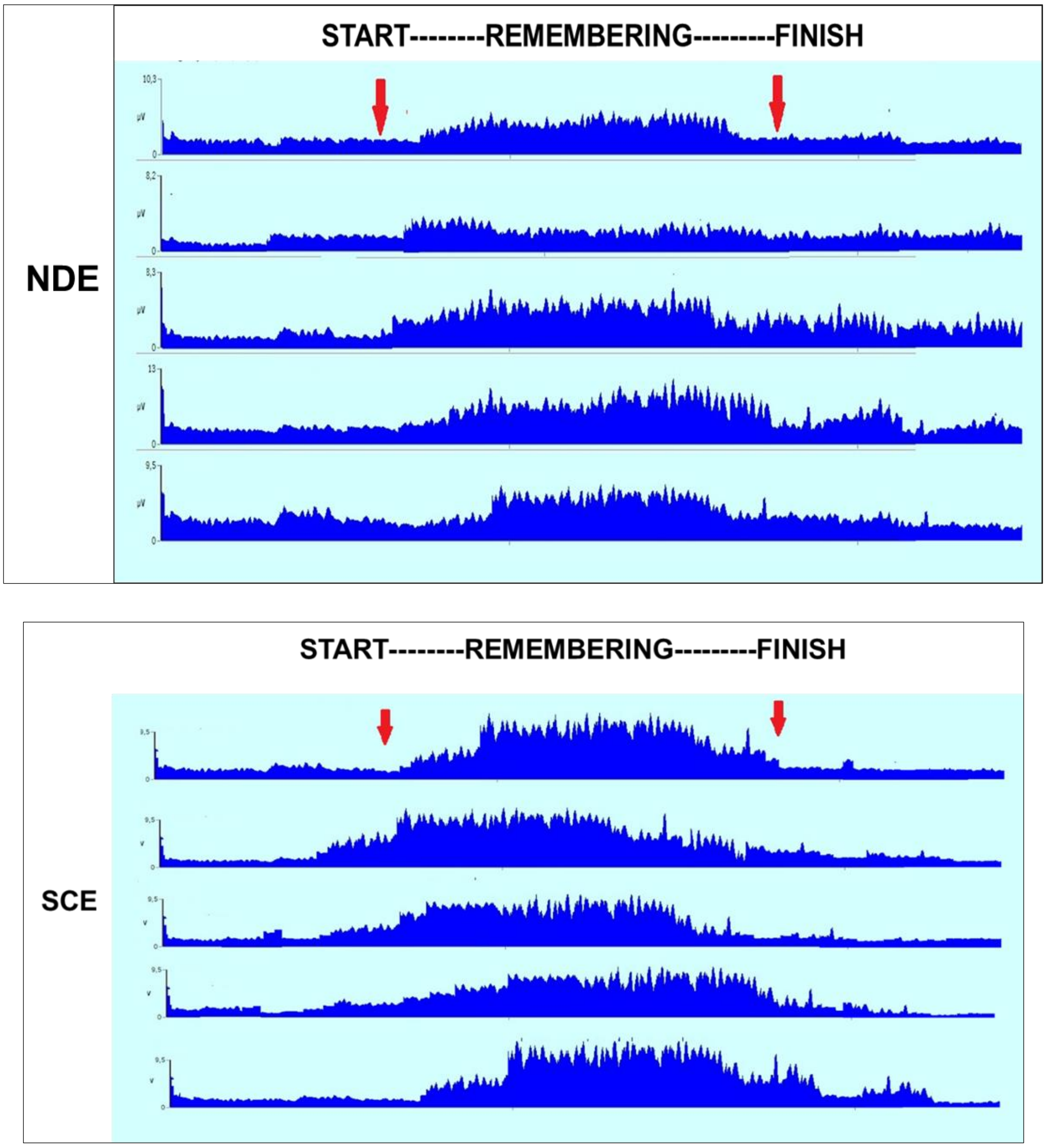

Figure 3 CEEG Grand Average of Both Hemispheres for Separate Subjects – Plot

Figures 4-5 show CEEG integrated amplitude assessed over only the EEG frontal leads with red arrows indicating the start and finish of remembering over seven minutes. Figure 4 shows the CEEG frontal leads as a grand average over both hemispheres and all subjects. Figure 5 shows the CEEG absolute delta and gamma wavelengths as a grand average of frontal leads for both hemispheres and all subjects. Discontinuous lines show a ±3 standard deviations (SD) with brown points indicating statistically significant values compared to the basal record.

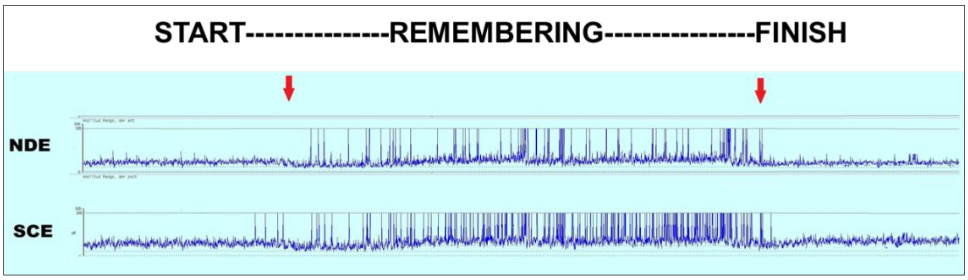

Figure 4 CEEG Frontal Leads: Grand Average of Both Hemispheres & All Subjects – Plot

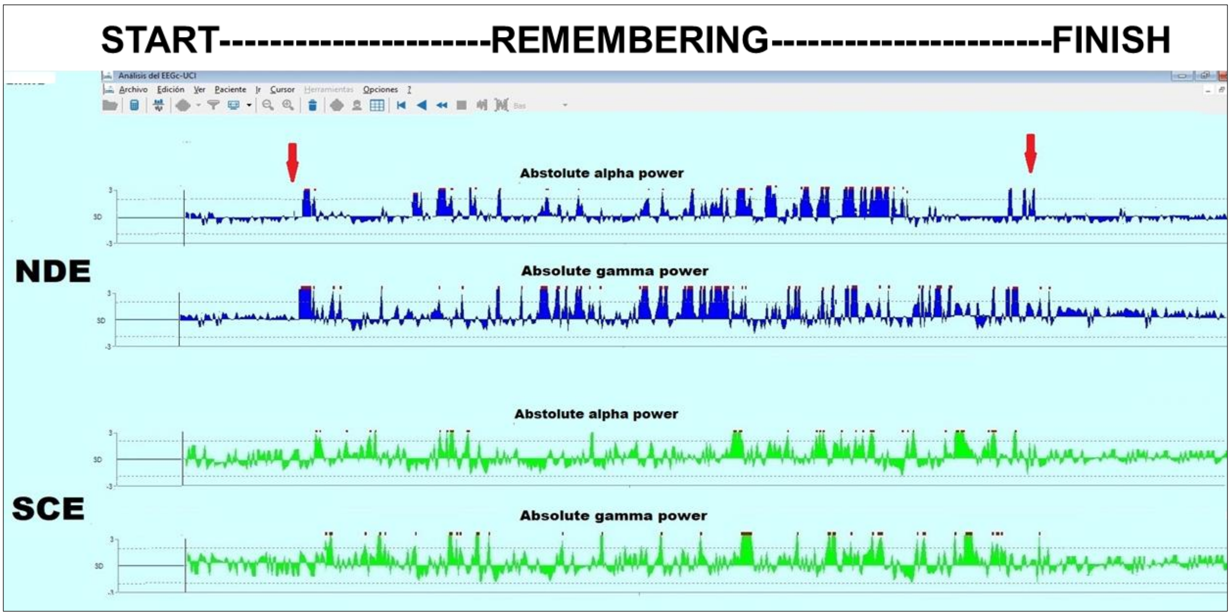

Figure 5 CEEG Alpha & Gamma: Grand Average of Both Hemispheres & All Subjects – Plot

4. Discussion

4.1. CEEG in ICU

Neuronic CEEG-UCI has the necessary options for the detailed and specific analysis of neurological monitoring studies, including:

- Detection of artifacts according to different established criteria.
- Calculating measurements on the EEG based on time domain: Integrated Amplitude, Amplitude Range, Envelope, and Suppressions.
- Calculating measurements on the EEG based on the frequency domain: Frequency Spectrum, Spectral Edge Frequency, Wide Band, Relative Alpha Variability, Asymmetry Index, and Brain Symmetry Index.
- ECG analysis includes automatic detection of bradycardia, tachycardia, arrhythmia, asystole, and heart rate variability.
- All the results are presented in the form of graphics on predefined screens and presentations, which allows a comparative analysis of the various parameters recorded, the calculations performed, and the events detected. The presentations have been defined using a graphical editor specially designed for the application, allowing users to create their presentations.
- Some results can be compared with limit values so that if they are exceeded, an alarm is activated and displayed on the screen.
- A wide range of options is offered to facilitate the review of the registry: changing the page one by one or automatically, increasing or decreasing the sensitivity of the channels, and increasing or decreasing the speed of the registry.
- One or two cursors are presented for measuring all the results shown on the screen.
- Neuronic EEGc-ICU User Manual / EEGc-ICU Analysis
- It allows making a report with the result of all the automatic information calculated and the visual inspection made by the user. Depending on the type of document you want to obtain, you can use Microsoft Word, OpenOffice Writer, LibreOffice Writer, or WordPad. Results were tabulated, and graphics were created to achieve a better analysis and presentation of this study—the StatSoft, Inc. Data Analysis Software System (STATISTICA) 2020 version 8.0. (ref. www.statsoft.com) was used for all analytical processing.

4.2. CEEG for NDE & SCE

We found that CEEG assessment showed increments of amplitude coinciding with NDE and SCE remembering period, although the amplitude increase was greater for SCE. The increment was also greater in the Gamma, compared to the

Alpha band. This method also showed a greater CEEG amplitude for SCE when frontal leads of both hemispheres were considered for the assessment.

Some people who had survived a life-threatening crisis report an extraordinary NDE. NDEs are reported more frequently because of improved survival rates resulting from modern resuscitation techniques. The content of NDEs and their effects on patients seem similar worldwide, across all cultures and times. The subjective nature and absence of a frame of reference for NDEs lead to individual, cultural, and religious factors, which determine the vocabulary used to describe and interpret the experiences. NDEs are reported in many circumstances: cardiac arrest in myocardial infarction, shock, electrocution, coma resulting from traumatic brain damage, intracerebral hemorrhage or cerebral infarction, near-drowning or asphyxia, and apnea.[34-39] Similar to NDEs, some experiences occur during the terminal phase of illness and are called deathbed vision.[37,40-44] Although these results cannot simply be correlated with human experiments, it suggests the brain's remaining activity may explain the NDE.[45,46]

As mentioned earlier, we have found, from anecdotal observations, that occasionally, when teaching CP to students, they would relive their previous NDE experience during their CP. Hence, it became clear that the four attributes described by Moody[47,48] to NDEs also applied to SCEs. Those are *paranormal* out-of-body, *cognitive* timelessness; *affective* peacefulness; and *transcendent* divine. This was the case even when CP practitioners never had a previous NDE. Our neural correlate research seems to confirm this anecdotal observation.

The fact that there is increased activation in the scans of SCE subjects is understandable since they remember an incident not connected with an impaired state of consciousness or suffering near death, compared to the scans of the NDE subjects. Moreover, SCE is more likely to occur with CP training, and the increments within the Gamma band, and ever greater in frontal lobes, indicate marked cognitive processing.[49-55]

Some researchers observed a surge of brain activity just moments before death. This raises the fascinating possibility that they have identified the neural basis for near-death experiences. However, that research on death-related brain activity was in rats, not humans. It is easier to study the death process in animals than in humans. The exact moment of death was identified as the last regular heartbeat. EEG was recorded during a normal waking phase, anesthesia, and after cardiac arrest, from the right and left frontal (RF/LF), parietal (RP/LP), and occipital (RO/LO) cortex.[56, 57]

These results might explain the brain activation we found in our subjects during remembering NDEs. To explain a greater activation during remembering SCEs, we can consider neuropsychological effects during CP meditation. Some authors have demonstrated superior performance on the test of sustained attention compared to controls, and long-term meditators were superior to short-term meditators.[58-67] The increment of attention performance during a SCE, might explain a grander brain activation than an NDE. Several authors have reported increased EEG Alpha and gamma bands during meditation. [60, 68-73]

The significance of CEEG measurement in the ICU setting includes detection of nonconvulsive status epilepticus in patients with unexplained consciousness disorder or mental deterioration, assessment of sedative/anesthetic state, early detection of delayed cerebral ischemia associated with subarachnoid hemorrhage, assessment of the outcome of patients with post-resuscitation encephalopathy or subsequent severe neurological disorders. CEEG can detect changes in EEG over time, thereby enabling the early initiation of treatment, and can evaluate response to treatment, if administered, over time.[16, 21, 74-79]

Considering the high-resolution time of CEEG,[30-33, 46, 80-83] this method offers a unique possibility to demonstrate that the brain undergoes continuous and dynamic functional changes during NDE and SCE remembering.

According to our literature review, this is the first article using CEEG to assess NDE and SCE.

Study Limitations

This study has some limitations, foremost the relatively small number of subjects. The subjective memorization of NDEs and SCEs may not adequately reflect past experience. The base case of not being asked to remember anything may not be as valid as being asked to remember something uneventful, such as peeling a banana. We plan to run future protocols to address these limitations.

5. Conclusion

In this paper, we demonstrated the usefulness of using the CEEG methodology to demonstrate increments of amplitude coinciding with NDE and SCE remembering period, although the increase of amplitude was greater for SCE. The increment was also greater in the Gamma, compared to the Alpha band. This method also showed a greater CEEG amplitude for SCE when frontal leads of both hemispheres were considered for the assessment. This suggests a greater cognitive function and attention increment during SCE remembering time.

Future research should be done on NDE and SCE using the CEEG methodology with more participants.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The Authors report no conflicts of interest.

Statement of ethical approval

Written informed consent was obtained from each subject with a form approved by IRB of the Institute of Neurology and Neurosurgery, Havana, Cuba.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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