Electrostatic discharges and their effect on the validity of registered values in intracranial pressure monitors

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Objectives

Intracranial pressure (ICP) monitoring is used extensively in clinical practice, and as such, the accuracy of registered ICP values is paramount.

Clinical observations of unphysiological changes in ICP have called the accuracy of registered ICP values into question.

Subsequently, we have tried to determine if the ICP monitors from major manufacturers were affected by electrostatic discharges (ESD), if the changes were permanent or transient in nature, and if the changes were modified by the addition of different electrical appliances normally used in the ICU environment.

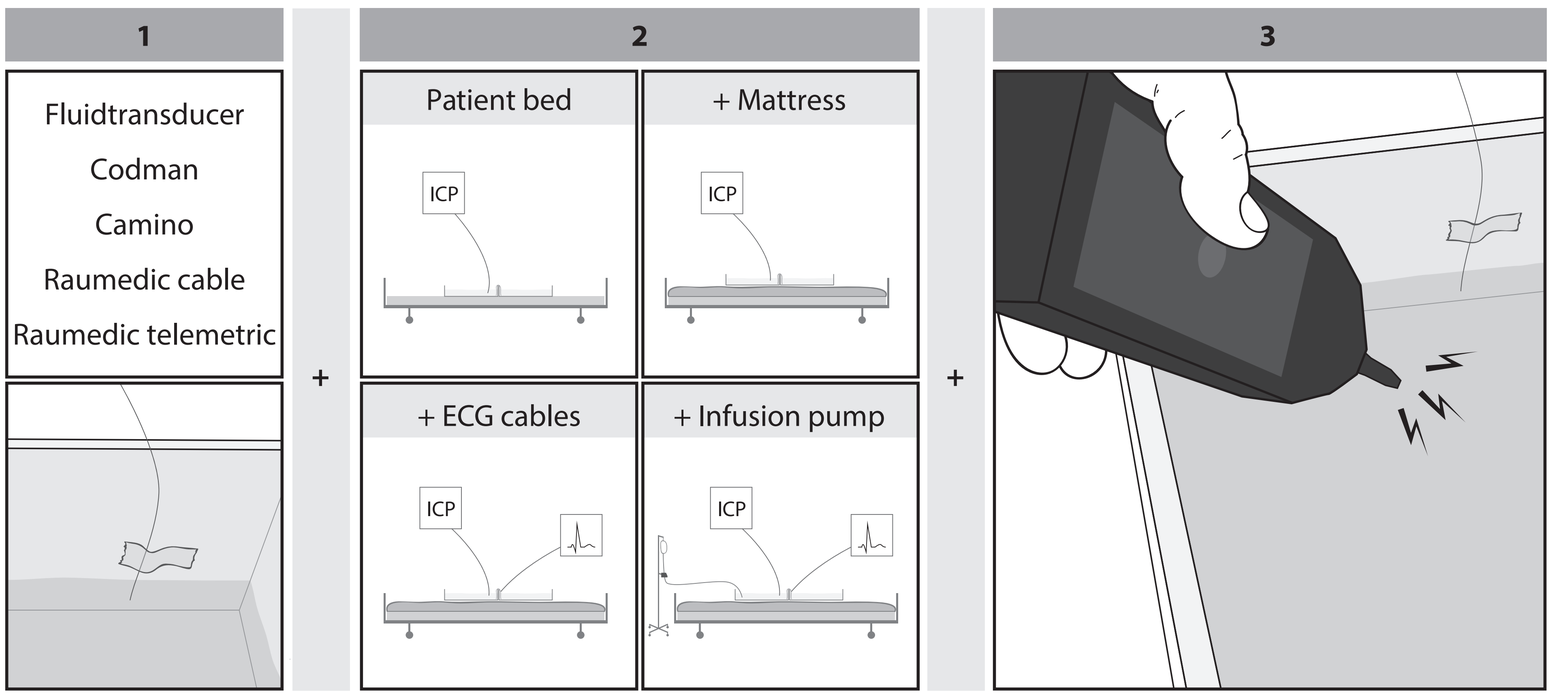

Figure 1. The test procedure was composed of three phases. ❶ Selection of ICP monitor, ❷ addition of 'challenges,' and ❸ sequential electrostatic discharges at 0, ±2, ±4 og ±8 kV. With four 'challenge levels' and seven 'discharge levels,' we gathered 28 individual recordings from each ICP monitor. During each recording five sequential discharges were performed.

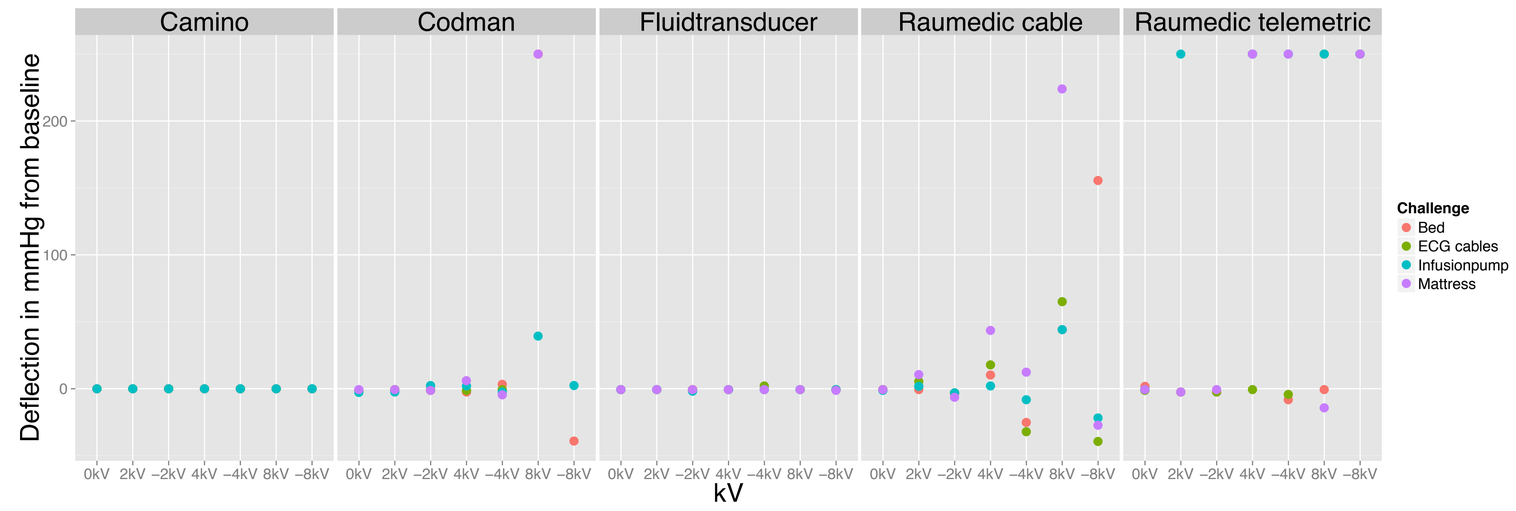

Figure 2. Maximum deflection of ICP in mmHg as a function of applied kV and 'challenge' levels. The fluid-filled transducer and the Camino monitor, were the only monitors not affected by electrostatic discharges. All monitors with electrical components at the tip of the transducer were affected by ESD. The polarity of the applied voltage affected the direction of the deflection. (A value of 250 mmHg is an error value indicating a lost signal.)

Methods

We established a test setup in the neurointensive care unit using a large container filled with isotonic saline, creating a phantom patient.

ICP monitors were sequentially lowered into the container, and subjected to a predefined test battery of electrostatic discharges (See Figure 1).

In sequential order, the following 'challenges' were applied: a patient bed, an electrically powered pressure-relieving mattress, ECG cables and pulse oximetry monitor, and finally an infusion pump.

Results

We evaluated five pressure monitors from four manufacturers. Three monitors containing electrical circuitry at the tip of the transducer were all affected by electrostatic discharges (See Figure 2).

We saw clinically significant permanent changes in the reported ICP values for one pressure monitor (See Figure 3), and temporary deflections for two other monitors.

The monitors had different levels of sensitivity to discharges at low voltages.

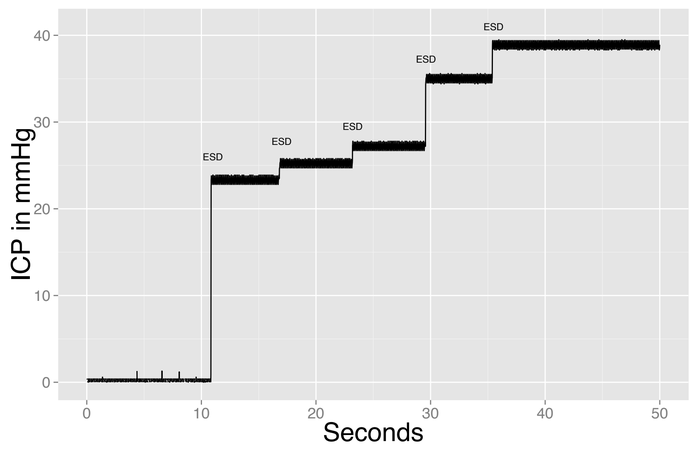

Figure 3. Permanent displacement of the ICP baseline in the Codman MicroSensor. On repeating the test, the sensor eventually permanently malfunctioned.

Conclusions

Our results explain some of the sudden shifts in ICP seen in the clinical setting. We did not, however, find a clear deflection pattern related to the addition of electrical appliances.

We recommend instituting policies for reducing the risk of subjecting patients to electrostatic discharges in the neurointensive care setting.

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