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BRIEF REPORT

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A comparison of extradural and intraparenchymatous intracranial pressures in head injured patients

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Abstract The reliability of extradural pressure measurements for the measure of intracranial pressure (ICP) is still controversial. This study was undertaken to assess the limits of agreement between extradural and intraparenchymatous pressures using respectively the Plastimed extradural sensor and the Camino fiberoptic system. The study took place in a neurosurgical intensive care unit. Ten head injured patients were included in the study, leading to the comparison of 1032 pairs of hourly ICP values. Although the measures were significantly correlated, there was no agreement between the two methods of ICP monitoring. Extradural pressure was higher than intraparenchymatous pressure (bias 9 mmHg; 95% confidence interval of bias −9.8 to 27.8 mmHg). The lack of agreement between the two methods is probably due to the unreliability of extradural pressure for the measurement of ICP.

Key words Intracranial pressure · Extradural pressure · Intraparenchymatous pressure · Monitoring · Head injury

Introduction

Intracranial pressure (ICP) monitoring is commonly indicated in head-injured patients, particularly when clinical examination has become difficult because of the institution of sedation and mechanical ventilation. The "gold standard" of ICP monitoring is a fluid filled catheter connecting the ventricles to an external transducer. Unfortunately, the cannulation of the ventricle may be difficult in the presence of a swollen brain and there is a significant risk of cerebrospinal fluid infection. The measurement of extradural pressure seems to be an attractive alternative for pressure monitoring because the procedure is almost free of serious complications. Thus, we have used it for many years in our neurosurgical intensive care unit (ICU) for the evaluation of ICP in head-injured patients. Recently, a new intracranial monitoring technique, the Camino fiberoptic catheter system, has become available. This system can be easily placed within the ICU, seems reliable for the measurement of ICP and has a low morbidity. But the replacement of a system of ICP monitoring by another one may change the management of the patients if the measurement methods are not comparable. Therefore, a study was undertaken to measure the agreement between the cerebral intraparenchymatous pressure using the Camino fibre optic catheter system and the extradural pressure using a fluid filled extradural sensor.

Material and methods

After approval of our faculty ethical committee and informed consent obtained from a relative, 10 patients were included in the study. All patients suffered a severe head injury (postresuscitation Glasgow coma score ≤ 8). In all patients, a fibre optic catheter (Camino Laboratories, San Diego, California, USA) and a fluid filled extradural sensor (Laboratoires Plastimed, Paris, France) were placed in the frontal region within the first 24 h following injury. Both systems were inserted on the same side, as close as possible from each other, via two different burrholes. The site of monitoring was the less injured frontal area of the brain to avoid the insertion of the

fiberoptic catheter inside the contused brain. The fiberoptic catheter was calibrated once before placement and inserted 10 mm into the brain. The extradural sensor was calibrated just after placement and then every 12 h. The reference point was the level of the external auditory meatus. The ICP waveforms were visualized on a monitoring system (PPG Hellige, Germany) and mean ICP was recorded and printed automatically every 12 min. The study was stopped when the pulsatility of one of the ICP waveform disappered or when one ICP did not increase during jugular or abdominal compression.

The ICP values were averaged hourly for statistical comparisons. The results are given as mean ± standard deviation. Statistical analysis used linear regression analysis and the method described by Bland and Altman for assessing agreement between two methods of clinical measurement [1].

Results

All patients were men, with a mean age of 26.8 ± 9.7 years (16–51 years) and a post resuscitation Glasgow coma scale score of 5.8 ± 1.9 (3–8). The diagnosis on the first computerized tomography scan (CT scan) were: isolated cerebral edema in 2 patients, cerebral contusions associated with cerebral edema in 8 patients. There was no complication due to ICP monitoring. The mean duration of ICP recording was 6.5 ± 2.0 days, which permitted the comparison of 1032 pairs of ICP values. The extradural device was responsible for the cessation of the study in 3 patients. There was no apparent failure of the intraparenchymatous device during the study period. In all other cases, the study was stopped because ICP monitoring was no longer indicated. The correlation between the two measurements was very significant ($p < 0.001$) but the correlation coefficient was low ($r = 0.53$, 95% confidence interval [0.48, 0.57]).

Using the method described by Bland and Altman, the agreement between the two methods of ICP monitoring was bad. The extradural pressure was higher than the intraparenchymatous pressure and the mean difference between the two measurements (the bias) was 9 mmHg. The standard deviation of the difference (the precision) was 9.4 mmHg. Thus, the 95% confidence interval of bias was −9.8 to 27.8 mmHg (Fig. 1). The same analysis was done for the first 24 h data. For this time period, the bias was 9.3 mmHg and the precision was 7.3 mmHg.

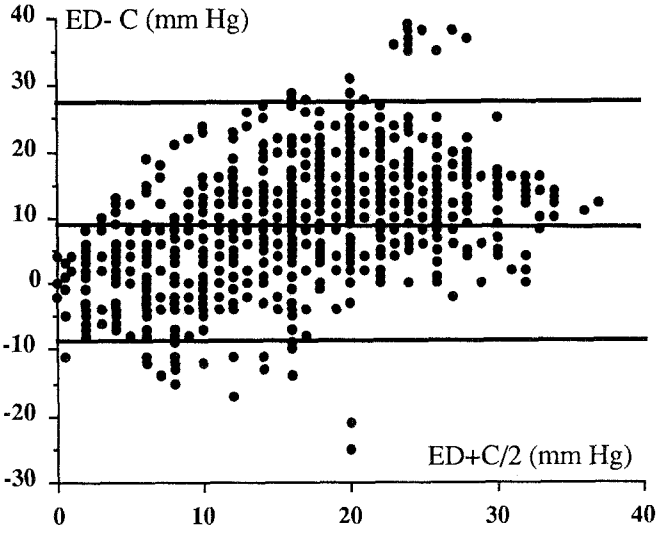

Fig. 1 Differences between extradural and intraparenchymatous pressure measures plotted versus the mean ICP value

Discussion

The choice of the measurement method for ICP monitoring must be made after an evaluation of the risk/benefit ratio. An ideal system should be accurate, safe to the patient, simple to use and inexpensive. Ventricular fluid pressure remains the standard by which all other methods must be judged and access to the ventricles makes it possible to withdraw cerebrospinal fluid to reduce ICP. But this method carries with it a significant risk of intracerebral hemorrhage or infection [2]. Extradural and intraparenchymatous pressure measurements are associated with a very low morbidity and can be placed easily within the ICU. Even if the two methods were comparable, it would be important to note that the cost of the extradural sensor is about 10 times lower than the one of the Camino catheter in our hospital. Our study has found a lack of agreement between extradural and intraparenchymatous pressures. This may be due to true differences in ICP between two different intracranial compartments or failure of one monitor to accurately measure ICP.

Case reports have shown that significant pressure differences between each side of the brain might exist in cases of unilateral mass lesions [3]. But two other studies in head-injured patients with unilateral mass lesions found either no difference or only transient gradients of pressure between the right and the left sides [4, 5]. Moreover, in our study, the two devices were only a few millimeters apart on each side of the dura-mater, making large differences in ICP very unlikely.

There are few studies in the literature comparing extradural and intraventricular pressures. In one experimental and clinical study, the relationship between extradural and intraventricular pressures was stable in patients suffering chronic hydrocephalus. But there was no close relationship between extradural and intraventricular pressures in the group with acutely raised ICP [6]. A more recent study demonstrated that the reliability of extradural pressure increased with experience and was acceptable for clinical use in head-injured patients [7]. In our study, although the neurosurgeons had experience for placing the extradural sensor, extradural pressures were on aver-

age 9 mmHg higher than intraparenchymatous pressures. Thus, 51% of hourly extradural pressures and 10.5% of hourly intraparenchymatous pressures were above 20 mmHg. One can suppose that the difference between the two measurements may increase with time. In fact, the results of the analysis for the first 24 h data are comparable to the results for the entire period of monitoring, excluding any significant time relationship between the two measurements in this study.

The Camino catheter has been extensively studied both in vitro and in vivo. The average daily drift of the system was ±0.6 mmHg and the average drift over a 5 day period was ±2.1 mmHg [8]. The correlations between the ventricular pressure measured with the Camino device and an intraventricular catheter hydraulically linked to an external transducer were high in two studies (correlation coefficients of 0.977 and 0.98) [8, 9]. The mean difference between these two ventricular pressures was 1.15 mmHg and 97% of the differences between the two systems were within ±5 mmHg [9]. The comparisons of intraparenchymatous and intraventricular pressures using the Camino device revealed a good correlation and a good agreement between the two measurements (bias 2.73 mmHg, 95% confidence interval of bias 2.61 to 2.85 mmHg) [8, 10, 11]. Thus, the data available on the Camino system suggest that it measures accurately ICP over a wide range of pressure and that intraparenchymatous pressures are very close to IV pressures [12]. Considering these data from the literature, the very large confidence interval of bias in our study between extradural and intraparenchymatous pressures is probably explained by the unreliability of the extradural sensor to measure ICP.

In summary, there was no agreement between extradural pressure using the Plastimed extradural sensor and intraparenchymatous pressure using the Camino system. We think that this study confirms that extradural pressure monitoring is inaccurate and unreliable for the measurement of ICP in head-injured patients and cannot be recommended in clinical practice.

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